COLOUR / SPACE: ITS QUALITY MANAGEMENT IN ARCHITECTURE

THE COLOUR/SPACE UNITY AS AN UNITY OF VISUAL COMMUNICATION

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I wish to dedicate my thesis to my parents. To my father, who always filled me with the desire to pursue knowledge and all my profound believes. Sadly, my father passed away seven years ago, but his dreams have stayed with me. To his memory I dedicate the effort of my research.
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DECLARATION

I declare that the research contained in this thesis was solely carried out by me. It has not been previously submitted to this or any other institution for the award of a degree or any other qualification.

ABSTRACT

In external city environment areas there is a poor understanding and often no conscious use of colour.

The experts that work with colour, in terms of the built environment, either as project-makers, or as managers (decision-makers), are poorly prepared to deal with it. As an answer they minimise the problem of colour in architecture, especially in exteriors, simply by omission; or, they introduce colour mostly without criteria - in some projects colour plays only a cosmetic role - supposedly aesthetical. Most project-makers do not consider colour as an integral part of the global design process.

Colour theory and teaching courses have been considered supplemental to the mainstream of architectural education; for most part of the students of architecture or landscaping architecture, colour remains a matter of individual taste.

People in general are very conscious of colour and texture in the built environment and they really like variations (as some studies done in Sweden (Küller 1981; Mahnke 1993) have already showed). They are negative and critical of austere, colourless environments in our cities; also colour has psycho- therapeutic effects that can be utilised to meet the physiological needs of people living in crowded environments.

Colour is one of the basic components of the environment, which influences life quality and it can be approached from different perspectives and different disciplines.

This research addresses the issue of colour in the architecture of the built environment, analysing the behaviour of the *unity* which results from the straight relationship between *colour* and *space* (as quantity of colour): the *Colour/Space Unity*. The investigation shows not only the existence of this unity, but also that it is a *unity of visual communication*.

In terms of allocating the findings and interpretations through a review of the relevant theory, the author uses a *survey methodology*: a full test response questionnaire to a wide range of members of society (to test theory) and semi-structured interviews with a panel of experts (as a feasibility test of the questionnaire design and contents). The questionnaire findings are used to test the theoretical position through further comments from the expert panel.

The research presents as results, not only the existence and importance of the *colour/space unity*, as a visual communicational one, such as the levels of articulation of the messages in the built environment or the contrast in the relationship between qualification and quantification in colour/space language; but it demonstrates the major importance of the colour/space unity in the architectural project and in the colour planning management within the built environment.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter describes the background support, the aims and objectives of this research, emphasising the importance of *colour* in the built environment planning, as well as it enounces the thesis layout and the thesis guide.

This is a study of the perceptive - communicative relationship between *Colour* in the architecture of the city and *Space*, as an area of colour, which defines an unity: *the colour/space unity*.

This *unity* intervenes in the visual methodological programming of the environment.

1.2 Background

"*Colour*, or the concept of colour, can be approached from different perspectives and different disciplines, such as the natural sciences, colour theory, technology, philosophy, biology, medicine, psychology, architecture and art" (Levin 1995).

In the twentieth century, interest in colour in architecture in Europe has been expressed in several ways (Lenclos 1995). Two periods can be distinguished, characterised by different perceptions of the issue. First, between the 1920´s and the outbreak of the Second World war, architects themselves tackled the question of colour, either by adopting some sort of polychrome, or, on the contrary, by excluding it from the design of their buildings. In the second period, in the 1950´s, new forms of coloration emerged, this time at the initiative of certain artist-painters.

One movement that had a great impact was that of the Bauhaus, a revolutionary and functionally sound school founded in 1919 by Walter Gropius. The Bauhaus established new modes of building design and construction, but with a definite lack of colour and ornamentation. Gropius became the leading advocate of a purist and functionalist approach to architecture. White, clear, and bright meant freedom and space. It seems odd that principles of colour and colour psychology were introduced into the teaching program at the Bauhaus. In the fine arts, such Bauhaus painters as Paul Klee, Josef Albers, and Johannes Itten produced some excellent work in colour. Yet no allowance was made for it in architecture.
Le Corbusier used colour in architecture with less regard to natural environmental conditions. He had a great fondness for colour and believed it can create a feeling of space. His compositions were based on sound geometry; in a Berlin apartment project, for example, he used red, yellow, green and blue, in a way that complemented the geometric architectural composition of the building (Mahnke 1993).

In her work, Galen Minah (1984) refers that the Dutch De Stijl movement was an important accomplishment in the use of colour as a tool in theoretical approaches to architectural form. The best known members of this movement were the artists Piet Mondrian and Theo van Doesburg, who became the prime spokesman for the movement, and Gerrit Rietveld, an architect who produced some of the only built objects of this period. De Stijl was a dramatic development in the use of colour as both an integral part of the design process and as a tool for the creation of a new spatial experience. No other movement had employed colour as a conceptually spatial idea to this extend and none had recognised and used in practice the destructuring capacity of colour.

Other movements employing colour as a basis for the conceptual design were Constructivism, in which colour played a symbolic role (Cheernikov 1989), and Expressionism.

The Expressionists were artists and architects who saw their creative role as a calling to save society through their inspired artistic achievements. For the Expressionists colour was powerfully emotive and highly individual and subjective, as seen in the architecture of Hans Poelzig and Hans Scharoun (Pehnt 1973).

A dramatic influence on architectural colour came in the 1970s when artists began to use buildings as canvases. In the early 1980s, a survey was conducted at Oxford Brookes University, comparing responses of both lay people and architects to powerfully coloured buildings (Porter 1996). This found a remarkable enthusiasm among the public for a more richly coloured built environment, much more than the architects.

Man recognises colours mainly through the eye globe (*sensations*) and through the brain (*thought and feelings*). The nervous system operates in such a way that the perception being determined by the integrated configuration of activities of a great part of the brain, and not exclusively by that sector that, initially, receives the messages of the first receiver. In the perception process there exists, therefore, an integrated activity of the nervous system.
Besides that, to see, to think and to feel are directly connected with each man's cultural background.

Concerning the natural order of the chromatic sensation, it's important to define the sense of colour.
The chromatic sensations, logically, and in physiological terms they adapt themselves at the different dimensions.
Therefore, the *sense of colour* isn't only restricted to what is coloured, it not only means what possesses sources derived from the spectral positions, but covers all the perceptive capacity of the other dimensions. So, in the sense of colour, the values of the light intensity, or brightness, are also considered, along with hue, intensity values, and saturation (chroma) (**Fig 1.1**).

Fig 1.1 The same street view in Seattle,with different light incidence (Minah 1996)

The visually significant result of the physical-physiological-psychological relationships form the most elementary components through which colour becomes organised under the form of *visual language* (Monzéglio 1978).

The relationship of those components co-ordinates colour in sensibility levels which differ in quantitative and qualitative contents of *hue, value and chroma* (Munsell 1976):

- *Hue* - attributes colour meaning of its position in the spectrum, defined by its wave length; is the quality or characteristic by which one colour is distinguished from another.
- *Value* - attributes value meaning of brightness; it's called lightness and it's the quality that differentiates a dark colour from a light one.
- *Chroma* - attributes intensity meaning or purity of colour; it's also called saturation.

Those three physical attributes allow to attribute to colour, as a sensitive element, not only precise and own definitions in *qualitative* and *quantitative* characters,

but also in *brightness* (value), *hue* and *chroma* (Albers 1963; Casson 1992).
As Faber Birren (1961a) has demonstrated the maximum favourable colour effects depend within reason on variety and contrast (**Fig 1.2**).

Fig 1.2 The coloured phantom of the buildings of Venice (Lancaster 1996)

In 1981 the researcher Dr. Richard Küller made an important study dued to his scientific way about the physiological and psychological effects of light and colour, as have others who have approached the subject from the same point of view (Berlin et al 1969; Gerstner 1986; Hardin 1986; Mahnke et al 1993; Ruling 1990; Simpson 1991).
Colour, which is created by light, is therefore a form of energy, and this energy affects the function of the body just as it influences mind and emotions (psycho-physiological effects).

Today, people know that colour affects cortical activation (brain waves), functions of the autonomic nervous system (which regulates the body's internal environment), and hormonal activity, and that colour arouses definite emotional and aesthetic associations (Moruzzi et al 1949; Goldstein 1942; Ali 1972; Gerard 1957; Jacobs et al 1974; Berlyne et al 1965).
As Richard Küller (1981) refers: "Stress symptoms (such as changes in the rate of breathing, pulse rate, blood pressure, muscle tension, psychiatric reactions of

varying types, increased susceptibility to infection, coronary disease, ulcers) are typical effects on those persons who have been subjected to overstimulation".

Colour has also been used therapeutically in treating emotionally and mentally ill patients. For instance manic and aggressive patients need cool colours to calm them down, while depressive and suicidal patients need warm and exciting colours to compensate for the melancholic inner state.

"All visually impaired students need environments that are at least restrictive. For visually impaired students with multiple disabilities, the use of colour and contrast can enhance their learning environment" (Gellhaus 1993).

Colour not only produces mood associations, subjective and objective impressions, but also influences our estimations of *volume* (**Fig 1.3**), *weight*, *time*, *temperature* and *noise*.

Fig 1.3 The pale blue on the wall at the end of the street in the fishing village of Gudjheim serves to exaggerate the distance (Lancaster 1996)

Many of the studies undertaken up to today are related with the control of the colour effects in the interior spaces (**Fig 1.4**) (Mcghinchery 1994):

- Hue effect, impressions and associations, and character of each colour; its location (top, sides, bottom);
- Centrifugal/centripetal action and complexity of colours;
- Perception of volume, weight and size;
- Time estimation (under the influence of a certain colour);
- Perception of temperature of noise and sound ;
- Associations of odour and taste

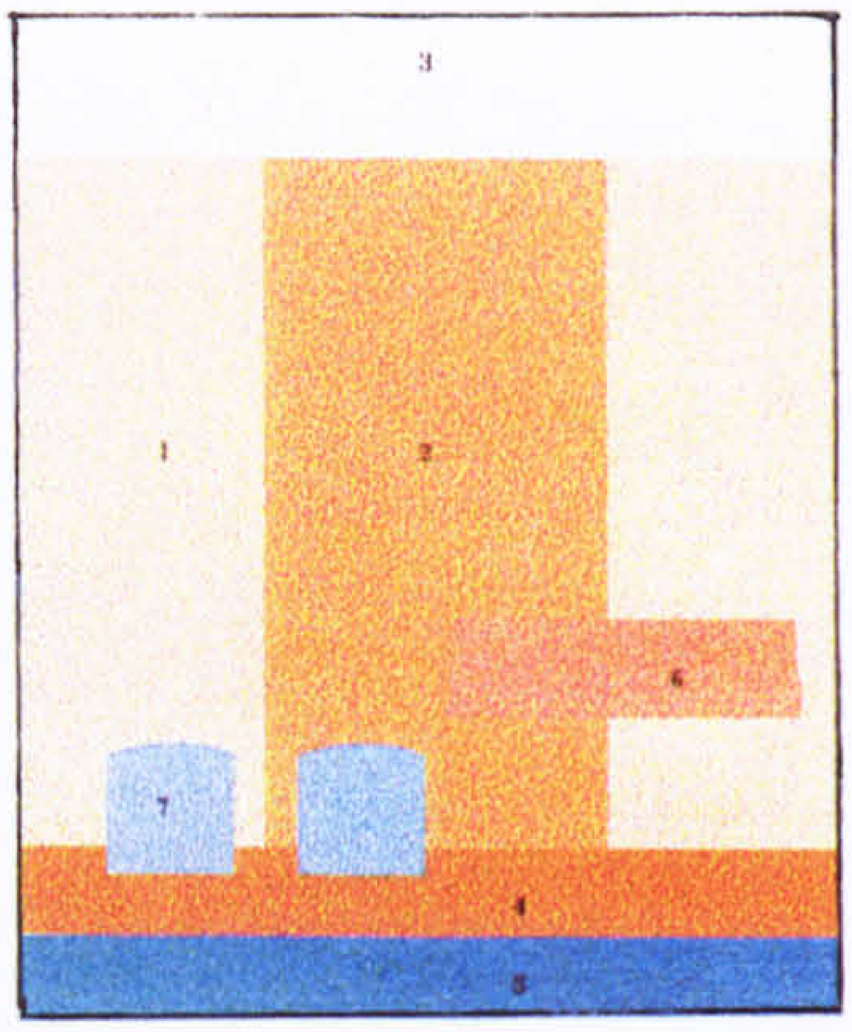


Fig 1.4 Colour collage of hospital patient room, cool colours, using Glidden notation: 1 Walls: 72-58; 2 Endwall: 75-57; 3 Ceiling: 70-26; 4 Floor: 72-15; 5 Bedspread: 72-14; 6 Upholstery: 76-06; 7 Upholstery : 72-14 (Mahnke 1993)

Cultural heritage also influences the effects of colour. Each culture has its own colour and pattern traditions (**Fig 1.5**) and, of course, there are economics, geographical (**Fig 1.6**) and religious factors, as well as fluctuations of taste (**Fig 1.7**) and educational levels (Macguire 1994; Sivik 1969).

Fig 1.5 Colour and pattern traditions are important in inhabitants personalisation. Colour is identity (Lenclos 1995)

Fig 1.6 The blue and green shuttered windows watch like bright eyes in the Mediterranean painters' town in the Roussillon region, eastern Pyrenees (Lancaster 1996)

Fig 1.7 Investigation on colour patterns (tradition, culture and taste) in Ireland (Lenclos 1995)

However, there are generic values valid for all men, as Edward Hall (1966) alleges, which allows us to elaborate selection criteria for certain chromatic messages. There are, for example, standard colours, in fashion cycles, whose permanency is not related neither with duration nor with sector (**Fig 1.8**).

Fig 1.8 The use of a colour scheme in Berlin: standard colours not related with a specific sector or city (Lancaster 1996)

As Marshall Mcluhan (1969) said, due to the radical revolution in the cultural field caused by the development of information systems by electronic computation, one can talk about an international culture, and in our particular case, an international colour culture. There are specific colours broadly used in many parts of the world. It's possible to create a colour directory which represents the range of colours used by a great number of societies .

With the intense circulation of the different media, it has become very difficult to consider a culture or a market in isolation; people are losing the boundaries which characterise different ethnic, religious or national groups. They are under continuous change, even the traditional and symbolic values that cultural minorities attributed to certain existing phenomenons in the colour culture.

When people think about *space* in its characterisation of visual perception, a certain relationship between man and the environment is created which is defined as *visual space*. This is the *space* this research is going to deal with.

According to James J. Gibson (1950), the *visual space* perception is based in the fulfilment of physic-psychophysiologic functions, which determine conditions "to be able to see".
In terms of colour/space, the type of communication is the visual one, because it relates itself to the specific perceptive channels for the vision chromatic sensations. *Space*, characteristically defining colour, belongs to the *visual communicative structure*.

According to Colin Cherry (1957), "*Sign* is the physic concreteness of a message". The *physical stimuli* of the perceptive structure are the *signs* of the issue in the *communicative structure.*

In the *language,* which interrelates *colour* and *space*, one considers *signs* the perception basic stimulus: *space/hue*, *space/value* and *space/chroma*, connected with *space/configuration* (Monzéglio 1979).

The anthropologist Edward Hall (1966) created the term *proxemics* (and also the science), that means the study of man's utilisation of the space, as a specialised elaboration of the culture, i.e. in which way and how man enjoys and uses, appropriates and interacts with the space.
Proxemics is a very significant step in the knowledge of the Man/Environment relationship, when it affirms that different cultural systems create "different worlds of sensations" for the people that use them.

Many researchers have been searching for values to be introduced in the urban environment, with the objective of increasing quality of life. Among them we find Gordon Cullen (1961) and Kevin Lynch (1974), whose concepts and methods are of great value in the incursions of *proxemics* character.

Colour is one of the environment's basic structures, which directly influences the quality of life.

"*Colour* is one of the most important aspects of the city life: it is one of the main factors in our description of a city's decorative effect. To be fully effective for city decoration requires some strategic policy which sets a colour agenda for the city and its main elements, districts, paths nodes, edges and landmarks. The city image from the point of view of colour is often formed over a long history and also strongly affected by its environmental setting. Determination of colour image requires a sensitive response from the urban designer. A response which should be based on a thorough survey of colour in the local environment (**Fig 1.9**). For the remainder of the city, colour can be used to highlight important buildings and landmarks (**Fig 1.10**), colour code important paths and give individuality within the overall pattern for important squares and meeting places" (Porter 1996).

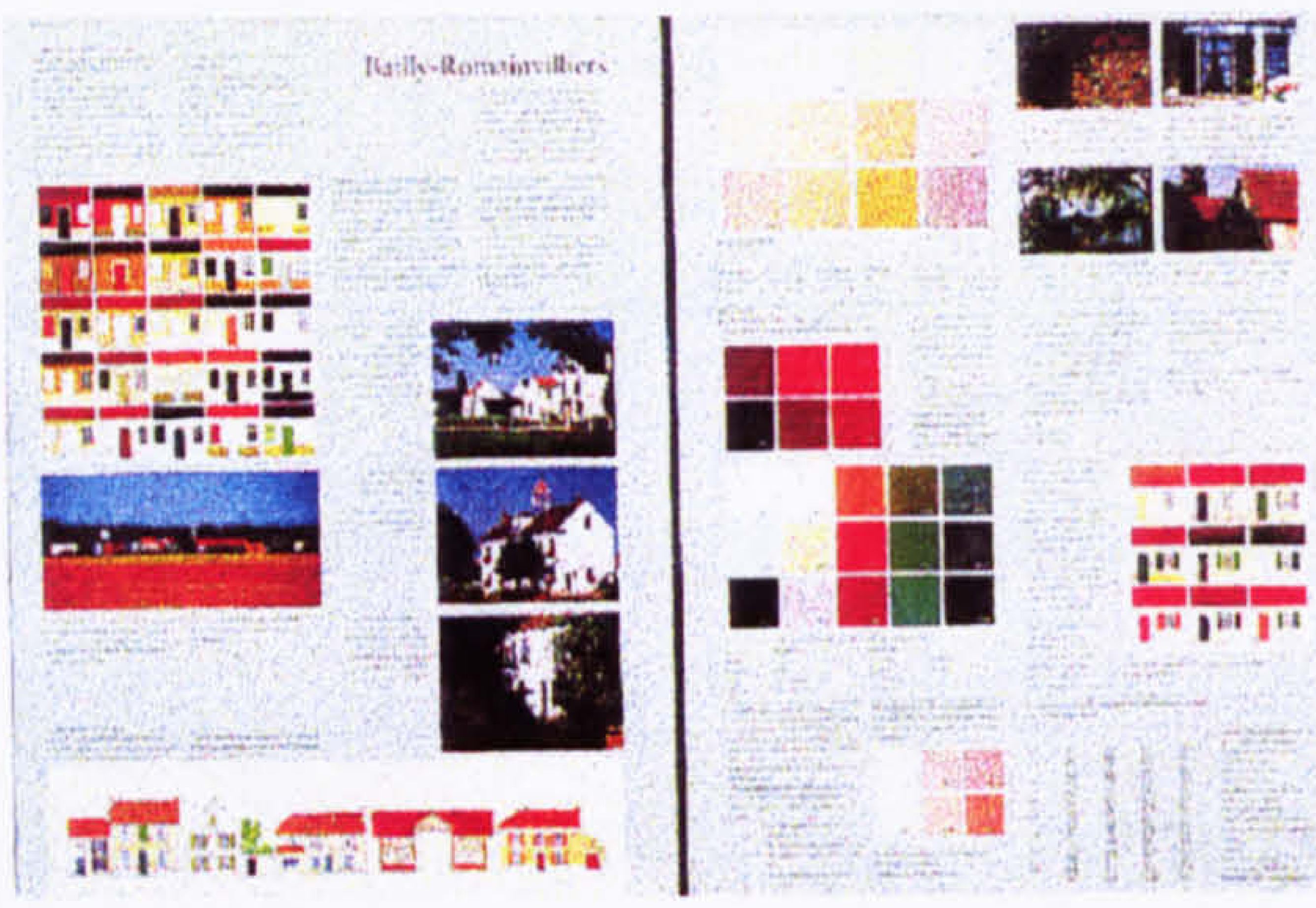


Fig 1.9 Survey of colours in France done by J.P. Lenclos in the local environment (Lenclos 1979)

Fig 1.10 Colour used to highlight and accent the individuality of a building in Mortlake U.K. (Lancaster 1996))

"The *colour* of one city is a necessary function of its light, as physically all colours, and it becomes a symbol **(Fig 1.11**). There are reasons of mental and cultural expression, as well as geographic one: cities of the north are darker; cities of the south are much more clear" (França 1993).

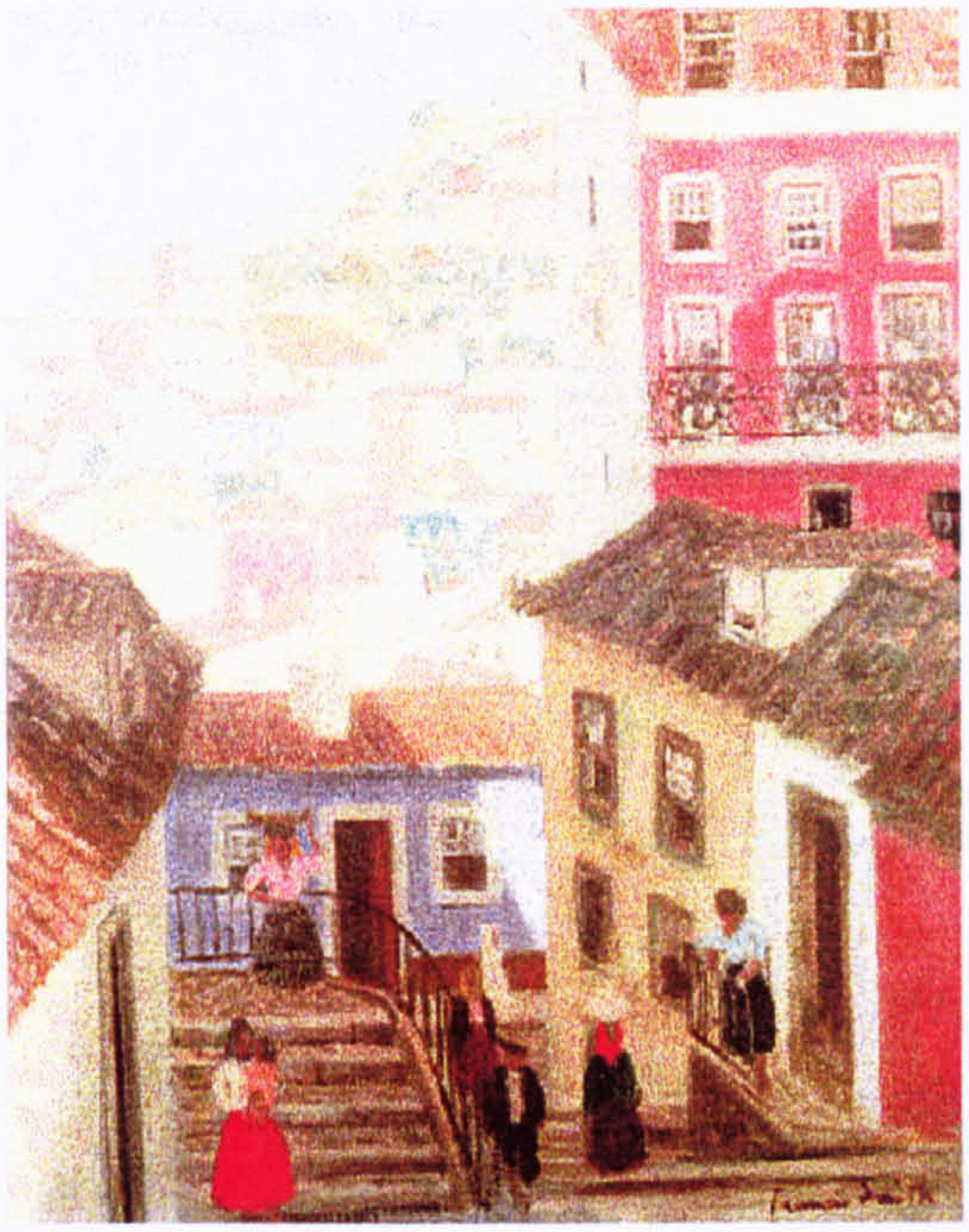


Fig 1.11 The colours of Lisbon seen by Francis Smith: the light of Lisbon which is a symbol and characterises the city (França 1993)

Human beings receive 80 percent of their information from the environment.
The perception of colour in the environment always carries visual, associative, synaesthetic, symbolic, emotional and physiological effects with it.
Mahnke (1990) assumed that six basic interrelated factors influence the "Colour Experience" and he used a pyramid to illustrate this (**Fig 1.12**):

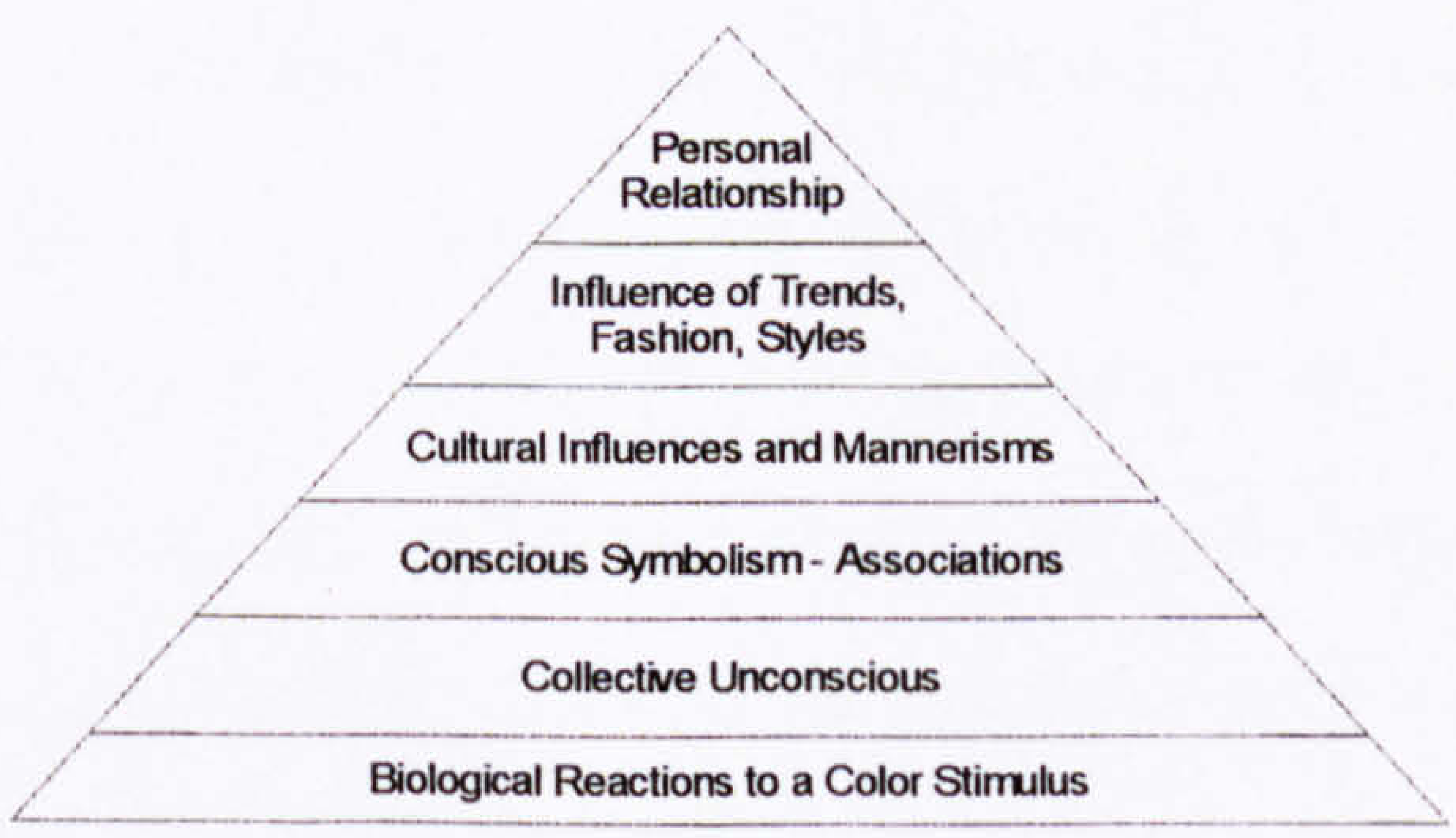


Fig 1.12 The Colour Experience Pyramid (Mahnke 1990)

People in general are very conscious of colour and texture in the built environment and they do like variations. Studies (Kawamoto 1993; Sivik 1974) point out that the presence of colour on exteriors gives rise to positive evaluations, while the absence of colour is generally considered negative. There are even many researchers that have arrived at the conclusion that colourless environments germinate or contribute to some of our social ills.

People are negative and critical of austere, colourless environments in our cities; also, colour has psychotherapeutic effects that can be utilised to meet the physiological needs of people living in unresponsive, crowded environments.

For many years Sweden has taken an active interest in the study of people's reactions toward and evaluations of exterior environmental colour. The Department of Psychology of the University of Göteborg conducted a series of investigations, and overall results show that the majority of people are critical of a lack of colour and positive about happier colours (**Fig 1.13**). In one of these investigations, 600 people were interviewed in two different housing areas: one with grey buildings and the other with strongly coloured buildings. Those living in the grey area described their homes as *concrete boxes*, *bunkers*, and the like, while almost all of those living in the coloured area were happy to have colour in their environment (Mahnke 1993).

It took barely 50 years for *concrete* - the material hailed as a liberator of architecture - to sink so low in public esteem as to appear most often within the unsavoury Homeric epithet *concrete jungle*. It also has the added disadvantage of social stigma. For example, England sophisticated building plans, associated with sophisticated use of concrete, are occupied by those at the margins of society. *Concrete*, lacking the glitter and shine of glass and metal, is generally characterised as grey, damp-stained and irredeemably unsexy, symbolic of the statist aspects of the welfare state (McKean 1996).

Fig 1.13 The happy and vernacular environmental colours used in Burano - Italy (Lancaster 1996)

Sweden (Sivik, Küller) showed that the dimensions of *hue*, i.e., the greenness, redness, or yellowness of colour, was much less important in environment colour than *chromaticness* or *blackness* for certain areas. For example, all dark colours were seen as being more masculine, more unusual and heavier than light colours and that former tend to reduce space and define it less clearly when judged in comparison with their tinted counterparts. Lighter colours, on the other hand, were judged as being more friendly, more cultured and more pleasant, and also rated as appearing more beautiful than the darker colours (Lancaster, 1996a).

Light and colour are inseparable and in the design of the *man-made environment (***Fig 1.14***)*, equal attention must be devoted to their psychological, physiological (Schuschke et al 1993), visual, aesthetical and technical (Gellhaus et al 1993) aspects.

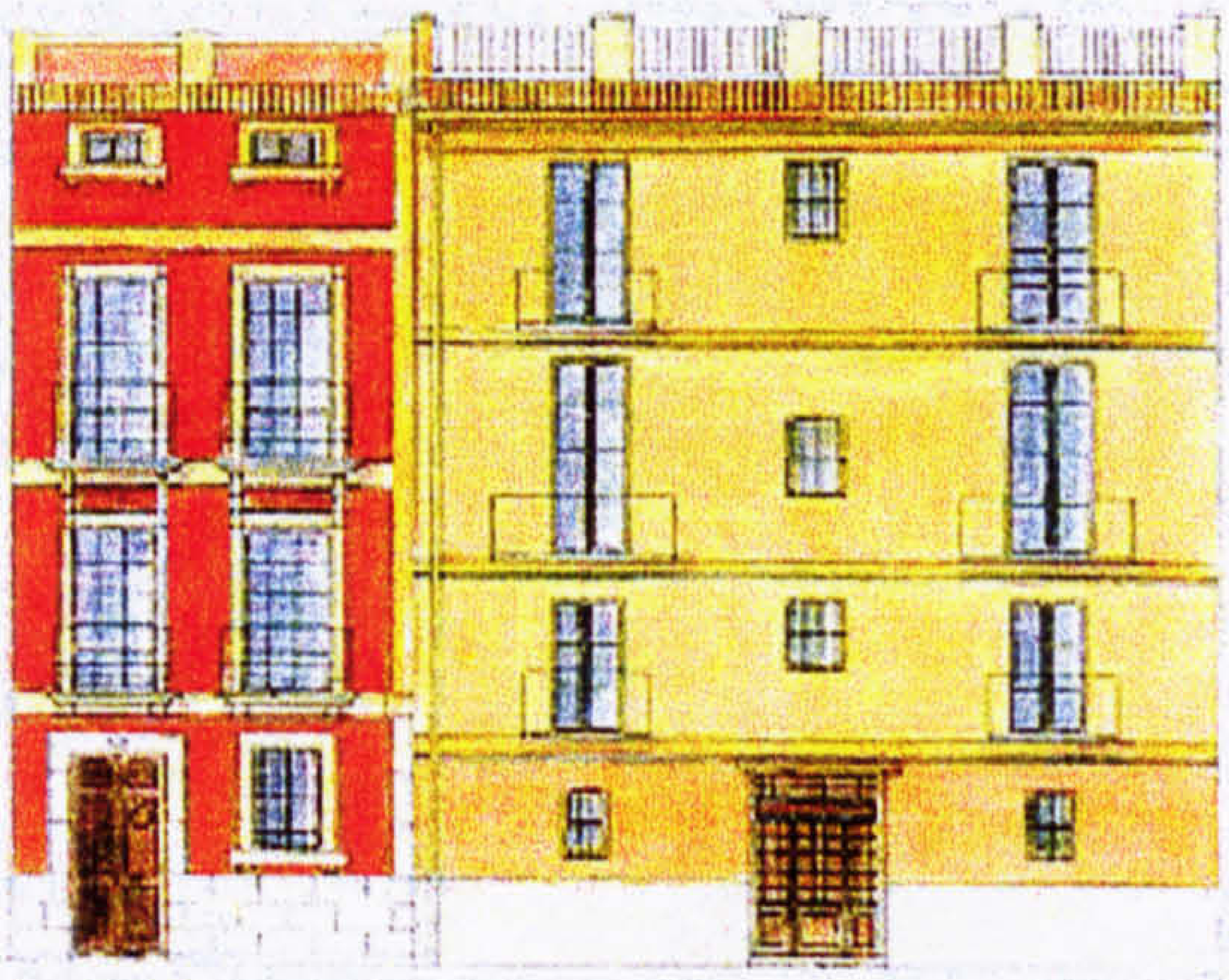


Fig 1.14 The colour scheme used in the historical centre of Valencia (Spain) reflects the straight relationship between light and colour in the design of man-made environment (Garcia et al 1996)

In the *architectural project*, the architect must always deal with the public's needs and preferences, as well as his own aesthetic aspirations. Colour becomes part of a conceptual understanding or architectural form in the design process.

In their coloration, individual buildings may appear pleasant or oppressive, well proportioned or distorted, stimulating or monotonous (as may be the case with achromatics). Buildings that exhibit the same or similar design can be given individuality through colour detailing (**Fig 1.15**).

A great part of the understood colours (i.e. Colours that the eye can easily identify), when one visually explores the urban environment, is connected with the superficial treatment or quality of the objects (texture).

Fig 1.15 The use of colour gave the individuality to these buildings in Gloucester Road-London (Lenclos 1995)

The revetments of the buildings have characteristics of their textures, such as: transparency, opacity, colour, brightness, smoothness, etc. (**Fig 1.16 and 1.17**).

These characteristics determine if the light will be reflected, transmitted, refracted, absorbed or if it will suffer a selected combination of those effects (i.e. glass acts as a filter, absorbing certain colours).

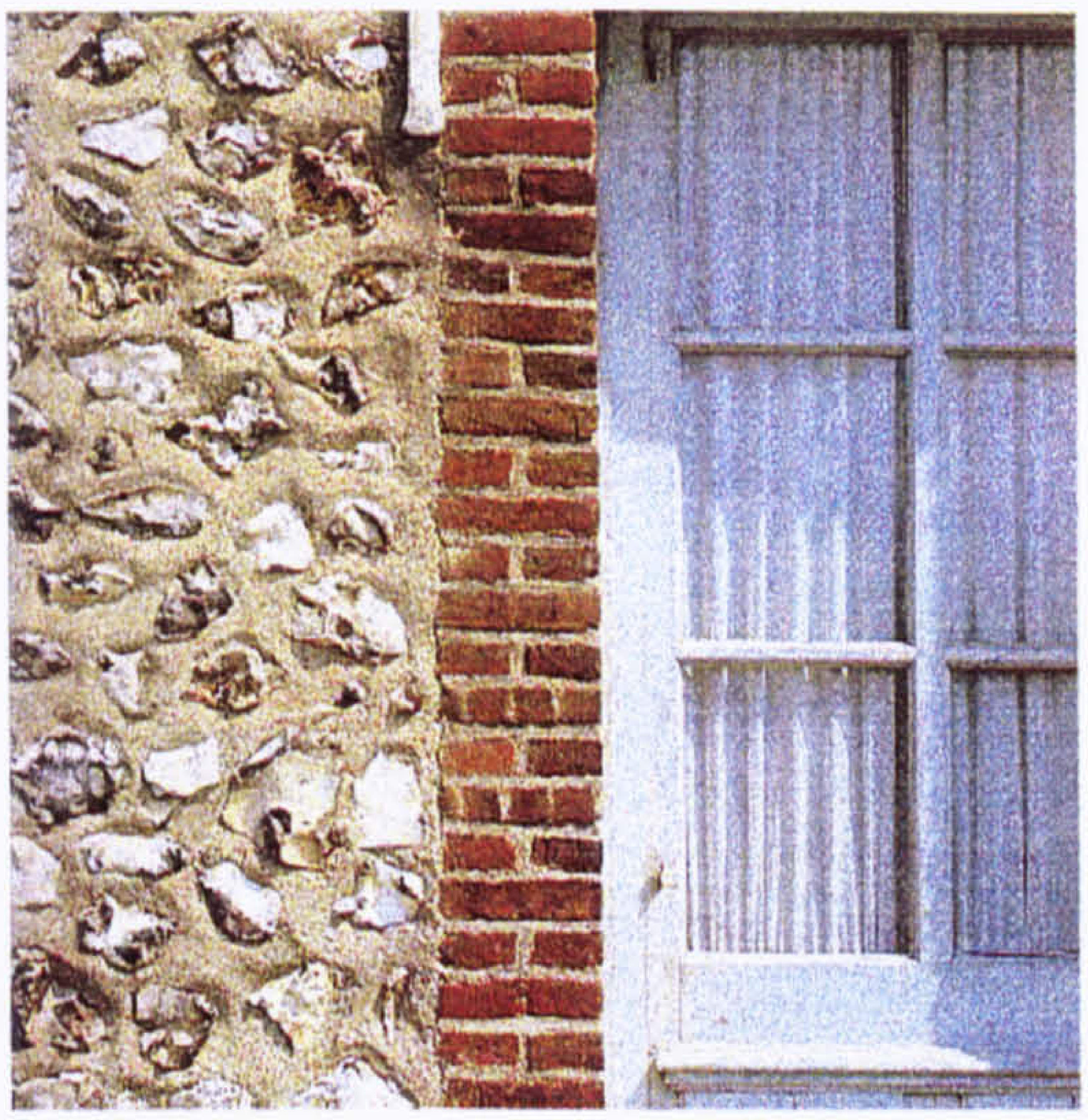


Fig 1.16 Different textures with specific characteristics used on the revetment of a building in Rouen France (Lenclos 1995)

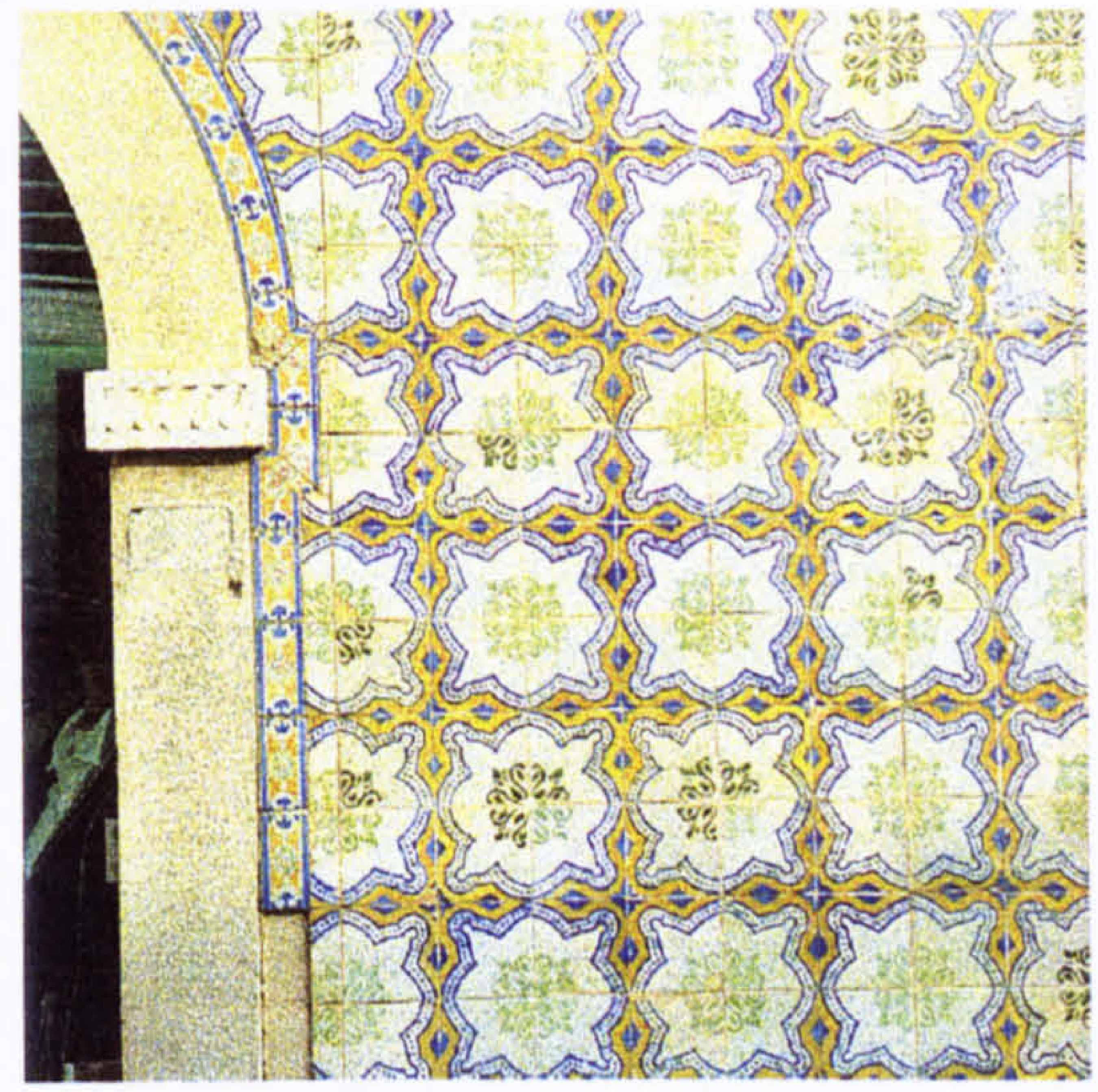


Fig 1.17 The use of tiles in the revetment of buildings in Lisbon: the light is reflected (Lenclos 1995)

Paints have a leading role in bringing colour into the public space, as do other materials such as ceramics, plastics, rubbers, metals, glasses, cements, concrete, asphalt and textiles. The great exception is represented by the natural elements: stone, wood, water, atmosphere, clouds and "greens".

In external city environment areas there isn't a conscious use of colour. Many architects are introducing colour into the environment but, unfortunately, mostly without criteria (in some projects colour plays only a cosmetic role - aesthetically). There are, however, good examples of colour application (Lenclos 1979), but they are still the exception rather than the rule (**Fig 1.18, 1.19 and 1.20**).

Fig 1.18 Housing complex with stores on ground level, Geneva, Switzerland (Mahnke 1996)

Fig 1.19 Housing complex, Carouge, Switzerland (Mahnke 1996)

Fig 1.20 Row housing complex in Öbergösgen, Switzerland (Mahnke 1996)

The choice of colours has almost always been a random process, based on personal preferences or on superficial functionalist considerations. Professionals connected with that choice need to have a consciousness about the importance of colour, with an expressive identity, in the determination of the product quality.

"The fact that many architects seem reluctant to use colour fascinates me. I believe this is something to do with their education and is best illustrated by two ways of viewing of the Parthenon in Greece. The first is an architectural perception that sees this temple as a monochromatic essay in proportional excellence. The second perception sees it as it actually appeared on its opening day in 447BC. Then, it was completely covered in paint and gilding. Both interpretations - the architectural and the Ancient Greek, concern concepts of purity. The coloured version involves *purity* because this is the very meaning of the work *Parthenon*" (Porter 1996).

The experts that work with *colour* and *space* (as an area of colour), in terms of the city, either as project - makers, or as managers, aren't usually well prepared to deal with it.

As an answer, they minimise the problem of colour in architecture, especially in exteriors, simply by omission.

Patient experimental attempts and meticulous research by a few forerunners gave rise to a new profession viewing architecture, that of the colour consultant, working especially with colour manufacturers (Prieto 1995). The importance of colour within the project of architecture is growing every day.
"When architects pick colours, they usually cling cautiously to whites, greys, and muted tones. But over the last 15 years, as interest in polychromy has resurged, more practitioners have ventured into the realm of brighter and more saturated tones. And as they have, a new specialty has emerged – the colour consultant. Many of those consultants are members of the Color Association of the United States (CAUS). Although most architects and all colour consultants stress the importance of considering colour early in the design process, few colourists are brought into the project at the schematic design stage" (Solomon 1992).
A very responsible and pragmatic work has been developed by CAUS - Colour Association of the United States, as well as IACC - International Association of Colour Consultants (Salzburg Austria) (**Fig 1.21**).

Fig 1.21 Colour proposal for Ganahl-Objeckt, Feldkirch, Austria, by colour designer Edda Mally -IACC Colour Consultant (Mahnke 1996)

"In the twentieth century, interest in colour in architecture in Europe has been expressed in several ways. A historical overview, marked by certain events in the 20th century architectural movement, illuminates in this discussion the origins and the need for the new profession. In a more detailed way, the working methods and some realisations of the principal French colour consultants are addressed – a presentation that is intended to interest researchers or professionals by providing specific information that, despite its importance, seems to be lacking in specialised publications" (Prieto 1995).

Building upon this theoretical support one can establish the relationship between the three attributes and space, in such a way as to define the *colour/space unity* and to study the *colour/space unity behaviour* in the perceptive reality of the chromatic attributes (*visual communication*).

The environment is permanently being visually destroyed and appended, reducing, very often, the urban spaces into unbalanced places in terms of colour and, therefore, very unpleasant.
The principle of unity and complexity balance is perhaps one of the major difficulties that the researcher may encounter, and at the same time it's one of great importance (Crewdson et al 1953).

Maybe for the first time in History people possess the necessary elements to achieve the production of a pleasant environmental atmosphere for all. This atmosphere should not exist only here and there, as in small holidays controlled environments, but should be accomplished all over the city where people live our daily life. The self-realisation of the aesthetic and cognitive needs depends on a correct and perfect identification of Man with the environmental systems of objects, in a communicational process.

1.3 Aims of the Study

Colour theory and teaching has been considered supplementary to the mainstream of architectural education. For the majority of the students, colour remains a matter of individual taste (Janssens & Mikellides 1998).

Some architects are still reluctant to consider colour as an integral part of the total design process. It is also true that most architects do not have the luxury or the freedom to design as they truly wish to do. Those much-publicised projects that serve as outstanding examples of the rebirth of colour usually are the work of internationally known architects of considerable professional reputation.

The average architect often must compromise to satisfy the demands of his client. Developers of office buildings, mass housing, shopping centres, and the like, often are concerned with public reaction and therefore the saleability of their projects. This leads to preconceived notions of public taste without a real understanding of people's desires and needs. Often local government officials also hold cautious views.

External colour not only is important in the psychological realm (achromatic versus chromatic), but also is an important element in the form of an architectonic ensemble (Mahnke 1993).

The primary aim of this research is to bring colour into a conceptual framework, where its relevance is part of the *design process* and, consequently, of *built environment management.*

To arrive there, the author will firstly prove that:

- There is an interrelation between *Colour* and *Space* (as an area of Colour), which defines a *unity* : *the Colour/Space unity*;
- *Colour/space unity* is a *unity of visual communication* , and so with strong implications in our *built environment.*

1.4 The Objectives of the Research

The objectives of this study are summarised as follows:

- To examine and analyse the extension of the concept of the message planning in the environmental relationship between *colour* and *space*, as elements of structural order, which define a *unity* : *the colour/space unity.*

- To model *colour/space unity* as a *unity of visual communication*, giving *colour/space system* an organisational *sign*.
- To observe the *colour/space unity behaviour* within the communicative system.
- To show the major importance of the *colour/space unity* in the project of architecture, on exteriors and in courses of architecture and urban planning.
- To develop a framework for the integration of *colour* in the project making process.
- To draw recommendations for future research.

1.5 Research Outline

The approach adopted by this study, to identify the colour/space unity as a visual communicational one and prove its importance in the process of the project of architecture, and therefore in the colour management within the built environment, is to channel down related colour and space information, in order to prove the existence and importance of the colour/space unity.

So, this study used structured methods of analysis: integrated the relevant literature review on the subject and the author's personal experience, with a survey methodology (questionnaires and semi-structured interviews).
The overall approach is represented in the chart of the research process **(Fig 1.22).**

1.6 Scope

Many studies have already been done on colour issue, but most of them are related with psychological or physiological influence of colour in human behaviour, or have addressed colour in architecture interiors.

Anyhow, there is a lack of information about colour, which conducts to the actual state of things:

. or people prefer not to use colour in architecture, which is impossible because if there is light, there is colour (as referred in the study);

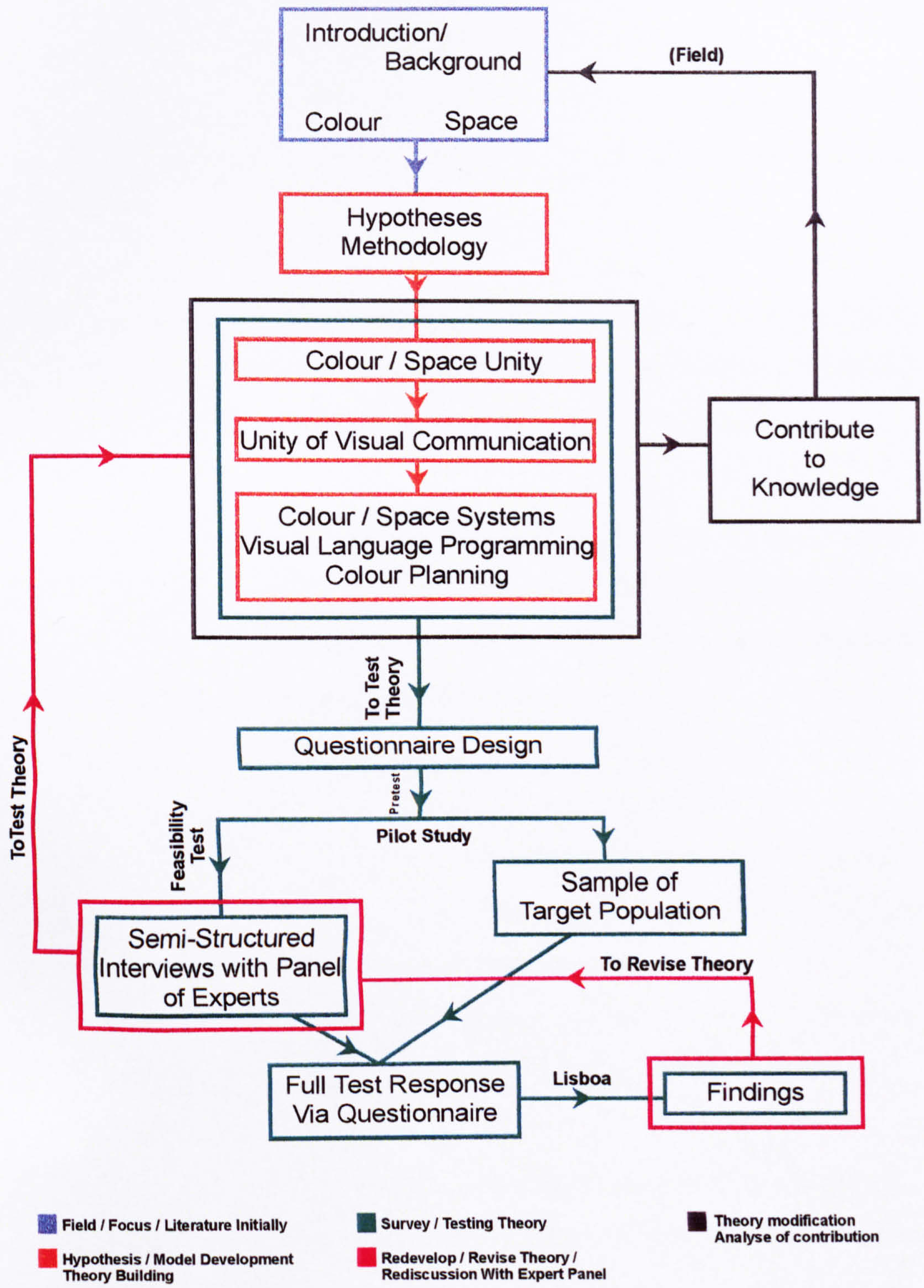


Fig 1.22 Chart of the research process

. or the technicians who work with colour use it in its *cosmetic* role, with no scientific approach to colour use or effect, and having no notion that colour is an essential element in the process of the project of architecture;

. or people who have to manage colour planning, they do it by *feeling*, without any knowledge in the subject area, or without the help of a colour adviser.

The only controlled situation still remains in the urban recuperation planning field, where fortunately and in most of the cases, the involved professionals implement a colour search which conducts to a defensible colour planning proposal.

This study has resulted in the development of a focused research into the effects and management of colour in the built environment, referring the existence and importance of a colour/space unity, which is a unity of visual communication, with strict implications in the project of architecture.

1.7 Guide to Thesis

The main purpose of this sub-section is to assist the reader by describing, at this early stage, the manner in which this thesis is ordered by concisely noting the structure of the thesis and the content of each chapter.

So, the structure of the thesis is briefly presented here. Consistent with the research tasks and objectives, the layout of the thesis is as shown in figure **1.23.**

The thesis starts with the background discussion and definition of the problem. This enables the problem to be stated and defined in a form suitable for research investigation.

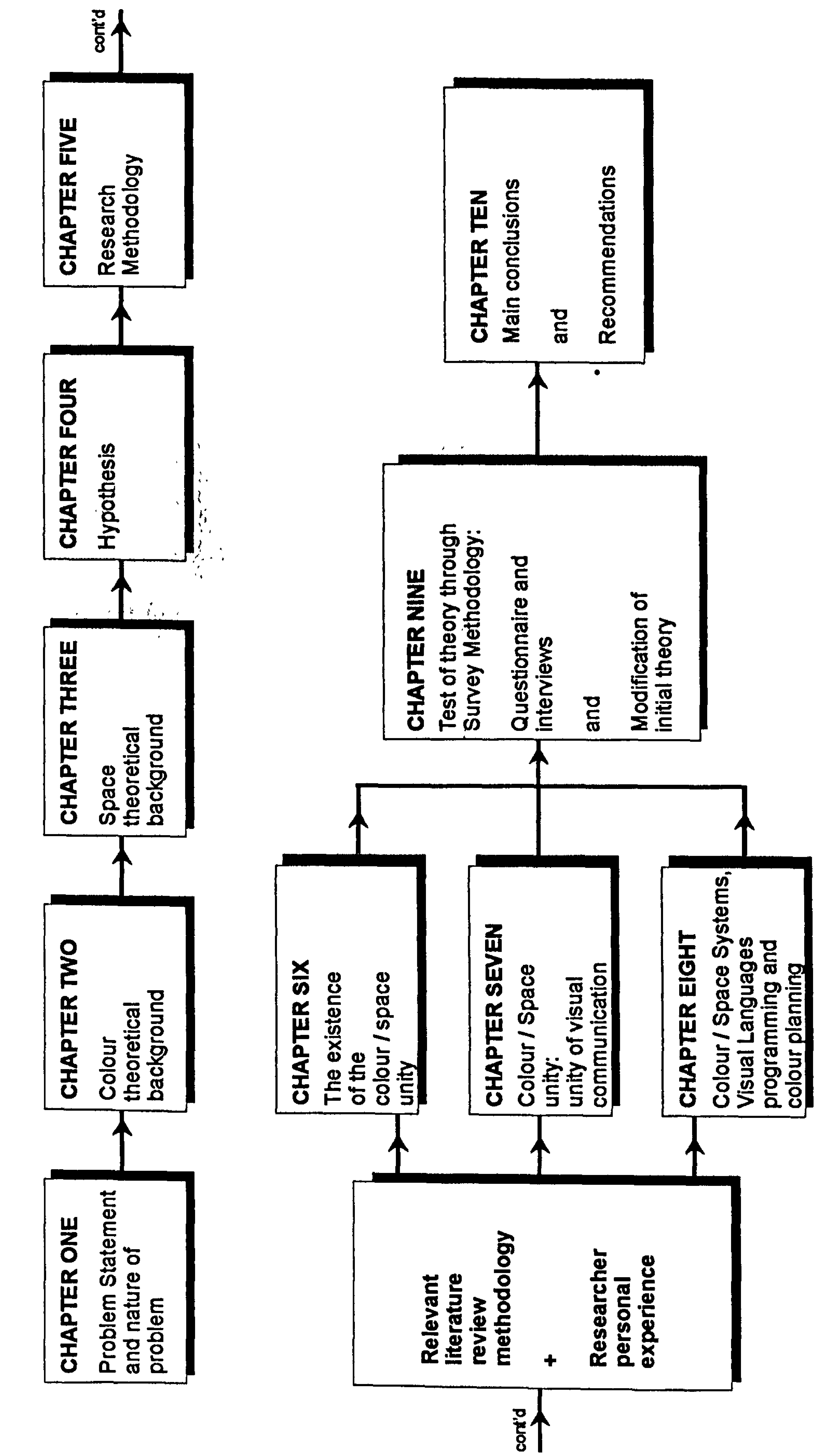


Fig 1.23 The layout of the thesis

Chapter 2

The pragmatic approach to the study of colour is introduced in this chapter. The origins of the term *colour* and the spatial value of colour. Colour is also seen as an element of the light structure. The study covers the different bi and tri-dimensional colour models, as well as the colour systems. Colour is addressed as an element of the visual space. The research goes through the physical, psycho and physiological characteristics of colour, and its relationship with the chromatic sensations. The study ends with the phenomena of the chromatic contrast in the different colour relations.

Chapter 3

This chapter addresses the *space* issue. The study firstly examines the elements for perceiving space, as well as the perception of the visual space through simple and complex senses. The conditions of picking up and selecting visual stimuli of spatial nature are also studied. The study continues through the visual boundaries of perception and threshold of spatial differentiation, the visual field and the construction of images and the organisation of the visual field in the structural relationship of figure-ground. Concerning the visual space and its perception, the study investigates the theories of perception, the opposition aspects and the contrast concept in perception of visual space.

Chapter 4

After the initial literature review on *colour* and on *space* issues, in this chapter the author introduces the *Hypothesis* of the research undertaken by this study.

Chapter 5

After statement of the research question, in chapter 5 the study designs the methodological approach to investigate the Hypothesis:

. a continuation of the relevant literature review, plus the author's personal experience on the research field; and

. a survey methodology through questionnaires and rounds of interviews.

Chapter 6

In this chapter, the investigation shows the existence of a straight relationship between *colour* and *space*, which forms the *colour/space unity*. It also proves that this *unity* can be designated and measured by the colour attributes: *hue, value* and *chroma*.

Chapter 7

After proving the existence of the *colour/space unity*, in this chapter the research proves that this *unity* is mainly related with *communication*, transforming it in a *unity of visual communication*.

Chapter 8

In chapters 6 and 7 the research investigated the first part of the Proposition, proving the existence of the colour/space unity, and that unity is a visual communicational one.

In this chapter, the research investigates the *colour/space systems* and the *visual languages programming*, as well as the *colour planning*.

Chapter 9

In this chapter the second part of the methodological investigation of the hypothesis is conducted: the survey.

To test the author's theory, a full test response via questionnaire is designed. As a feasibility test, and later to revise theory with the support of the questionnaire findings, the research produces rounds of semi-structured interviews with a panel of experts.

The results of the analysis of the data collected from the questionnaire survey, as well as from the interviews, are discussed in this chapter.

Chapter 10

The thesis ends in this chapter with the main conclusions on the research findings. Comments on the general quality of the research and how it affects the research findings are also made in chapter 10. The chapter ends with recommendations on possible areas of further research to enhance its use.

CHAPTER 2

COLOUR

2.1 Introduction

Since visual language is a basic element of architecture and of the urban design project, this research is focused upon fundamental components of the visual message. They are always present in every phase of its organisation, in every moment of its happening, in every variety of its expression and its environmental behaviour, participating in all the visual communicative process in the permanent relationship between man and the environment.

Based on the understanding that architecture is dealing with ordered spaces in accordance with their several functions, and that urban planning deals with multiple spaces co-ordinated in accordance with multiple functions and uses, the participant languages are therefore arranged, ordered and co-ordinated, by the designer, for perceptive-communicative sets of adequate relationships between functions and uses.

The *visual space* is a member of those spaces which, for its constitutional nature, relates man and the environment by the light phenomena.

Colour being a component element of the *light structure*, it is also, therefore, a component of the *visual space structure*.

So, *space and light languages* are in a permanent dynamic relationship, which are as follows:

- essential elements of the visual environmental organisation;
- fundamental participants of the architecture message and of the city.

"The relationship between light and design is inseparable.

Light reveals form, space, texture and colour – all of which are fundamental architectural considerations" (Steemers 1994).

"Colour may be defined as the whole of those sensations produced in the human brain as a result of the light waves that reach the eye retina" (Monzéglio 1978). Colour is not the property of objects, spaces or surfaces; it's the sensation caused by certain qualities of light that the eye recognises and the brain interprets (communication).

"Colour is a property and the language of form" (Mahnke 1993).
"Colour is light made visible through interaction with surfaces of all kinds. It is the surfaces – whether they are opaque or translucent – that make colour visible" (Lancaster 1996b).
"Colour exists only in our brain and is the result of light of different wavelengths reflecting from surfaces to varying degrees, stimulating parts of the brain" (Mahnke 1996).

The importance of colour in the perception of space results from not only the fact of being a participant element of the visual unity in the formation of its first image, but also from being a participate element of its own central essential stimulus, once it takes part in the structure of the light physic energy.
"Form is the body of colour and colour the soul of form" (Gerstner 1986).

This chapter reviews the relevant literature and highlights the colour fundamentals, showing colour as an element of the light structure and of the visual space.

2.2 The spatial value of Colour

The recognition of the spatial value of colour brings about the inevitability to accept the significance value of the chromatic phenomena, which are consequence of the following :

- *Colour – structure*
- *Colour – significance*
- *Colour – significant*

The grammatical structure of colour comes from the fact that colour has by itself, a *mass*, a *weight* and a *character*.

Mass is the amplitude of the chromatic surface: it is quantitative, mechanical.

Weight is the middle term between mass and character; it is the weight that gives shade to colour.

Character is the qualitative term, of value, and it implicates intensity (Marcoli 1986).

The term *weight* was adapted by the British Standards Institute (BS 5252) with *greyness* to describe more precisely the differences between paint colours. While greyness expresses the practical difference in apparent grey content between one colour and another, weight is a modification of value, referring to lightness or darkness (Gloag 1978).

2.2.1 Colour Meaning: Gestalt Colour (Marcoli 1978)

Each cultural pattern establishes a perceptive qualification, which reflects itself onto the chromatic nomenclature, in such a way that it seems possible to associate the cultural development directly to the capacity to nominate the chromatic impressions.

Colour is never static: it develops, it moves and changes itself according to the hours and the seasons, with changes in the colour of the light and in the composition of the air, with the cycle of night-day and with artificial light. Finally, it even becomes *achromatic* below certain limits of illumination.

2.2.2 Colour Significant: Topological Colour (Marcoli 1978)

The movements of colours characterise their continuous transformation. The movements of one colour to another form the chromatic scale and characterise their topography.

The chromatic ordination systems happen by the topographic organisation of colour and they search for the basis of the chromatic harmony. They fulfil two objectives: the objective identification of any colour and the colour harmony, which is a consequence of having identical essential values, as saturations or hues, originating, therefore, the harmony law from the chromatic topography.

2.2.3 Colour as Meaningful: Phenomenological Colour (Marcoli 1978)

The phenomenological dimension of the chromatic phenomenon signs the sensitive colour.

In practice, the work of architecture is done with pigments and substances, which reflect, absorb or refract wavelengths: the Colour, however, is fabricated by the Mind.

Colour is the spirit of things, of shapes and acts; colour is "to seem", because it has a pre-conscious life, which is stronger than the conscious life, provenient from the observer's background".

2.3 Colour, as an element of the light structure

"...Colour is the visual form of light..." (Leck 1980)

"Six different areas were distinguished in the sun light spectrum, corresponding to six different radiations, which produce, respectively, the sensations of: Red, Orange, Yellow, Green, Blue, Purple" (Ovio 1927).

This subdivision, accepted by Goethe and other scholars is therefore wilful.

Newton, following a similarity with the sounds has distinguished in the same light seven areas, with seven different colours, which meant a subdivision of the blue area into two, which in reality in the sun light spectrum, through the optic prism, is extended by a space which corresponds to the double of the other colours' space (Ovio 1927).

Colour is a component of the light, i.e. it belongs to the light structure. We are aware of the white colour, or sun colour, as a complex radiation, to which belong

the monochromatic radiations, refracted by the prism and corresponding to the colours of the sun spectrum. These radiations are characterised in the light structure by certain vibrations, each one to a different colour, with particular wavelengths. Our vision organ is sensitive to them and is capable of distinguishing them, resulting from this different sensations:
The colour sensations.

The functions of colour are to attract attention, to impart information, to aid deception and to stimulate the emotions (Lancaster 1996b).
Tom Porter (1997) refers that whatever the function of colour in buildings, the choice of hues together with the intensity of their variables, value and chroma, seem to respond also to a kind of colour fashion. This appears to reflect a spirit of the time.

The reasons why the surfaces are coloured are:

- because they reflect the light indiscriminately. It is the process known in physics as refraction and division of light, which consists of the absorption of some wavelengths and reflection of the remaining ones
- because the reflected light stimulates the retina, activating the optical nerve and the net of neurones which connect it to the brain.

It is the conjugation of these two effects, one of them intrinsic to the surface and the other one external, which in the joined experience originate the conditions leading to the perception of colour.

There is a reason for the spectral of reflection of a certain surface not looking constant. If the colour of a surface is the sum of its reflected light, it means that the colour of this surface could be affected by an alteration in its quality or composition, which is in the intensity or spectral balance of its lighting.

As one can see from experiments, and the individual life experience confirms it, all surfaces reflect some light without selecting it. Even the chromatic surfaces, which acquire specific hues.

It is, therefore, from the equilibrium between these two types of reflection that the colour of the surface comes from.

"As part of their characteristics, however, the architectural elements have surface quality. As such, they are governed by the same laws that apply to the other spatial elements but, unfortunately, surface colour and texture seem to occur in our built environment more by accident or whim than by design. Texture and colour play an important role in the environment at large for, in the modulation of surface, they signal scale and depth.

They can also define zones of territorial space by communicating go and no-go areas" (Porter 1997).

"Textured surfaces reflect diffusely; smooth surfaces reflect directly - always subjected to the relative angles of the light source and the observer. Textures vary with scale and distance. The colours are visible through the process of colour assimilation or optical mixing. Wet surfaces and smooth materials reflect more intensely than dry or rough ones.

The pigmentation contained within any material - whether it be natural or artificial - determines the colour by its capacity to absorb a proportion of the constituent colours of natural light" (Lancaster 1996a).

Different spectral compositions can stir up the same sensations.

This phenomenon is called *metamerism*, and the denomination of *metameric colour* is applied to any two colours which, although having various spectral compositions, seem indistinct because they correspond to identical tri-chromatic values.

It seems important to refer to the fact that the tri-chromatic values depend on the lighting used. So, two surfaces can be called *metamerics* when they seem identical under certain lighting, and different under another lighting (Loução 1993b).

The word *Colour* is frequently used with two completely different meanings. According to the correct meaning, one should call it *chromatic pigment* when people refer to coloured materials or substances used for painting and, *colour* when it is referred to the visual perception which the eye *sees* when stimulated by beams of light of certain wavelengths.

It is considered that the attainment of colour is processed in three ways:

- *Subtraction*
- *Summing up*
- *Partition*

These three ways originated three systems. The *Subtractive System* or Subtractive Synthesis, the *Additive System* or Additive Synthesis and the *Partitive System* or Optical Synthesis.

The first one of these systems deals with the colour while substance, the second one refers to colour while energy and the third deals with colour while sensation created at the retina level from two or more coloured elements.

2.3.1 Subtractive System: Subtractive Colour (or the colour of the objects)

Light, natural or artificial, is filtered and diffused by the atmosphere, in a process denominated *subtractive synthesis*.

When the light reaches a surface, three things can happen:

- The light can be absorbed and the energy turned into colour
- The light can cut across the surface
- The light can be reflected

The three situations frequently occur at the same time. In this case, the object absorbs some of the incident light and reflects the remainder.

The surfaces have characteristics such as: transparency, opacity, whiteness or colour, shine or smoothness. Those characteristics determine if the light will be reflected, transmitted, refracted or absorbed, or if it will suffer a selected combination of those effects.

The colour of the objects is a sensation provoked by the light, as a result of the absorptions and subtractions occurring on the surfaces, which are denominated *pigments*: small solid particles, not solvent in liquids, having the function of agglutination.

The subtractive colour handles the *pigments*.
The mixture of *pigments* is called the *Subtractive Process*, being the colour thus remaining.

Theoretically, the mixture of the three primary colours will produce *black*, since the resulting mixture of the molecules of the pigments should absorb all the frequencies of visible light.

Following this principle, *black*, *white* and *grey* are called *Non-chromatic Colours* because their appearance does not result from wavelengths of reflected light, but from the quantity of light reflected.

Red, *Yellow* and *Blue* are considered the primary colours of the pigment.

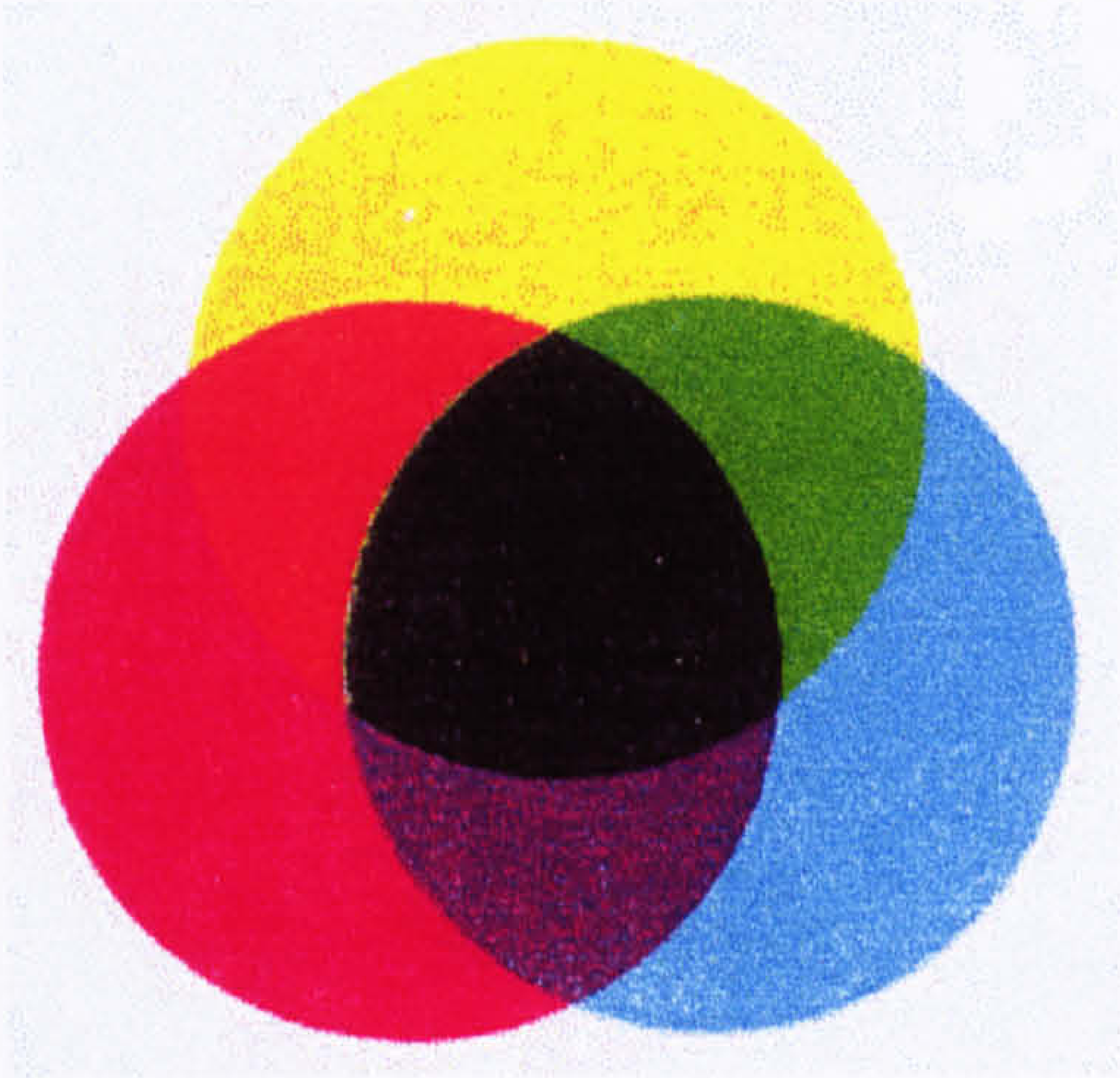


Fig 2.1 Subtractive colours (Grandis 1986)

A great number of the understood colours, when people visually explore the urban environment, is due to the superficial treatment of the objects.
Paintings play an important role in introducing colours into public spaces.

Other artificial materials are laminated plastics, glass, concrete, mortar, asphalt and textile products. The main exception is represented by the natural elements: water, atmosphere, clouds and greens. The colour sensation produced by the absorption and reflection of the natural light rays is the common characteristic of all the artificial objects (Loução 1993b).

2.3.2 Additive System: Additive Colour (or colour of the light)

When all the wavelengths of visible sun light join at the same time, they originate a *non-chromatic light* or *white light*, in which the colours are not visible while separate entities.

It is from this evidence that the *colours of the light* are called *Additive Colours*.

One of the ways to obtain colour sensations is called *additive synthesis*.

When grouped in pairs, these colours originate *additive secondary colours*:

Yellow (red+green); Cyan (blue+green); Magenta (red+blue).

The primary and secondary colours of light and pigment oppose or reciprocate one another because they have two different dimensions (additive and subtractive) of the same phenomenon: *the visible light*.

The primary colours of light are *red*, *green* and *blue*. They are the reds that tend to orange, the green which is symmetric to it and, the blue, which is called, usually, purple blue.

These colours, when mixed in different proportions, while light, produce all the other colours and, when mixed in nearly the same proportions they originate a *white light* or *lack of colour*.

Luminous beams of different colours, projected on a screen, compose a different and lighter colour. It is, therefore, impossible for the human eye to distinguish the component colours. Sight is not analytical.

In the additive synthesis, the different wavelength radiations are added. That simultaneous stimulus will produce a more and more closed sensation to white light, whichever the bigger of the overput radiations the number is.
The obtained colour will always be the lighter of the component colours. The possibilities of obtaining colours by additive mixture must be correctly manipulated, bearing in mind the public streets, squares, buildings and monuments lightning.

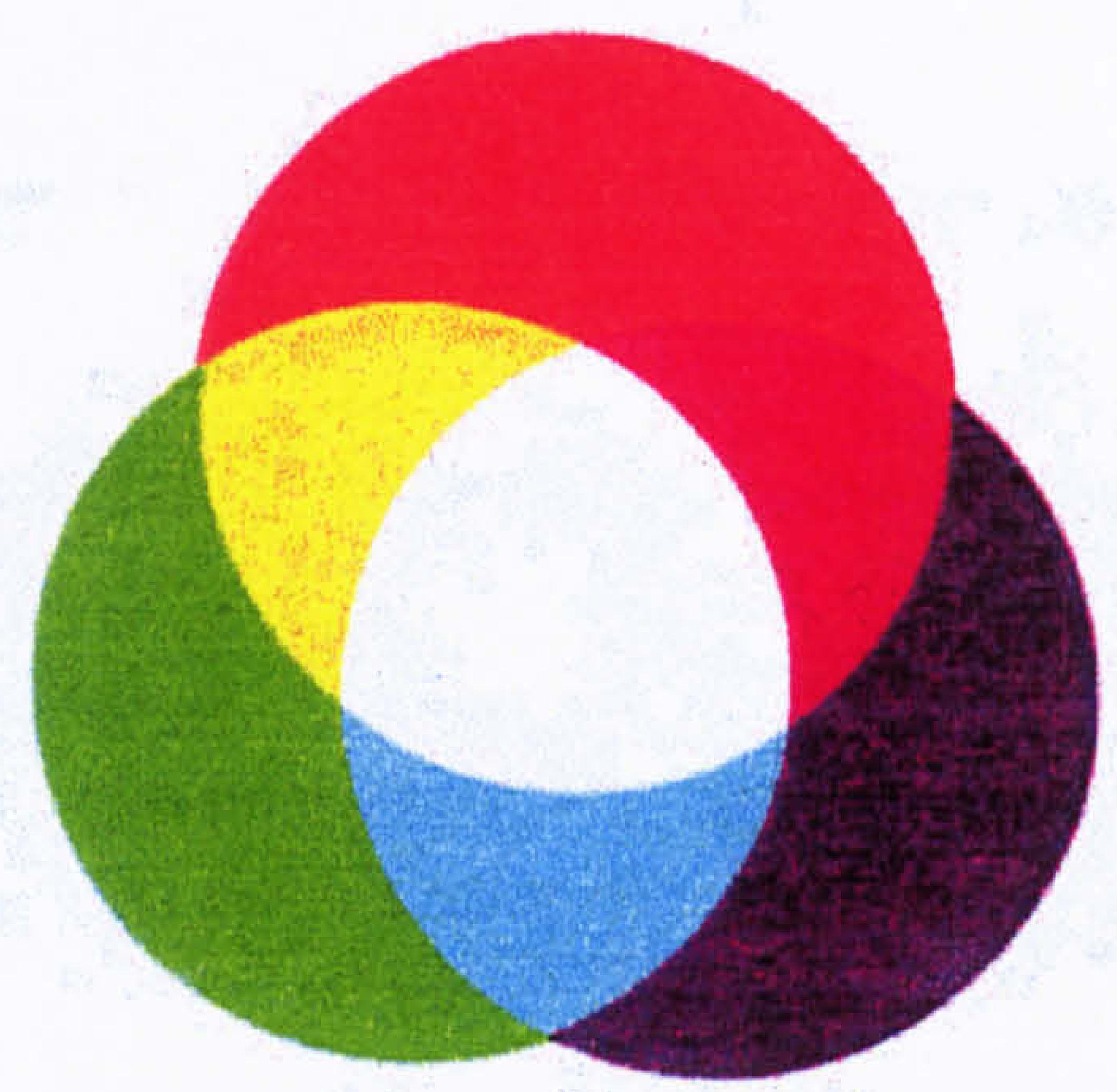


Fig 2.2 Additive colours (Grandis 1986)

2.3.3 Partitive System: Optical Colour

The experiment of three primary lights' projection against a white surface, in order to obtain the chromatic synthesis, could also be obtained using the *Maxwell Disc*.
If in the same rotating disc three colours were put as painted surfaces, and if the disc should rotate more than 50 revolutions per second, the reflected light from various coloured surfaces would create white.
On one hand, this technique allows the appreciation of a subtle distinction between additive colours and visual colours and, on the other hand, it shows the not so subtle distinction between additive colours and subtractive ones.
The principle of visual mixtures or the reason why one sees, for example, magenta, or purple red when these colours are put on the disc in identical sections, means that the red and primary blues (of light) don't come out from the fusion of reflected light on the disc but from the incapacity of the retina receptors to react quickly enough to all the individual chromatic stimuli.

The chromatic sensations of magenta persist like *"afterimages"* or persistent images during various periods of time, according to the colour intensity.
A similar reaction to the one described before happens when any two colours join together sharing such a small surface, it being impossible to perceive them separately (Loução 1993b).

Colour obtained by *optical mixture* is a *visual impression*, which has the medium values of hue, value and intensity, of the mixed components.

So, the three optical primary colours are the primary ones of light.

It was Kandinsky (1975) who declared that colour without limits, colour as infinite, is only an act from the mind, because the entire colour of the surface suggests a sense which occurs from the spatial dynamics itself.

If the question of primary colours resume itself to the search for colours, which by mixture produces all the others, and if the mixture of light accomplishes this, it is obvious that the true colours are three: *red, green* and *blue*.

If one accepts that the primary colours are the ones which by mixing together create all the others so, neither the *magenta* nor the *cyan* couldn't be primary colours at any time because they are not indivisible or pure.
The constituent colours of *magenta* are red and blue, and of *cyan* are blue and green.
Some declare to have seen yellow and blue when one observes the green and, therefore, the yellow would also be a primary colour of pigment.
The green and purple are stable when seen from the chemistry point of view.
The primary colours of pigment would then be five.

Is there a reason for the colour purple not to be considered pure, merely because it is not present on the visible spectrum?

William Charles Libby (1974) declares the existence of 5 elementary chromatic colours, and defends them as having their intrinsic structural relations as basis. What is not apparent:

"... When these colours and the intermediate one, put themselves systematically in the chromatic circle, one discovers that the intermediate one is complementary to one of the primary colours. And one easily understands that without this internal order, the chromatic circle doesn't have any sense..."

2.4 Colour Temperature

With regard to Colour Temperature, there are four types of colours:

Hot colours, Cold colours, Neutral colours and Achromatic colours.

2.4.1 Hot Colours

Dark colours, because they absorb a higher percentage of incident light, are hotter than the lighter colours.

This means that under the same lighting a dark red surface is probably hotter than a light red one, and that the temperature of any colour is determined by its value.

The scale of natural chromatic temperatures organises itself in the following way:

1. red
2. reddish yellow (orange)
3. yellow
4. blue
5. purple blue
6. purple
7. white

The electronic sensors which measure the reflected heat on surfaces prove that, under the same circumstances, the red surfaces and the reddish yellow ones are hotter than, for example, the green or blue surfaces.

2.4.2 Cold Colours

The existence of hot hues implies the existence of cold hues.

2.4.3 Neutral Colours

The separation of hues in groups of hot and cold is only an emotional and associative consensus.

Yet, like many other conclusions obtained by "collective intuition", it seems to be more rational that it looks and, its supported in the classical chromatic circle.

But, before one looks to the way the hot and cold colours are displayed there, one has to consider for a moment the two hues, which by consensus, are neutrals.

They are the green and purple elementary hue, in which neither the hot (red or yellow) or cold current (blue) is present.

They also remain more unchangeable in the space, producing less tension in comparison with, for example, the red, which apparently comes forward, or the blue, which goes back, in accordance to the observer.

The facility to migrate from the hot to the cold and its spatial stability are in the origin of the visual comfort they cause and in its shining under different lighting.

2.4.4 Achromatic colours

"Colours without hue: black, white and neutral grey" (Lancaster 1996a).

The colours of each complementary pair neutralise themselves by mixing only when they have the exact tonality and the exact saturation, which is, when they have the same intensity (in relation to the respective hues) and the same degree of colour density.

As it is very difficult to establish precisely this combination of relationships, it is also difficult to reach the achromatic result. The shade of grey is not important just by itself, as colour, but as a demonstration that the colours of the pair are in equilibrium.

When the eye observes a colour the appearance of its complementary one is instantly stimulated; while when the grey is observed the eye is in equilibrium.

In the context of colour temperature, the Swedish studies support the traditional belief that red appears warm and blue cold, except that a blue-red was judged as being as visually cool as the blues and blue-greens (Lancaster 1996a).

2.5 Pigments

The pigments can be divided in two categories, according to their provenance: *Naturals* and *Artificials or Synthetics.*

Natural pigments can be *Organic* or *Inorganic*, according to whether they are of animal, vegetable or mineral origin.

Each pigment has to show the following requisites:

- Not reacting with the light or any other liquids with which it could be mixed.
- Resistance against atmospheric agents, heat and chemical agents.
- To have a good covering power and intensity of colour.

2.6 The Chromatic Circle

For the production of a continuous band of natural hues, the necessity arises to use an expressive form, which would be in this case a *polygonal* shape. This is because, if the spectral band was elastic, when the ends were joined together this band would assume a form of an exhagonon, with each fundamental hue occupying each angle of the figure.

Of course, with the addition of the intermediary hues the form would get closer to the circle.

It allows for the visualisation of hues, a fixed and natural distribution, besides allowing the measuring of contrasts.

Through the use of chromatic circles, the contrast of hues can relate to distance, because when the dominant hues of spectrum, including purple, distribute themselves with the same distance in a circular model, it is clearly seen that the hues with more contrast are in a distance diametrically opposed.

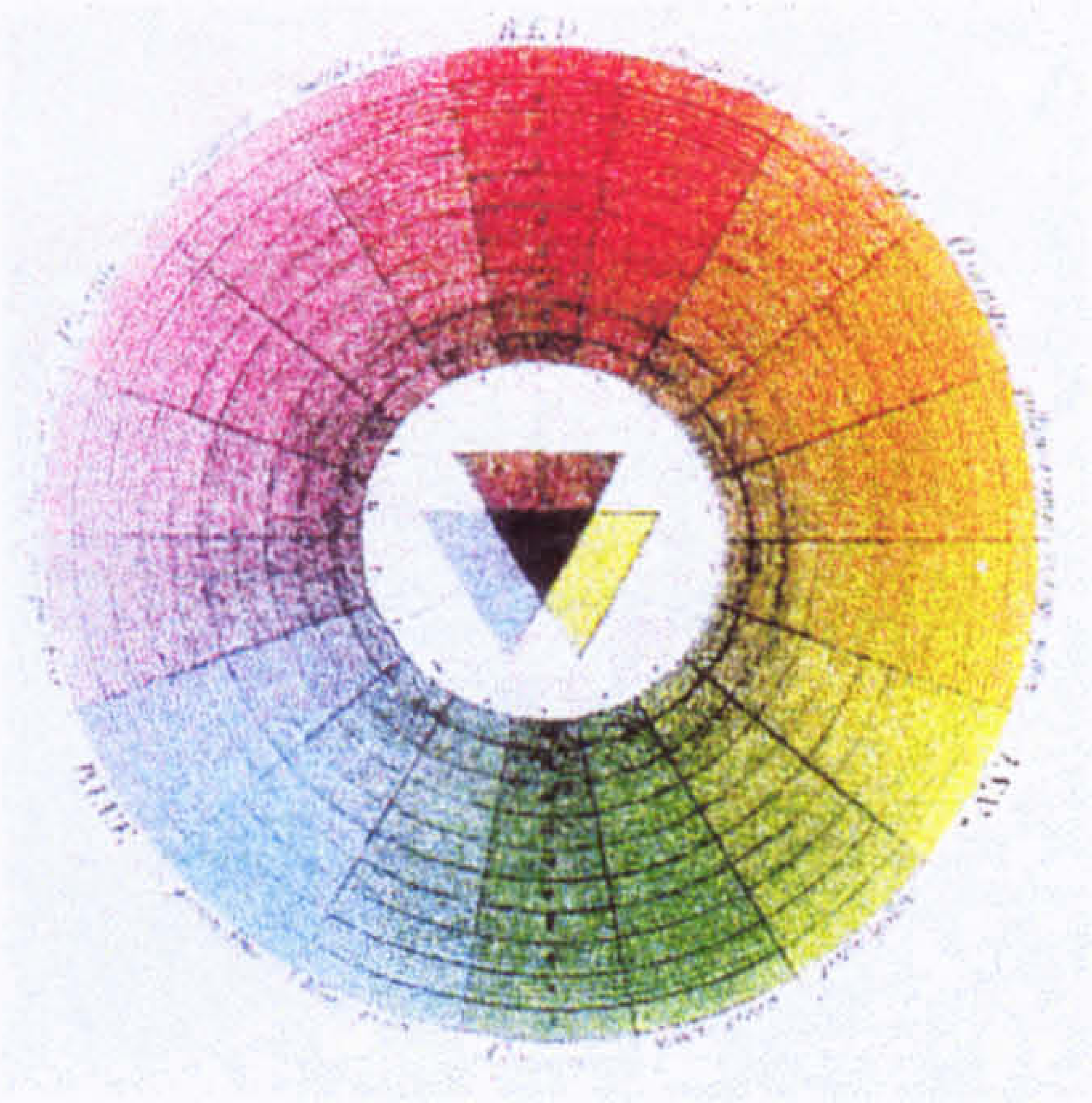


Fig 2.3 Moses Harris' chart of colours:
the very first one (1766) (Birren 1991)

To give each colour its correct position, the circle sub-divides itself in sectors, alternating primary and secondary colours.

2.6.1 Newton's Circle

Newton created the first colour circle and invented a convenient format for the first of the three attributes or dimensions of colour - *hue*.

Newton's circle has 7 colours, the same amount as the musical notes of a diatonic scale and the sphere of the planets.

The colours organise themselves the following way:

Red (C note)

Orange (D note)

Yellow (E note)

Blue (G note)

Indigo (A note)

Violet (B note)

In this circle the dimension of each sector corresponds to the extension of the respective colour in the spectrum.

It is, therefore, a circle, which tries to systematise the colours according to *Additive Colour*.

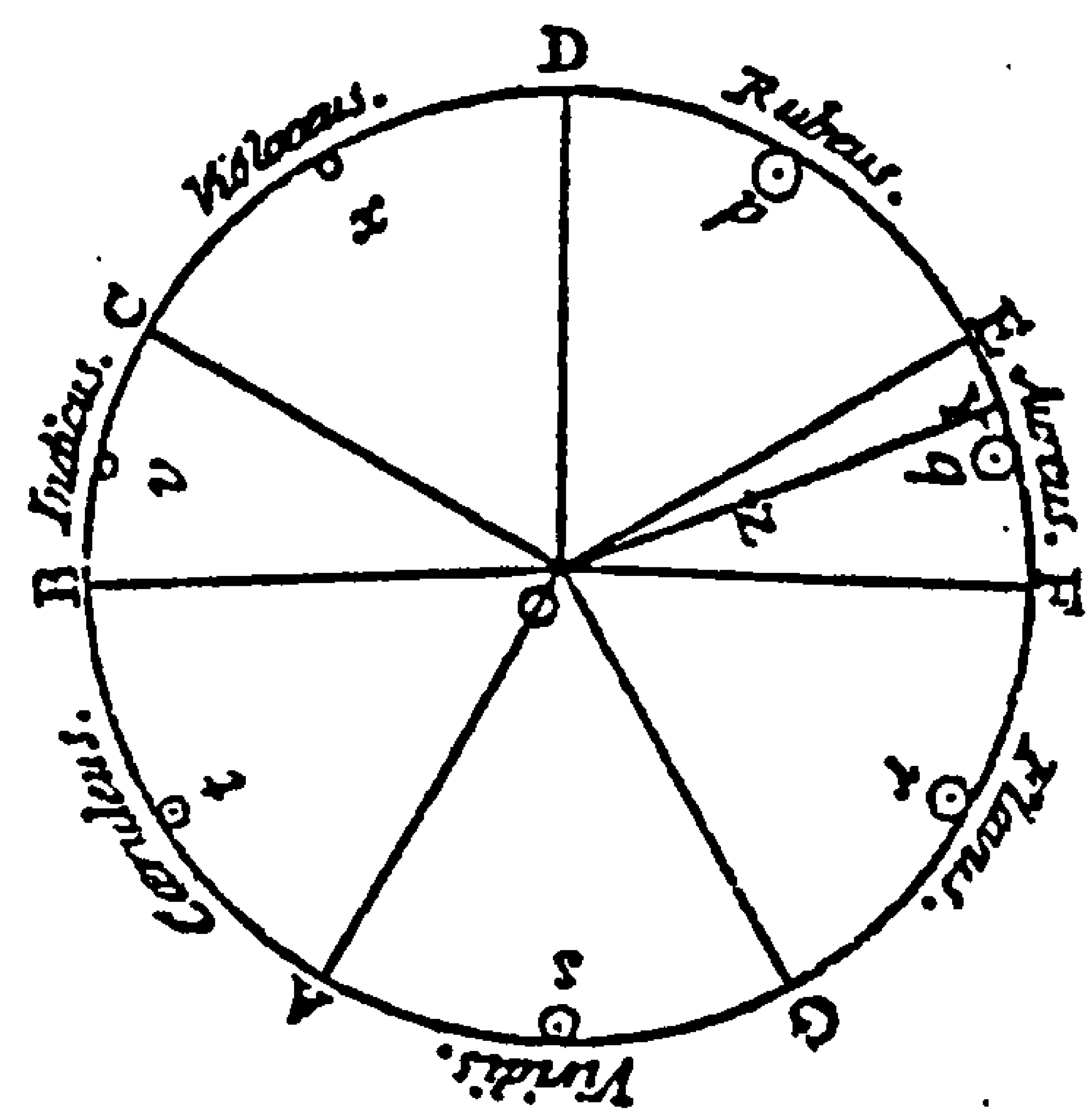


Fig 2.4 Isaac Newton's colour circle (Porter 1997)

2.6.2 Goethe's Circle

Goethe organised the colours in a circle and in a triangle.

6 colours compose the circle:

Red (R)

Orange (O)

Yellow (Y)

Green (G)

Blur (B)

Purple (P)

They are pigmentary or *subtractive colours*.

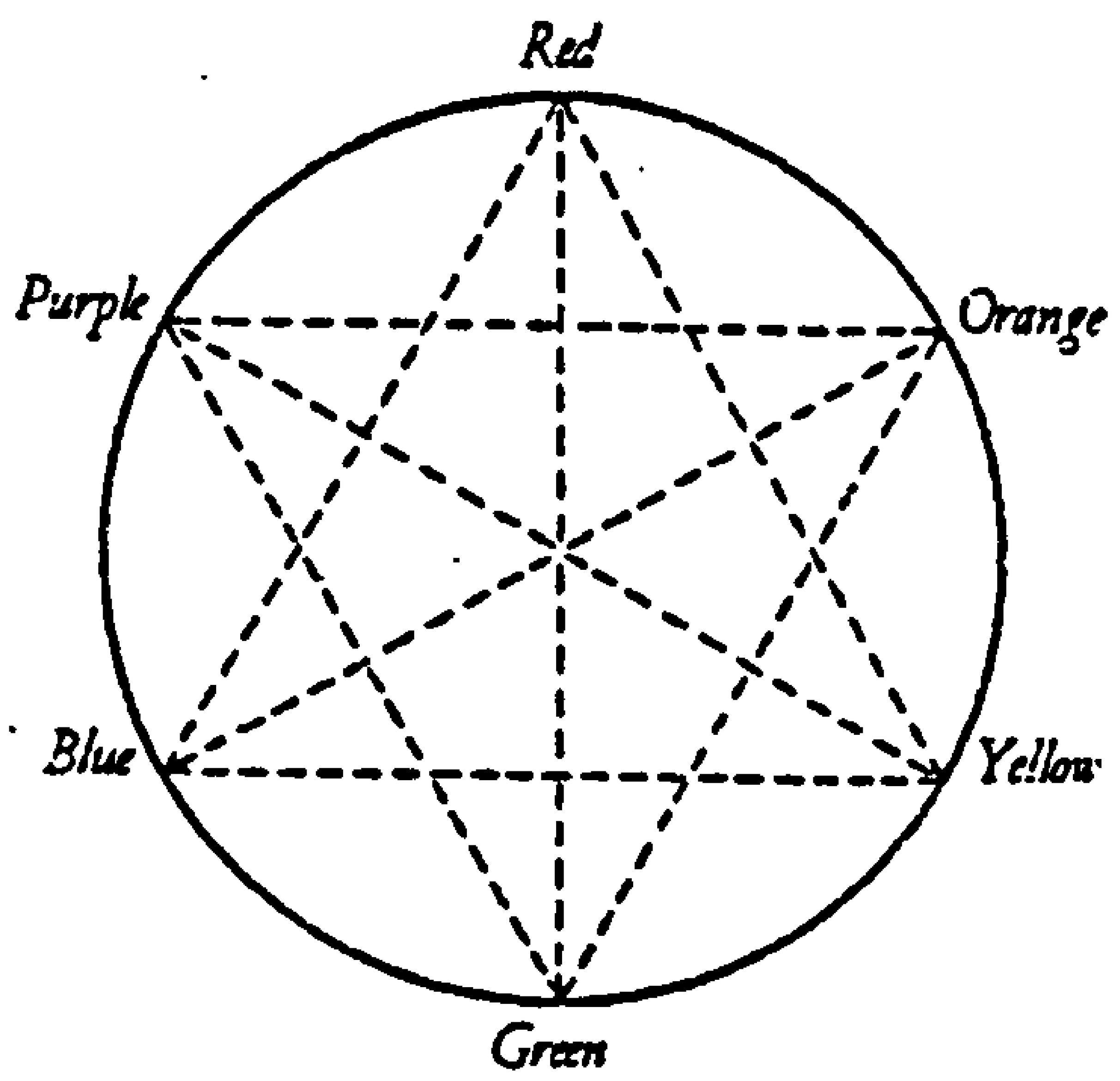


Fig 2.5 Goethe's colour circle (Birren 1969)

2.6.3 Chevreul's Circle

Chevreul also based himself on subtractive primary colours or the pigment, using yellow, red and blue for his circle. Yet, more than the circle, it was determinant for the systems' history, the theory of harmonies in "De la Loi du Contrast simultané des couleurs" (Chevreul 1967).

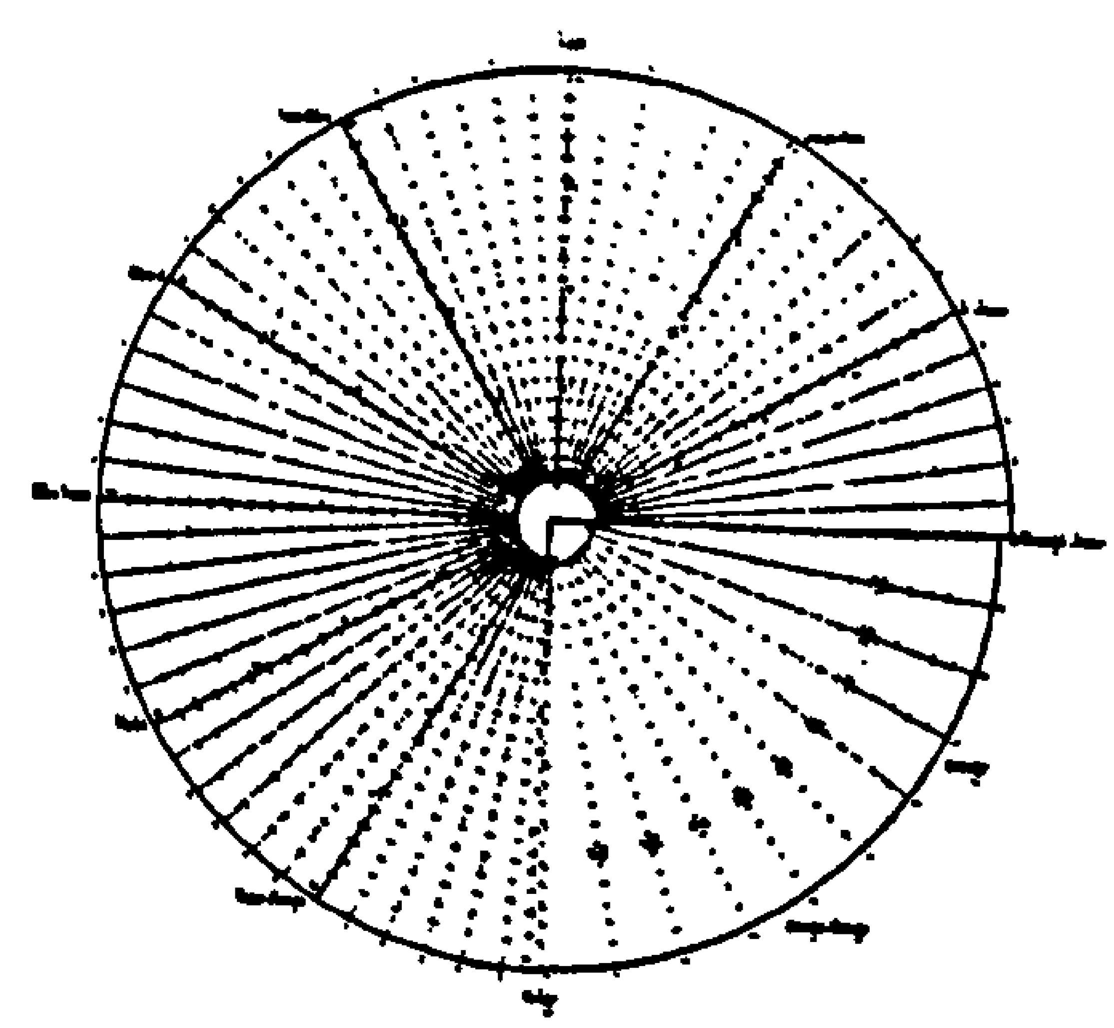


Fig 2.6 Chevreul's colour circle (Chevreul 1967)

2.6.4 Wilhelm von Bezold's Circle

Von Bezold's circle is part of the whole of the statements in his book "The Theory Color" (Loução 1993b).

The characteristic of this circle is that it has a central triangle, directed to the red (vermilion), the green and the violet blue. Besides this, it is constituted by 12 colours located in the external circumference, separated by the criteria of "apparent difference". This circle, which also has the primary colours of light, searches clearly for a systematisation of perceptive colour (Loução 1993b).

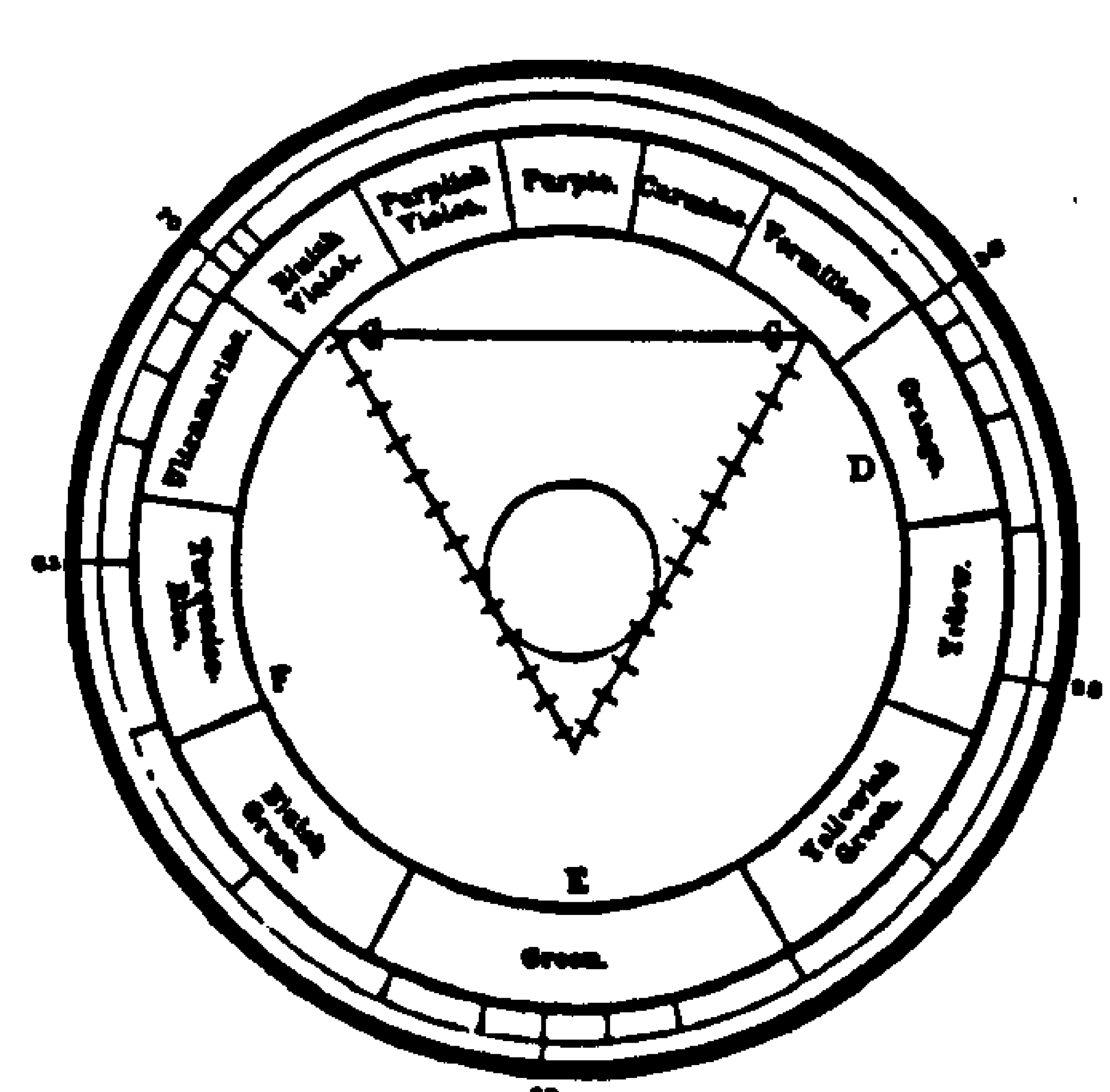


Fig 2.7 Wilhelm von Bezold's colour circle (Birren1969)

2.6.5 Ewald Hering's Circle

Ewald Hering's circle presented, for the first time, the 4 colours, which were conventionally, called psychological primary ones, after adopted by Ostwald:

Red

Yellow

Green

Blue

The circle was constructed by the principle that the eye responds first to red, yellow, green and blue and, only after that does it respond to the remaining colours. The 4 fundamental colours, white and black, assume an essential role in the visual universe, the role of essential colours in the optical mixture.

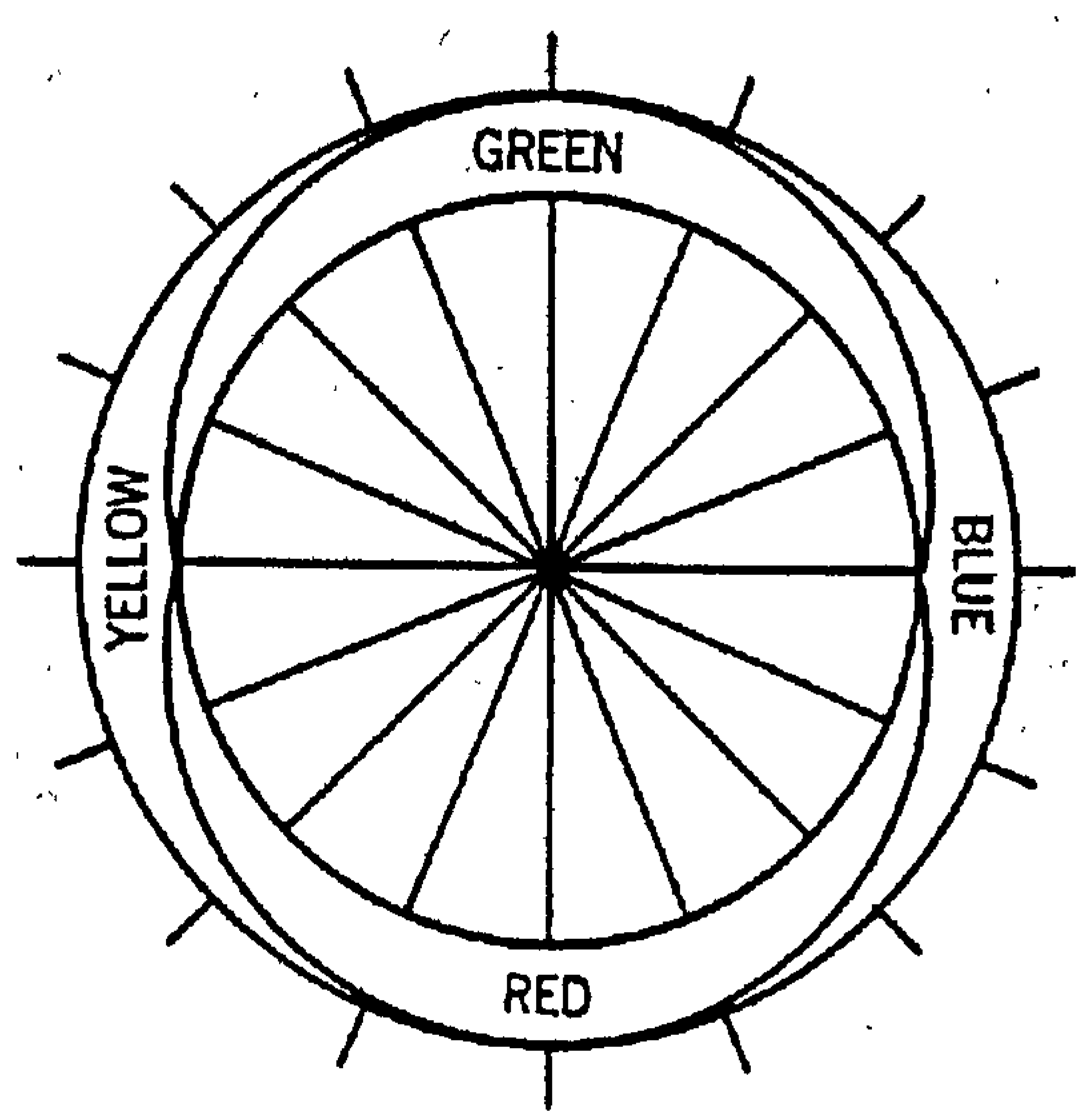


Fig 2.8 Ewald Hering's colour circle (Birren 1969)

.2.6.6 Munsell's Circle

Munsell's circle adopts the primary colours of light as fundamentals, as they are visible in nature. If three equidistant points are obtained, starting on the green, the remaining two points will touch the red, which has a small amount of yellow (vermilion), and the purple blue.

This circle of 10 colours has 5 principal colours and 5 intermediary ones.

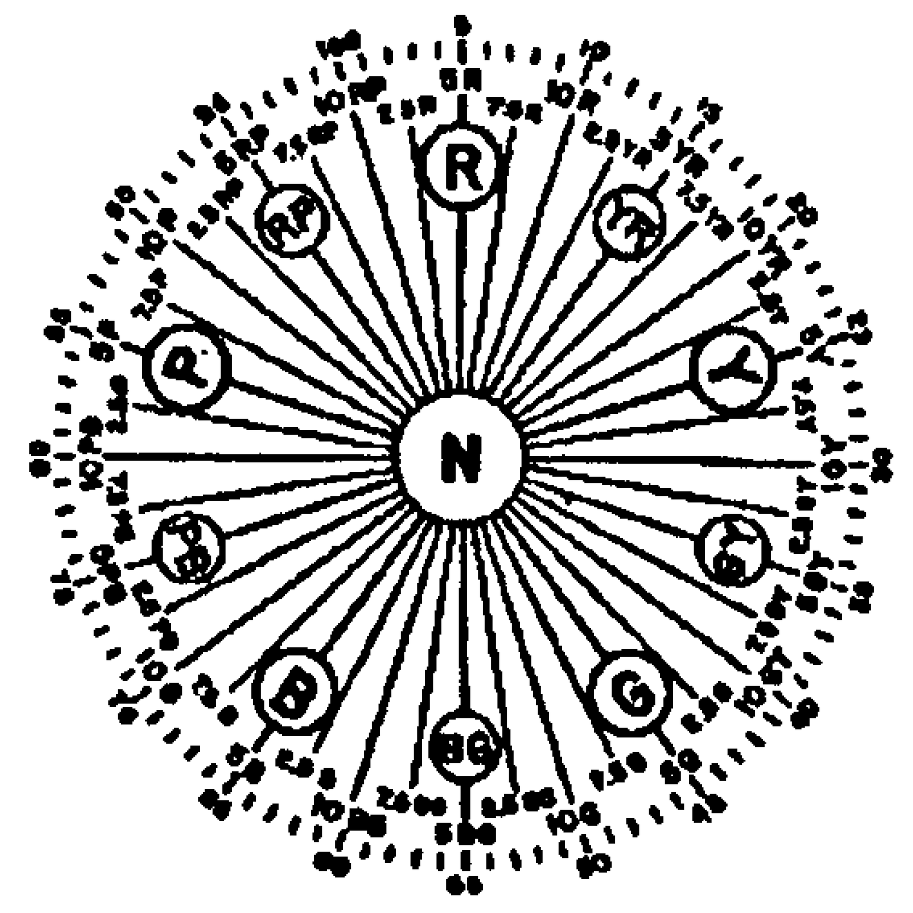


Fig 2.9 Munsell's colour circle
(Munsell 1976)

2.6.7 Ostwald's Circle

Ostwald's circle derives from the theories of Ewald Hering.

The fundamental colours of this circle are:

Red

Yellow

Green (sea green)

Blue (ultramarine blue)

in the quality of psychological primary ones.

The intermediary ones are orange, leaf green, turquoise and purple (Gerritsen 1976)

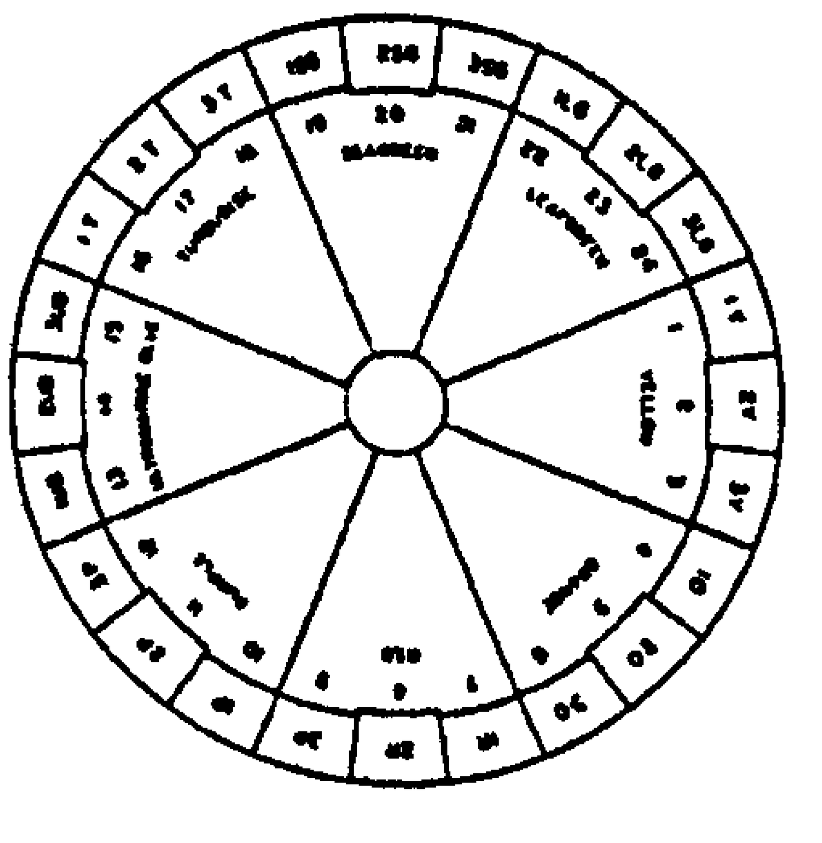


Fig 2.10 Ostwald's colour circle
(Birren 1991)

2.6.8 Johannes Itten's Circle

Itten's model was clearly influenced by Runge's sphere, which Itten represented by planning it out.

As well as Runge, Itten uses the three primary subtractive colours, which he puts in an equilateral triangle in the centre of the circle. This central triangle, together with the others, occupied by the secondary colours, rebuilds the hexagon.

The colours in the circle, which circumscribe the hexagon, are the primary and secondary ones of the hexagon, and the tertiary ones resulting from the mixture. This circle organises the colours in such a way that they are visually equidistant (Itten 1961).

Fig 2.11 Itten's chromatic circle in twelve parts
(Itten 1961)

2.6.9 Paul Klee's Circle

Paul Klee also adopted the primary colours of the pigment or subtractive ones, as primary colours: yellow, blue and red, which were on the vertices of the equilateral triangle inscribed in the circle.

He also produced another model, which he called *Canon of the Totality*, where the three primary colours, in constant movement, originate all the remaining ones (Klee 1961).

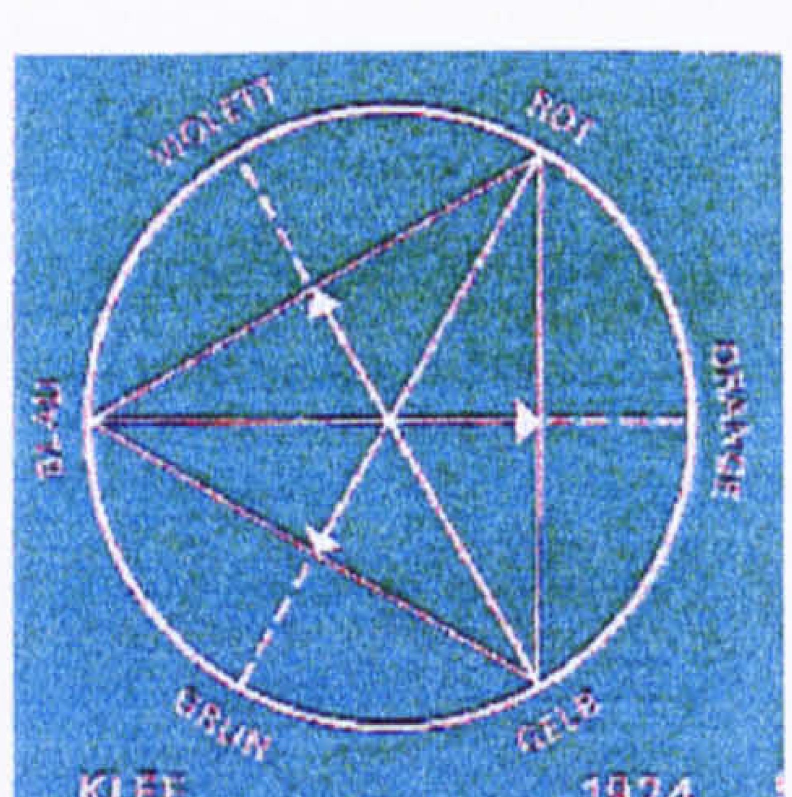


Fig 2.12 Paul Klee's colour circle
(Klee 1961)

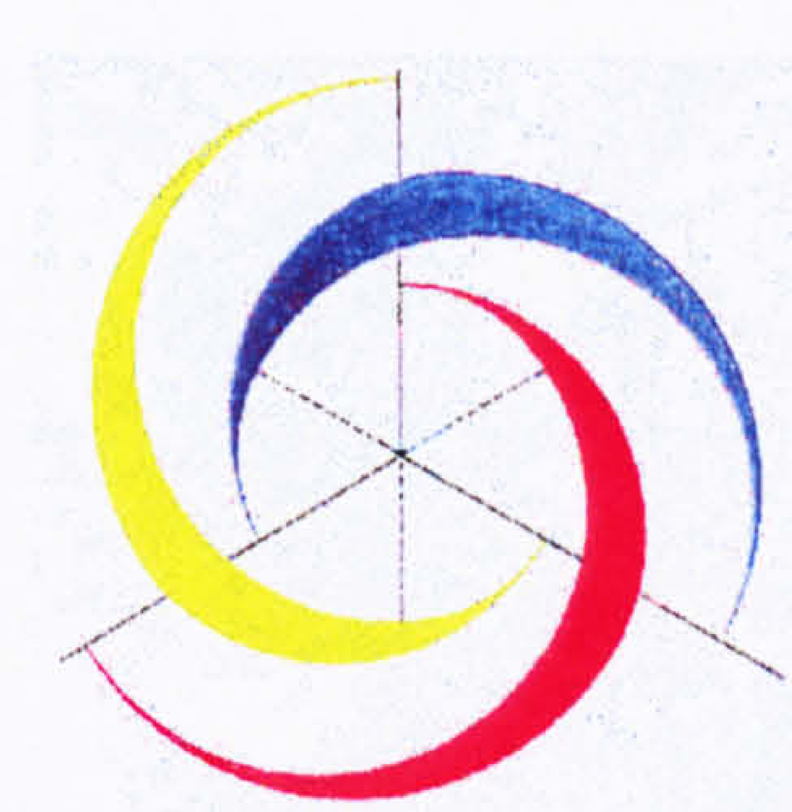


Fig 2.13 Paul Klee's *totally canone*
(Klee 1961)

2.6.10 Faber Birren's Circle

From the analyses of various chromatic circles, Birren constructed a circle, which he called the *Rational Chromatic Circle*.

The circle, constructed from primary psychological colours, yellow (Y), red (R), green (G) and blue (B), has grey as the synthesis colour of the optical mixture putting it as a deviation from its interior.

He presents as secondary colours orange (O), leaf-green (L), turquoise blue (T) and violet (V) (Birren 1969).

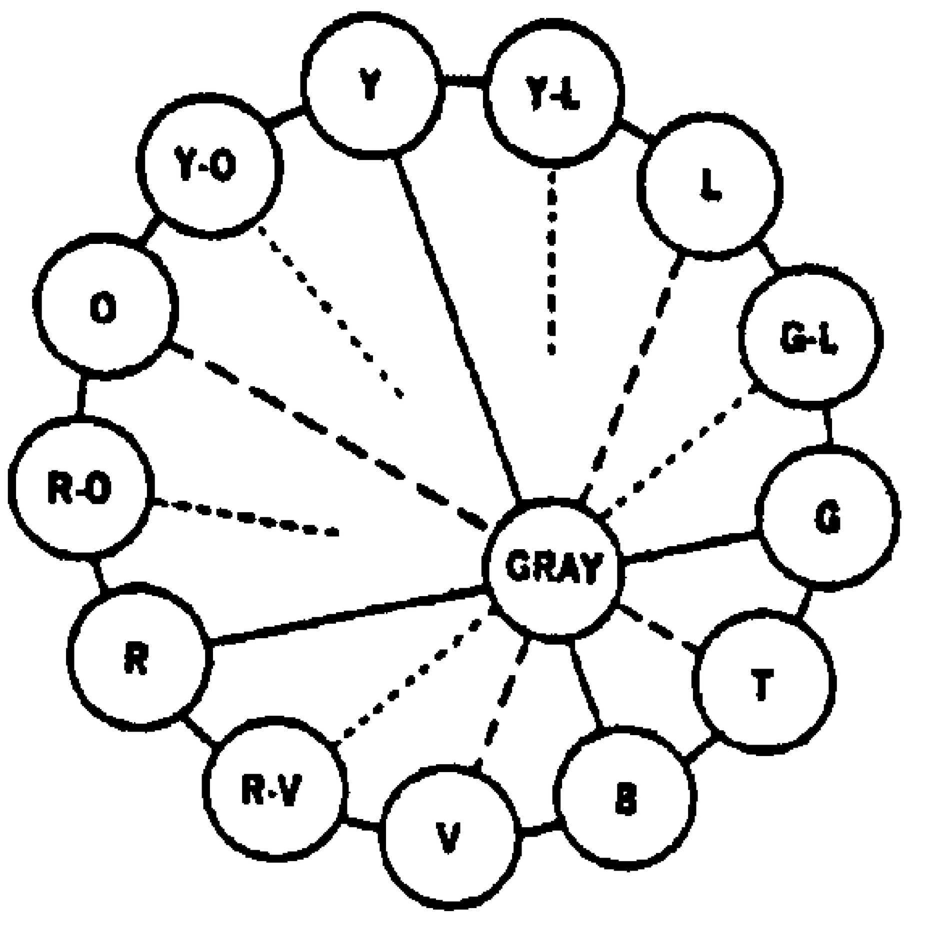


Fig 2.14 Faber Birren's colour circle (Birren 1969)

2.7 The Triangle

There are other bi-dimensional models which are not circles, such as:

- Tobias Mayer's bi-dimensional triangle - 1745
- Maxwel's Triangle - 1872

2.8 Tri-dimensional Models

There are also important tri-dimensional models for the colour study, such as:

- Philippe Otto Runge's sphere of colours - 1810 :

Later used by Itten, this sphere has:

The white on the higher pole.

The black on the lower pole.

On the surface of the higher hemisphere it has the colours which have been lightened by the addition of white.

On the surface of the lower pole, it has the colours darkened by the addition of black.

On the equator one finds the pure colours.

In the interior of the sphere one finds the darkened colours.

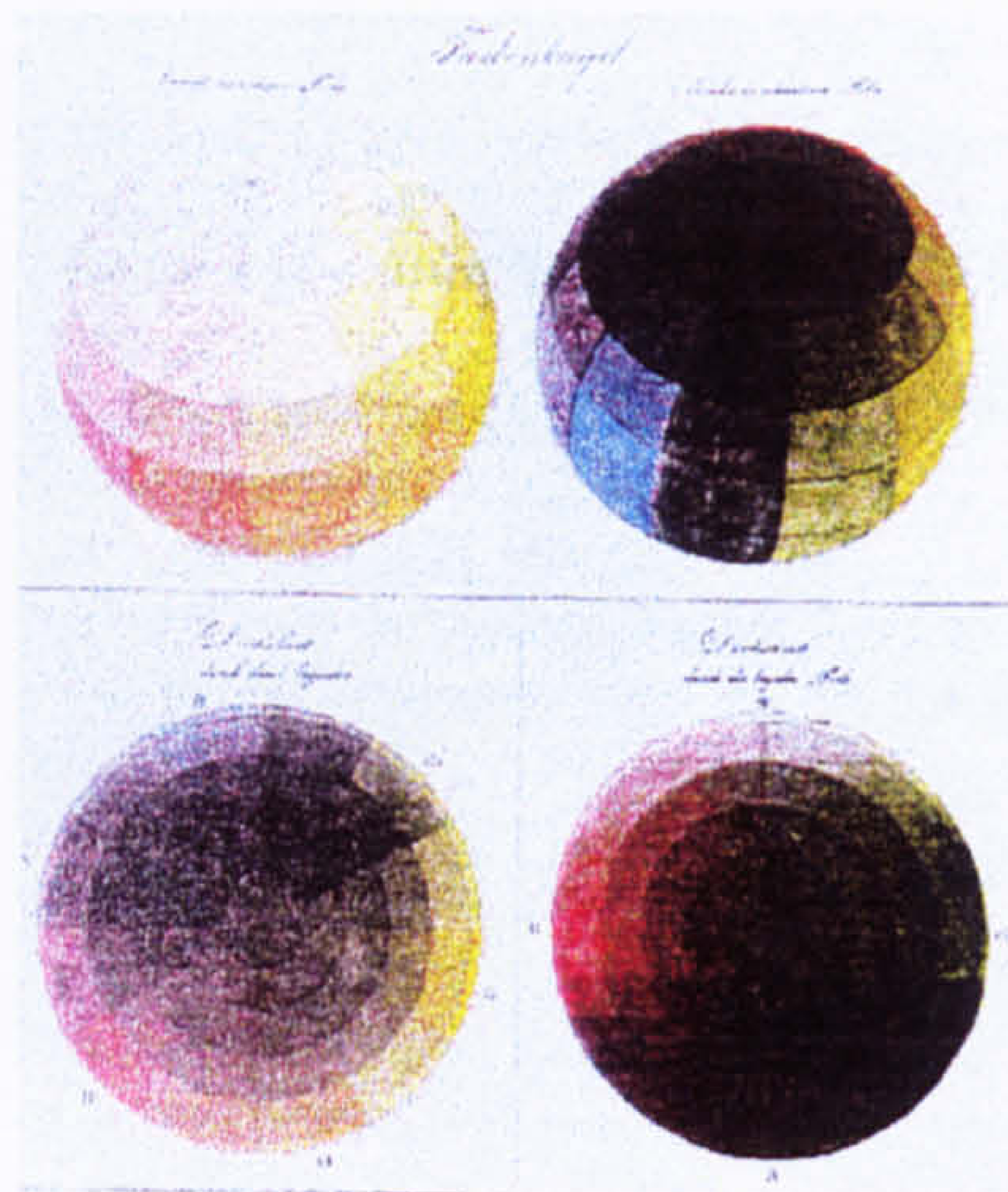


Fig 2.15 Otto Runge's sphere of colours
(Itten 1961)

- Chevreul's solid - 1861
- Munsell's solid - 1915
- Ostwald's solid - 1917
- Hickethier's Cube - 1940
- C.I.E.'s triangle – 1953 (Loução 1993b).

2.9 Monochromatic Systems

When working with colour, it is important that individuals can accurately communicate their specific colour requirements, such that any colour can be reproduced in any given situation. Unfortunately there is no world-wide standard notation, and many different models have been developed.

As already referred to in the first chapter, there are some colour systems which are very important for the study of colour fundamentals.

2.9.1 Munsell's System

There are many models, each of them performing the same function, but the system in most widespread use is Munsell's system.

Munsell implemented a nomenclature system, which wanted to get closer to the system of musical notes, without success.

It is true that sounds vary in pitch, intensity and duration and, that colours also vary in three different ways. It is also true that colours as well as sounds vary separately in each one of these three modes.

Munsell saw each colour as a tri-dimensional construction and he concluded that for this reason, each colour could be set in a geometrical form, occupying an exclusive position.

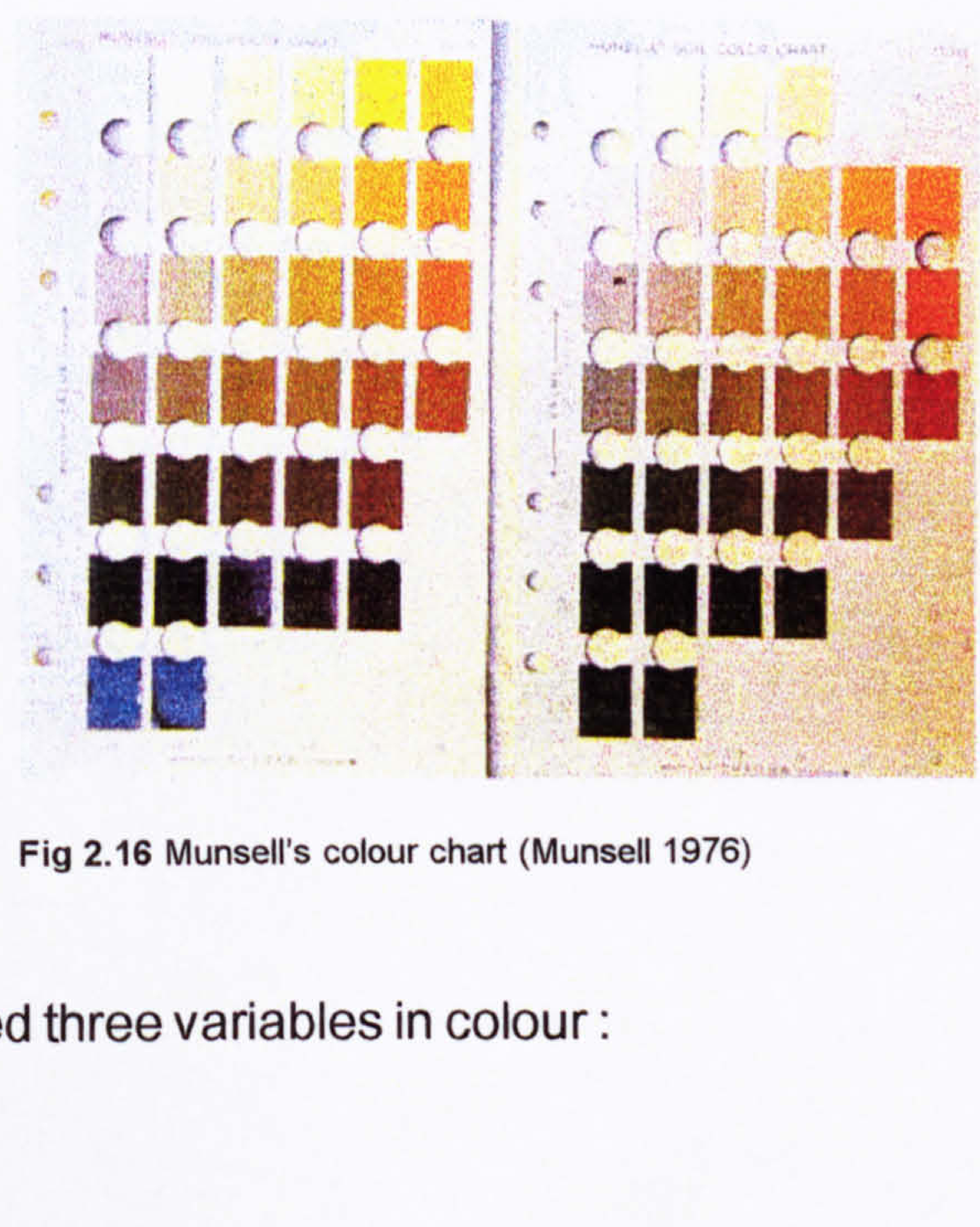


Fig 2.16 Munsell's colour chart (Munsell 1976)

Munsell considered three variables in colour :

Hue

Value

Chroma

When explaining his system, Munsell denominates Hue, Value and Chroma as the dimensions of colour. He organises in his system the classification of each hue, with a number which is particular to it, to indicate the tone's weight and two letters to indicate the colour, e.g.: R – red, BR – blue + red, and two numbers separated by a dash to indicate the value and the intensity (Munsell 1976).

2.9.1.1 Munsell's solid

Munsell's solid seems to have appeared from a necessity to correlate the basic scales of measuring the *hue*, the *value* and the *chroma* of a colour.

The essential structure of this solid is a vertical scale of values with 9 regular gradients between the black and the white.

At the level of each gradation, a horizontal disc has to be visualised; in the centre of this horizontal disc are 10 hues, spaced regularly and in natural order, in other words in its maximum intensity.

Besides this, each hue is radial and, as they expand themselves centrifugal, they are also graduated showing the increasing of intensity.

The solid is ready to work when the beam of a certain hue is in the same vertical plan.

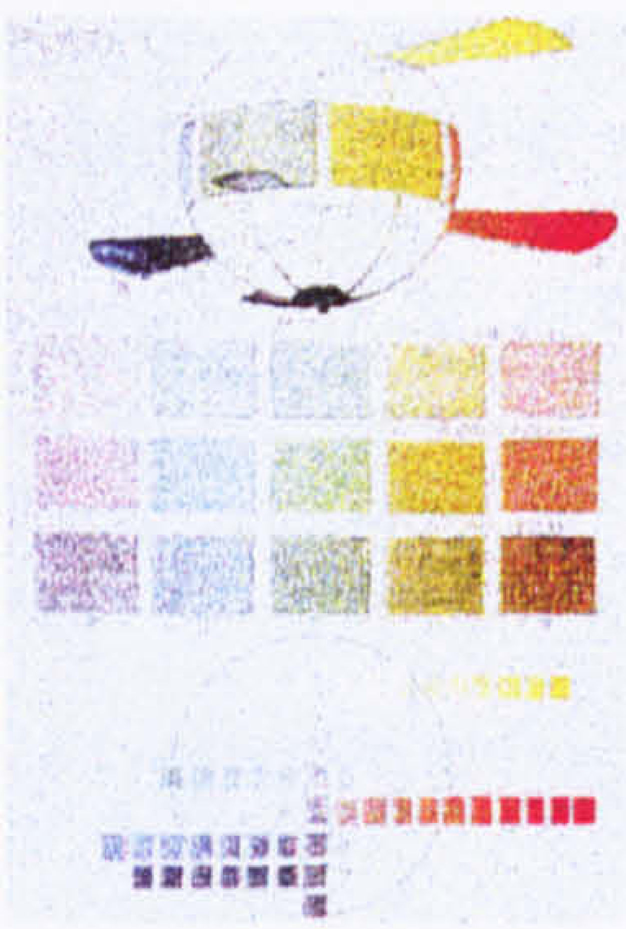


Fig 2.17 Plate I of Munsell's study for his solid of colours (Munsell 1976)

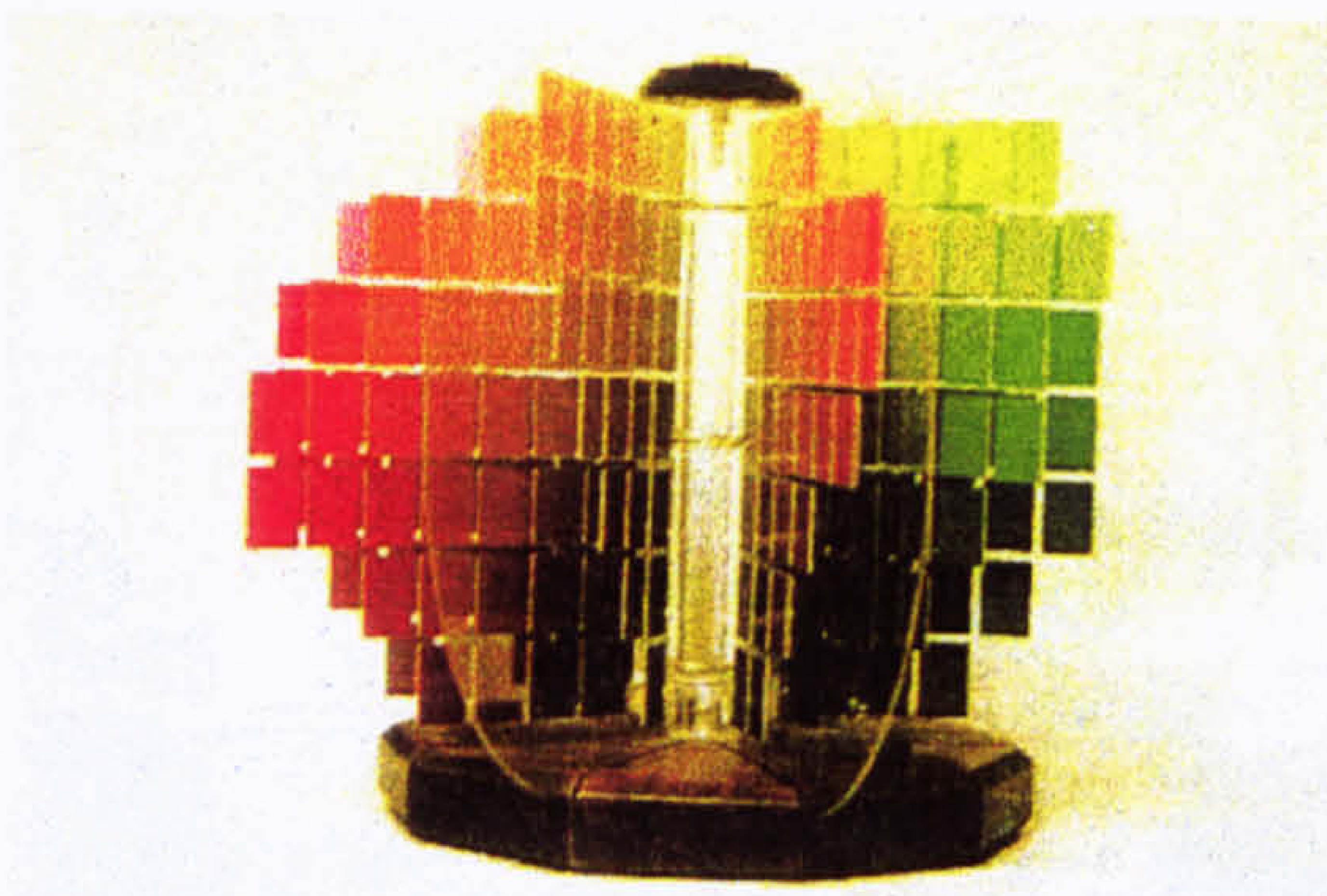


Fig 2.18 Munsell's colour solid (Munsell 1976)

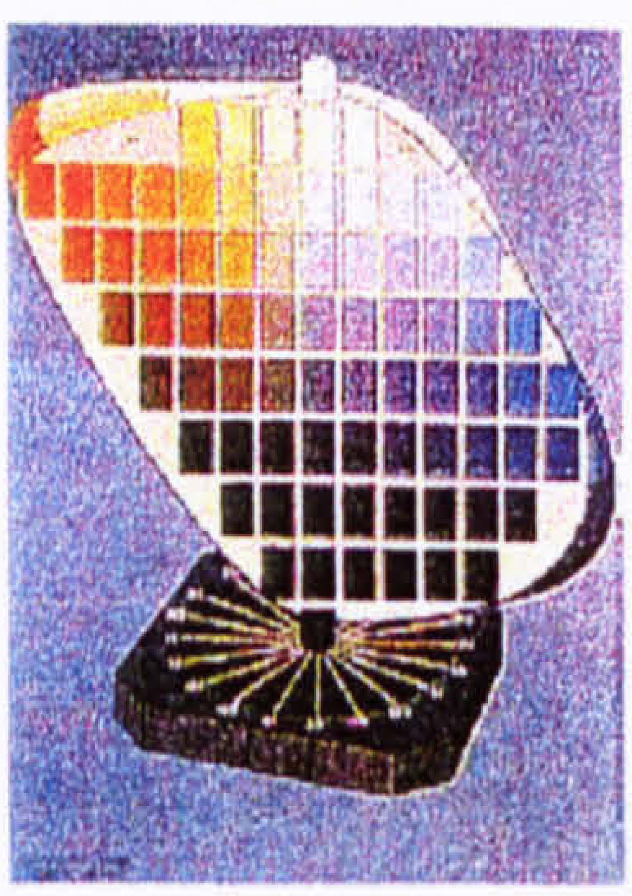


Fig 2.19 Horizontal section of Munsell's solid of colours (Munsell 1976)

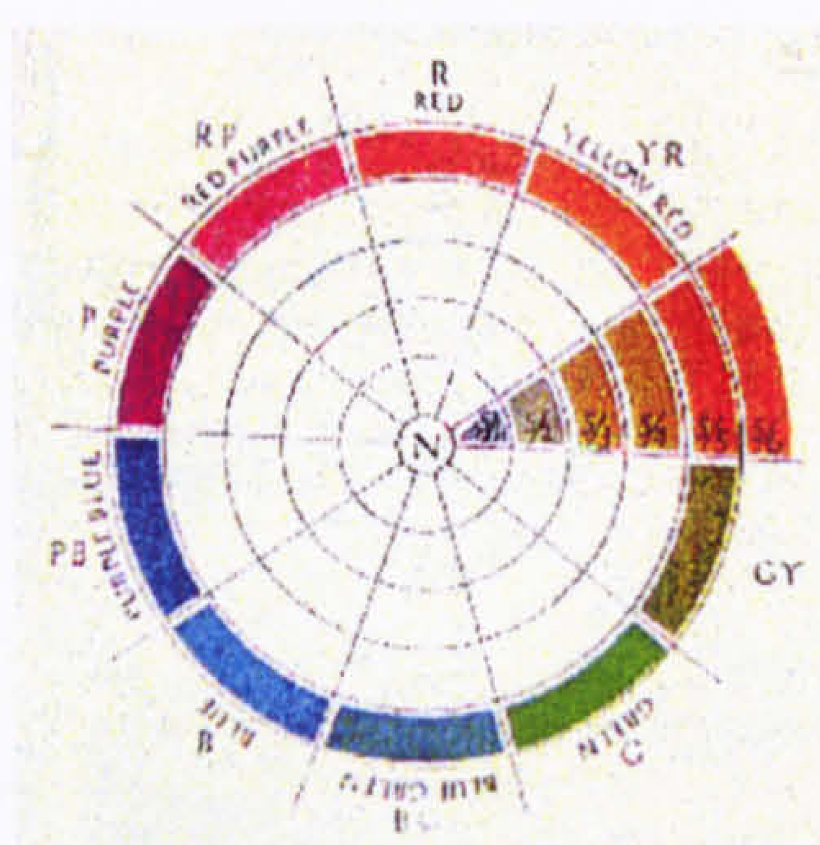


Fig 2.20 Vertical section of Munsell's solid of colours (Munsell 1976)

In order to find the exact and only position of each colour one has to move the solid to the correct level of value, to move sideways and along the beam, to find the correct hue and to continue until reaching the correct intensity (chroma) (Munsell 1976).

2.9.2 Ostwald's System

Ostwald's system is a double cone or circle of light, which comprises a vertical axis representing the scale of greys, from white to black, and the central section or equator constitutes the basis of two cones, where the chromatic circle is.

Since the height of each cone is half the dimension of a diameter, the solid divided vertically shows two monochromatic equilateral triangles, each one of them with full colour on its external angle.

These full colours are complementary.

The scale of greys, through its central position, divide each lozenge in two equilateral triangles, making a connection of the three vertices according to the pure colour, the white and the black.

In Ostwal's system, the three dimensions of colour are:

Tonality (hue)

Luminosity (value)

Saturation (intensity)

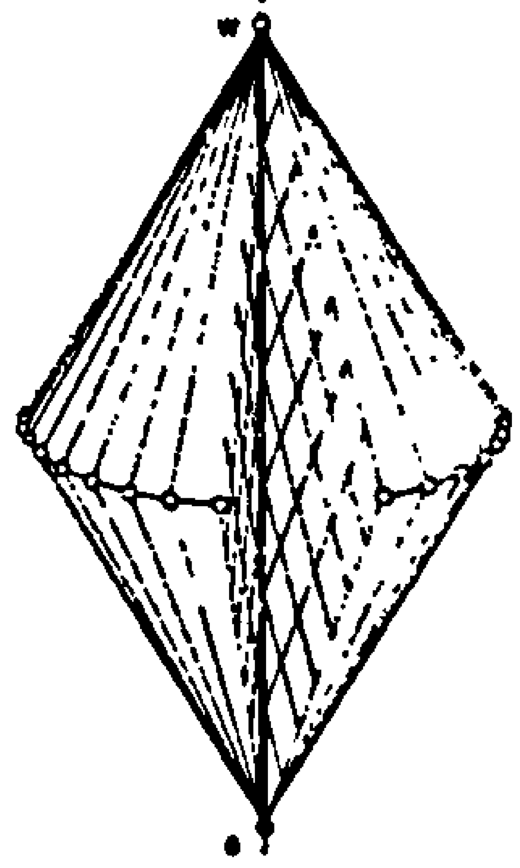


Fig 2.21 Ostwald's solid of colours (Birren 1969)

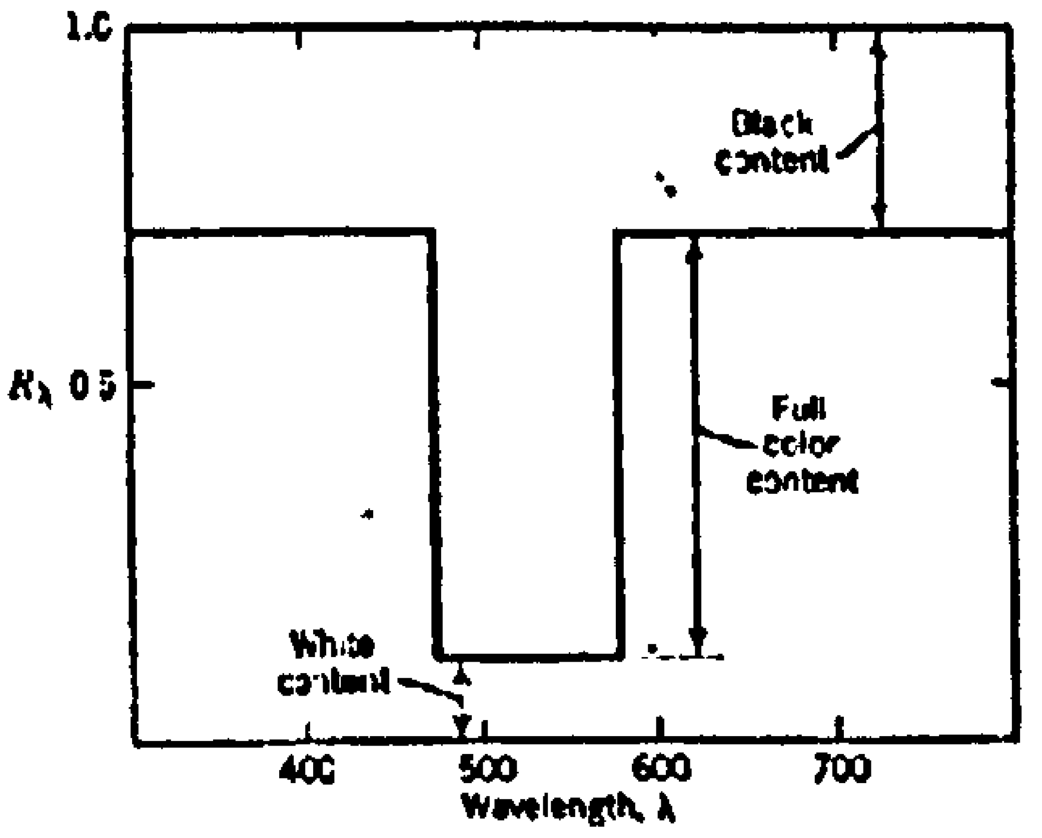


Fig 2.22 Magenta colour represented in the Ostwald's colour system (Birren 1969)

In Ostwald's system, the three variables of colour are represented by a number and two letters.

The digit corresponds to the number of the colour in the chromatic circle, from one to yellow, until 24, for greenish yellow and, simultaneously he adjusts the number of triangles that vary for each shade.

The first letter indicates the content of white and, the second one the content of black (Loução 1993b).

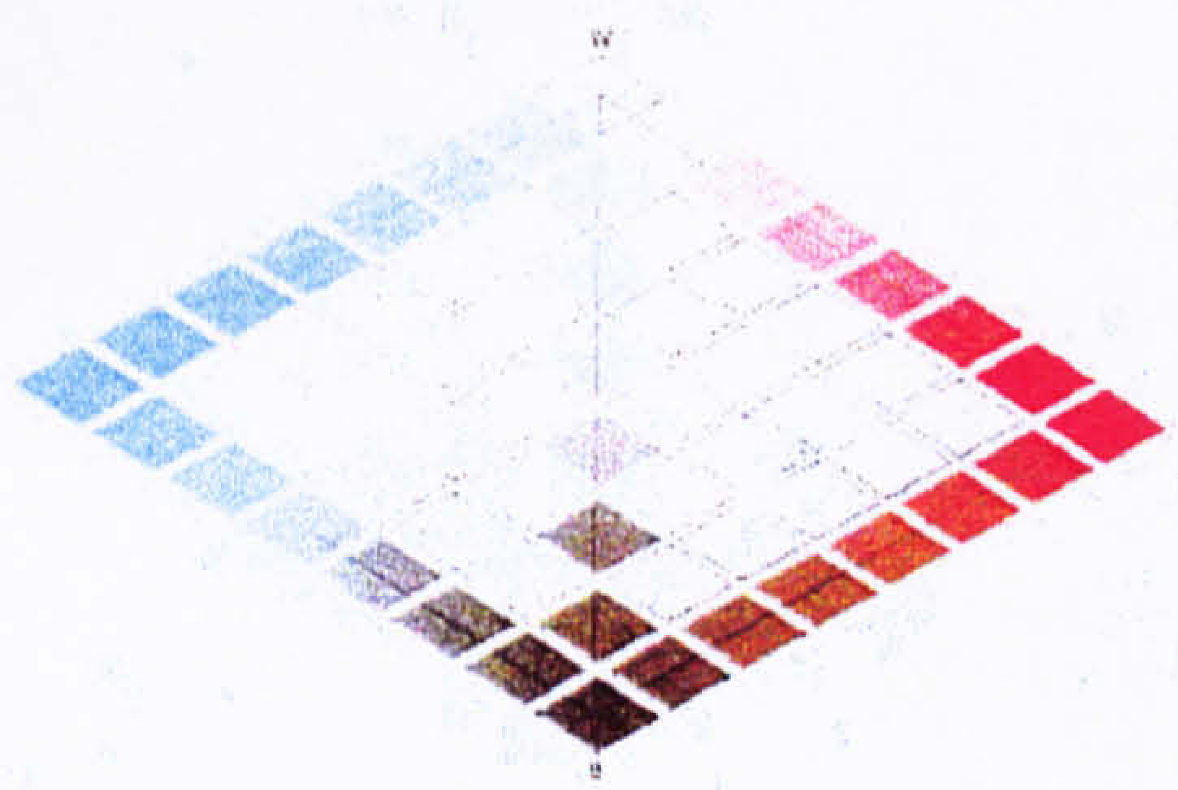


Fig 2.23 Ostwald's system nucleus with a vertical series of six grey (Grandis 1986)

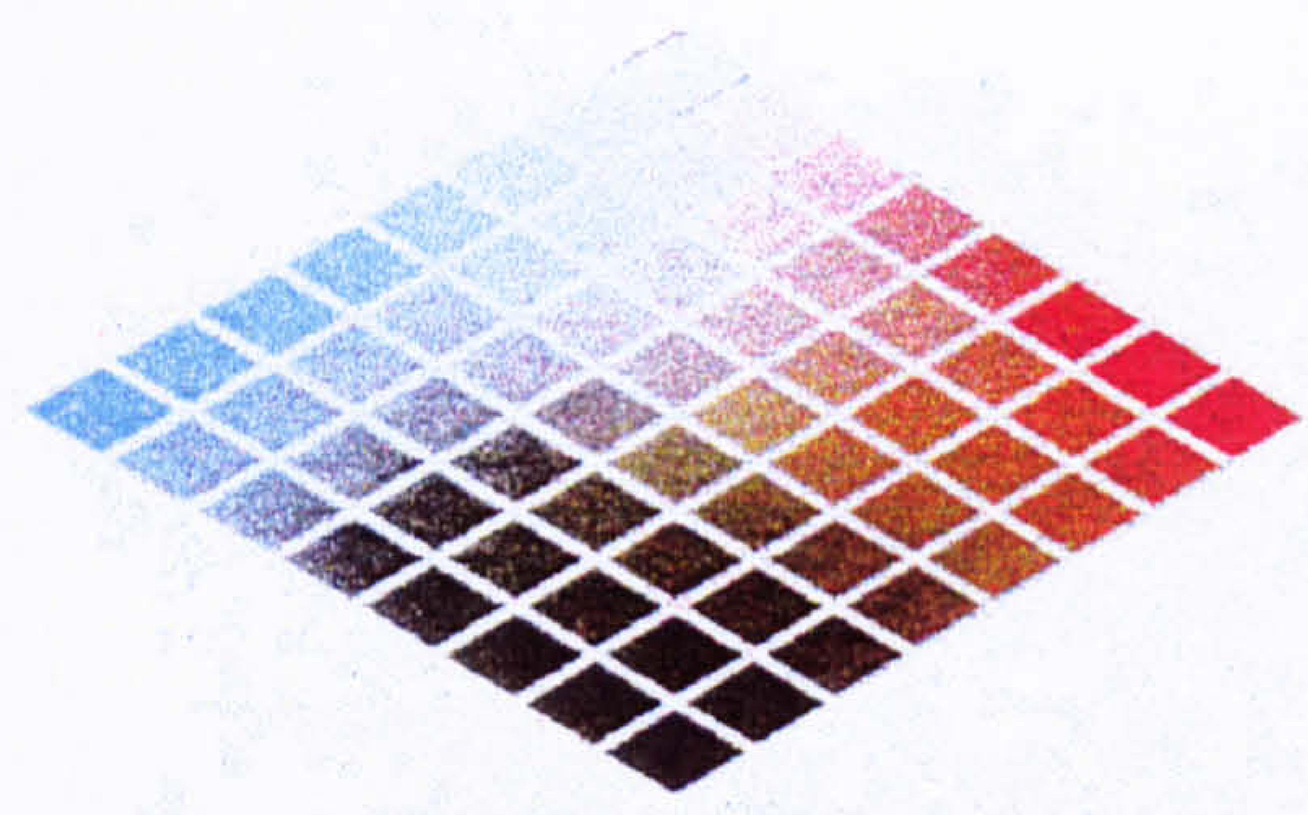


Fig 2.24 Vertical section of the Ostwald's solid (Grandis 1986)

2.9.3 Hickethier's System

To define a colour, separating it into its various elements, or imitating in the most precise way, a given colour has to be described.

The question is to analyse this colour, to have its colouring substances in detail, in order to establish a recipe from which each colour might be fabricated.

It is upon these presuppositions that the system is based.

1000 colours constitute this system's cube.

Hickethier considers that each colour, which can only be clearly represented through a tri-dimensional structure, "a volume" as he says, only admits three possible alterations.

To know:

Gradation of darkening (degrés de rembrunissement)

Gradation of tonality (degrés de tonalité)

Gradation of saturation (degrés de saturation).

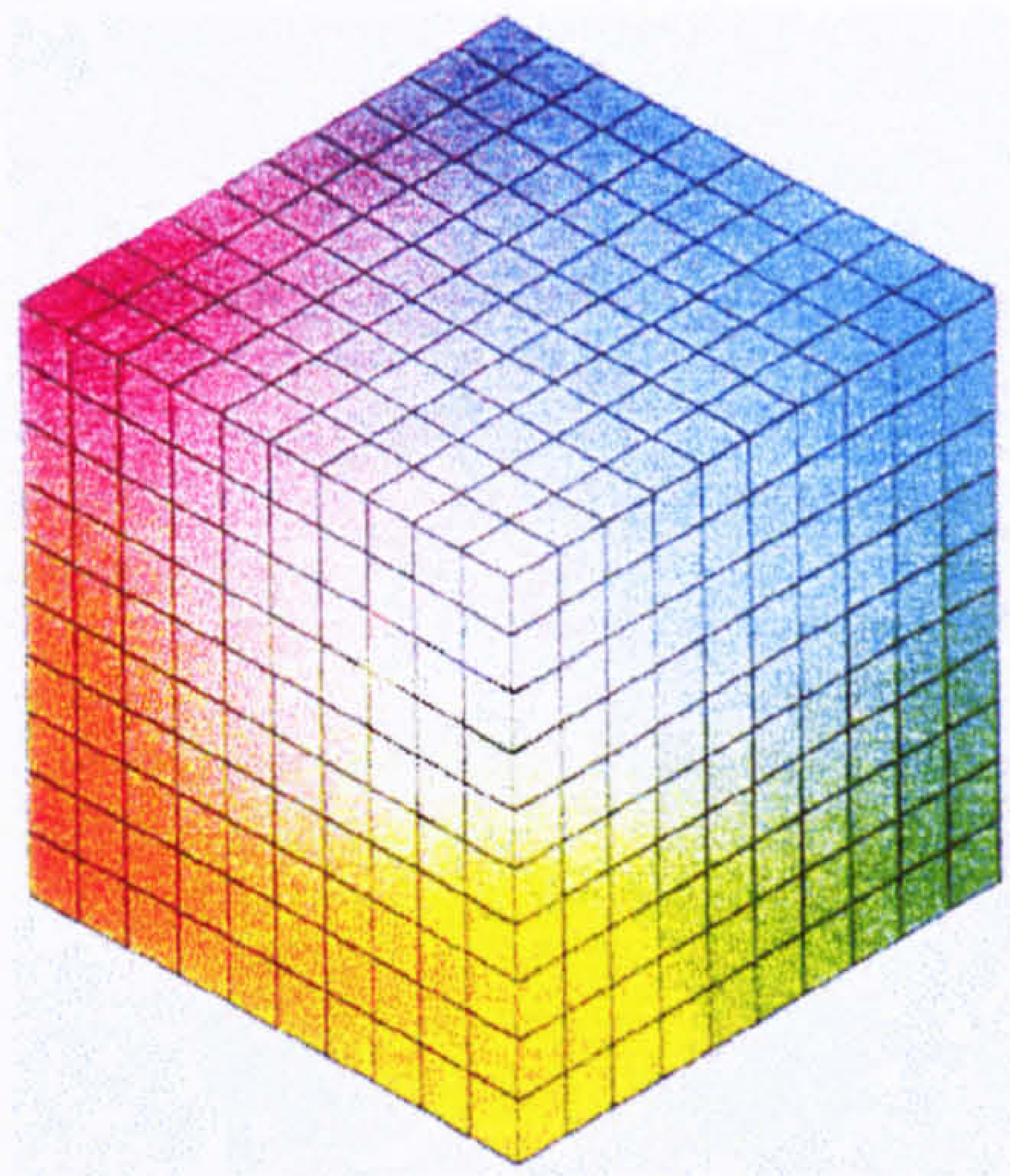


Fig 2.25 Hickethier's solid of colours
(Grandis 1986)

This system adopts three colours as its basis, the three subtractive primary ones:

Yellow

Red (magenta)

Blue (cyan)

All the remaining colours are obtained by mixing the primary colours.

This system, which allows a mathematically exact specification of one colour, belongs to the group of systems of tri-chromatic colour (Monzéglio 1972).

2.9.4 C.I.E.'s Triangle

C.I.E.'s triangle appeared in 1931 as a system of immediate identification of the wavelength of a given colour, as well as its grade of saturation.

In that same year, the "*Commission Internationale d' Éclairage*" recommended a system for the numerical definition of colours based only on the physical nature of the chromatic phenomenon.

The system, denominated C.I.E. 1931 Standard Calorimetric System, is based in one of the basic laws of the Tri-chromatic Theory, in which a colour can be created by mixing three primary colours with a given proportion.

The system derived from the R.G.B. calorimetric system; a system based on the use of the three monochromatic colours: red, green and blue.

However, the use of a chromatic diagram presented some disadvantages, the biggest being that chromatic spacing was not uniform, thus the identical spaces in the abciss didn't correspond to identical chromatic differences. Therefore, in 1960 the C.I.E. recommended a new chromatic diagram, the U.C.S. diagram, where the chromatic scale is uniform.

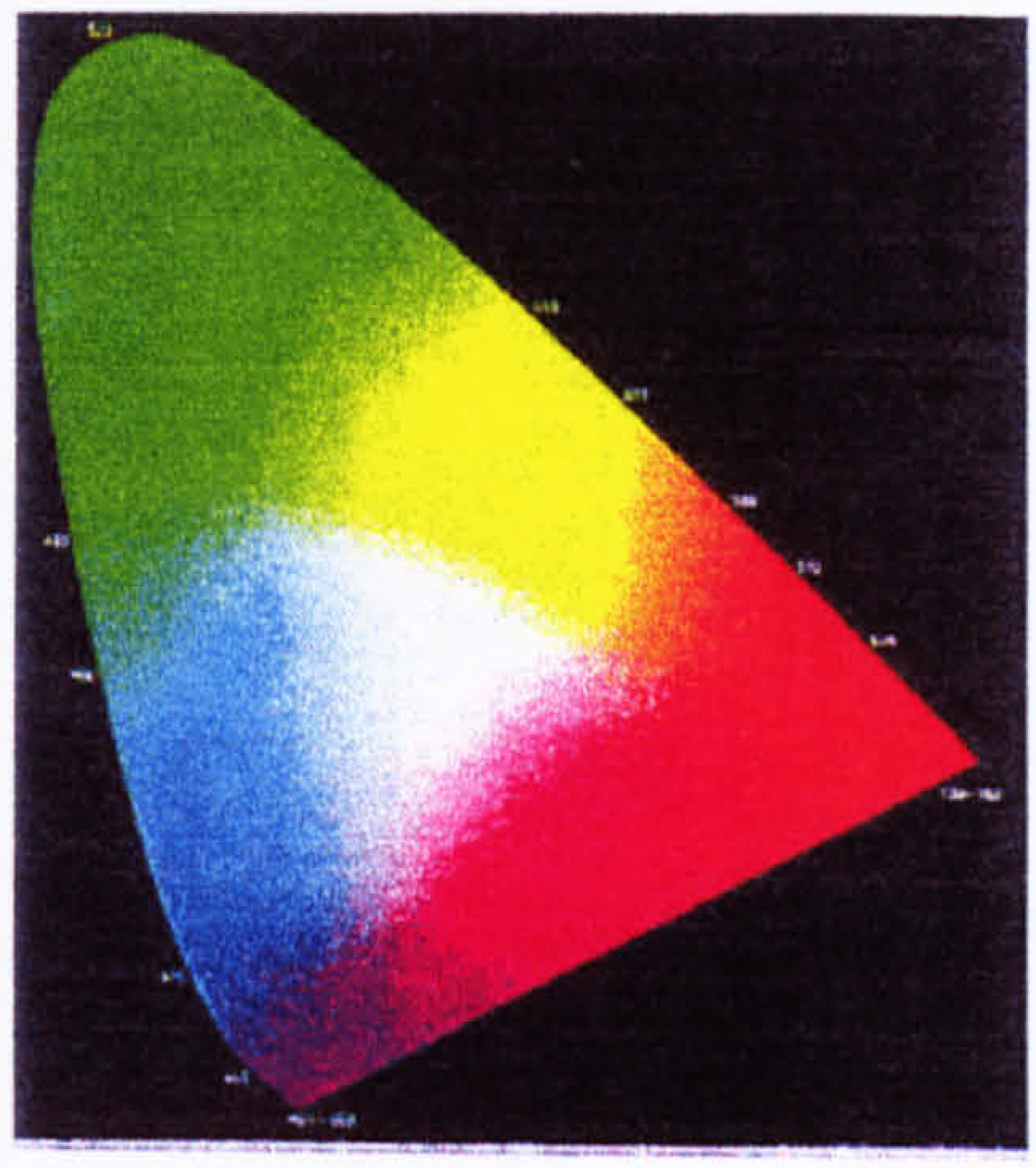


Fig 2.26 Bi-dimensional diagram of the CIE's triangle (Prado 1961)

This bi-dimensional diagram represents the spectral colours and in its interior there are non-spectral colours.

Organised according to the Cartesian system, the coordinates (X, Y) allow the location of any colour that comes from the mixture of two or more colours.
The colours are more or less saturated regarding the position they occupy on the external limit of the triangle, according to its wavelengths, which go from 400 *milimicrons* to 700 *milimicrons*.

In conclusion, the C.I.E. Triangle makes it possible to specify the chromaticity of a colour and, consequently, its purity and saturation, the equivalent to the Hue and Chroma of Munsell's System.

"All systems of colour have a fundamental failure: they consider the chromatic phenomenon like something isolated and they take conclusions more or less elaborated from there. The coloured cards illustrate the basic laws of the chromatic spectrum.
However, in reality (and the reality refers to the materialisation, because it is there that the decisive factors synthesise themselves) these factors are not present in the coloured cards.

The relation between colour and form, the relation between areas of colour of various dimensions and, finally, the relationship between one colour and another, is not a chain of factors taken into consideration by any ordering system "(Loução 1993b).

2.9.5 NCS – The Natural Colour System

For environmental proposes the inevitable confusion between colours and the descriptions, terminology and systems applied to them in different contexts has to some extent been resolved by the Natural Colour System (NCS), developed in Sweden, which depends particularly on the fundamental ways of perceiving and of using colour in the environment. This system is one of the more recent landmarks of colour research, based entirely on human perception of colours. This recognises the importance of the *achromatic* colours black and white, together with yellow, red, blue and green as *elementary* colours. Black, white and green are included because the system is based not on how colours are mixed, but on how they are perceived. The colour solid adopted for this system is a double cone with the polar axis extending from white to black, crossed in the middle by blue-yellow and red-green axes.

NCS in some respects corresponds to "the Munsell Renotation", being the two systems compatible by means of a translation key.

The NCS has been adapted by ICI in Britain and used as a basis for a wide range of colour products. The Colours Dimensions Association draws on these (Lancaster 1996a). This system is accepted as the national standard in many countries and has become popular among colour practitioners all over the world.

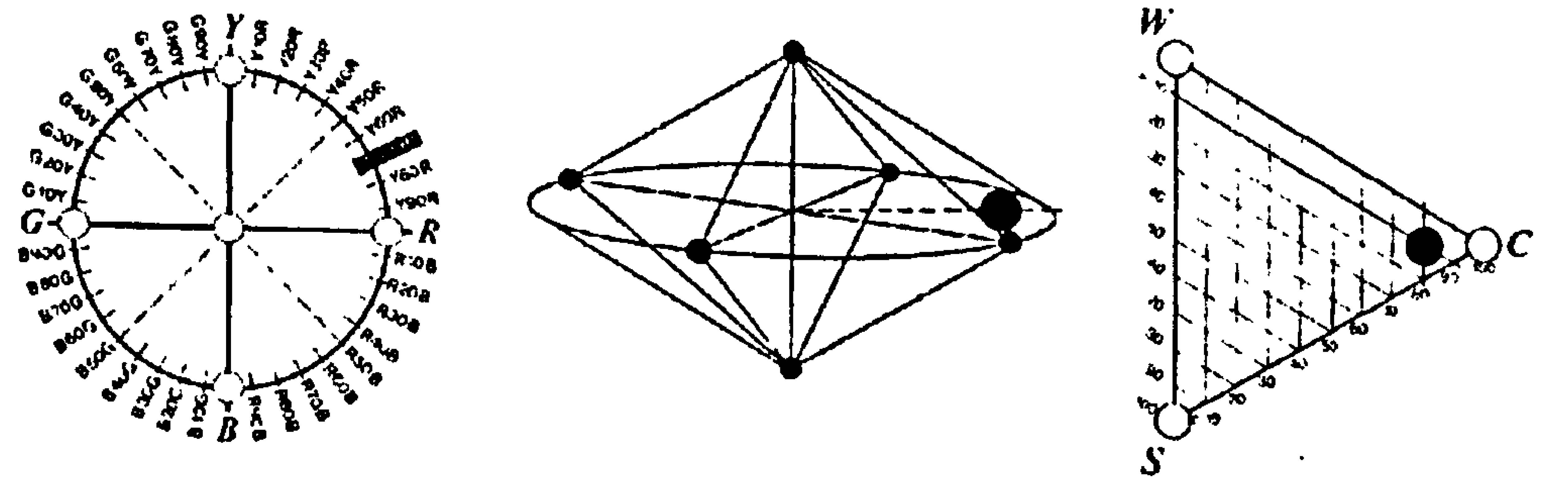


Fig 2.27 The Natural Colour System (NCS): colour circle; colour figure; colour triangle (Lancaster 1996)

2.10 Colour, as an element of the visual space

"The visual system is adapted to obtaining a maximum of information with a minimum of effort: that which is not immediately required, or can be taken for granted, can be considered redundant; the eye has evolved to see the world in unchanging colour, regardless of the always unpredictable, shifting and uneven illumination" (Lancaster 1996b).

Colour belongs to the visual message structure and takes part in its language, in the communicational process. Colour language diverts from the physic process of light energy, which transforms itself in a visual perceptive process in a way to carry out the communication. Every visual message depends on the light physic stimulus, therefore, every visual message is also chromatic.

While the space of geometric characters is detectable by several of the senses, colour is detectable only by sight.
So, the space defined as *space of light and colour* is only detectable by this sense of sight.
This issue reassures the importance of considering the *visual space* because, while the sensations produced by other senses are only related to distances and geometric characters, those produced by *sight*, add to these the sensations of *light and colour.*

2.10.1 Neurophysiological Component

Analyses the neurophysiological mechanisms of perception.

2.10.1.1 From the Eye to the Brain

A substantial quantity of visual information treatment occurs in the eye, but the fact is that an even bigger quantity occurs after the nervous signals have left the eye.
It is in the brain that the visual stimuli are elaborated and associated in underlying structures to the basic mental functioning. Although much information about the

external reality comes from the sense of vision, the answer to its profitability is in the brain.

"For the purpose of colour perception, the opponent-process theory postulates a differentiating light receptor system. Cones, the light receptor cells in the eye responsible for colour vision, are characterised as three types, as variously sensitive to short wave, middle wave, and long wave radiation (roughly blue, green, and red). With higher level, or post-receptoral, cells of the visual system, differentiation (rather than mixture) of the neural output of various cones determines our colour response" (Simpson 1991).

Colour may be defined as the whole of the sensations produced in the brain, as a result of light waves that reach the eye retina.

2.10.1.2 Optical routes

The movement of visual signs to parts of the brain goes through what is called optical routes. The ganglionaries cells in the retina receive the visual information which arrives from the cones and nervous cells and pass it along to the optic nerves, converging at the optic chiasma. Here the images are organised in such a way that information which either one or both eyes see in the left field of vision travels to the left half of the brain, and information which either eye sees in the right field of vision travels to the right side of the brain (**Fig 2.28**).

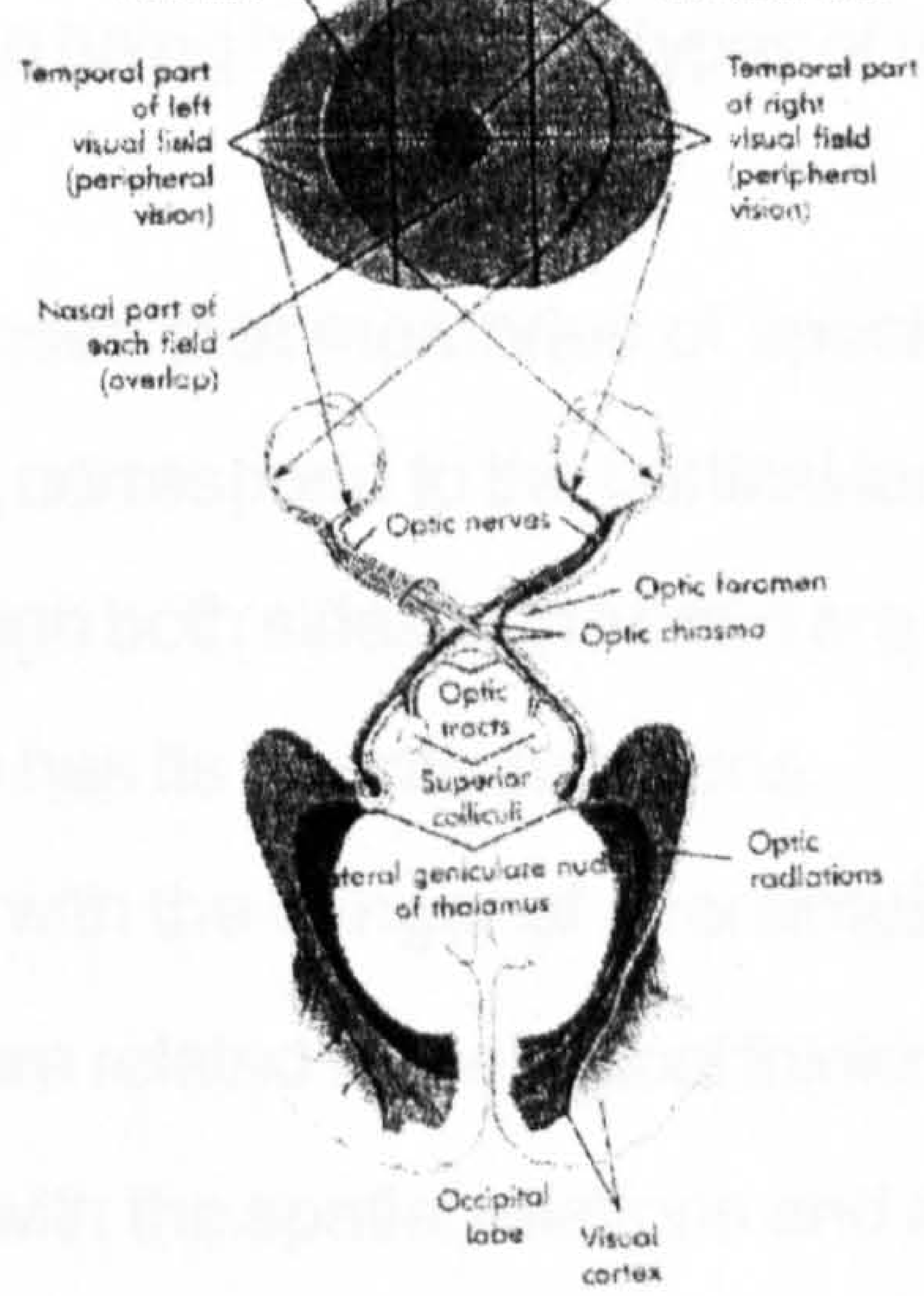


Fig 2.28 Visual pathways (Rowling 1997)

There are still many doubts regarding the way the transformation of visual signals are operated from the eye, to the vision perception in the brain. What is already known is that the process is more complex and subtler than a simple chain of connections.

After this quick trip through the optical routes, it can be confirmed as conclusion that chromatic vision occurs when the light, after crossing many routes reaches the photosensible elements of the retina. There it starts a complex series of biochemical processes, which transform the energy radiating from the various wavelengths in nervous impulses. Afterwards, these impulses reach visual centres in the brain where after being analysed, are kept as memory.

However, at the same time as it receives the visual impulses the brain also receives information arriving from sensorial organs. When the stimuli reach the correspondent sensorial organ, they produce specific registrations in certain areas of the brain.

This fact seems to justify some chromatic associations to odours (sweet colours, bitter...), to sounds (metal colours, silence colours...), to sensations of touch (velvet colours, dry colours...) and also to names, to the written or spoken language, because the various memories are temporarily and intrinsically connected (Monzéglio 1979).

2.10.1.3 Visual perception and Memory

The human being has various types of memory which correspond to various brain locations.

It is supposed that memories of specific functions, with locations more or less identified, correspond to the cortical location.

Even though both sides of the brain are involved in mental functions, it is know that each side has its specific functions.

Although with the danger of oversimplifying, it is possible to confirm that the left side is more related to the logical thinking and speech, while the right side is more involved with the spatial relations and answers of artistic type.

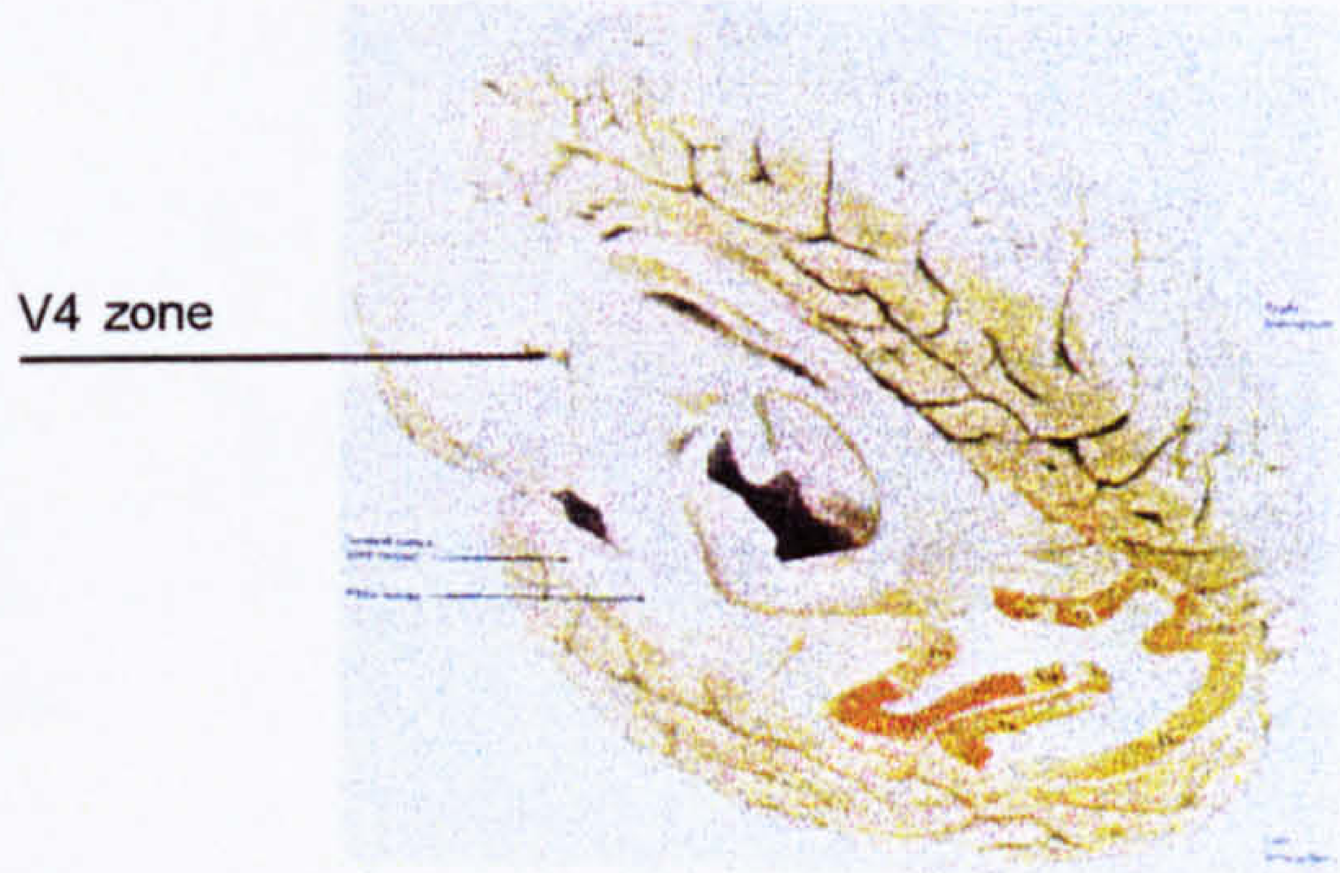


Fig 2.29 Brain image showing the V4 zone - brain centre of the colour vision (Zeky 1990)

The discoveries of Zeki came to demonstrate the presence of multiple functional subdivision in the visual areas and, consequently the alteration of the vision concept as a function (Monzéglio 1978).

The chromatic vision results from a very complex process, in which the nervous system makes a comparison of light intensity in various wavelengths, through specific interactions, which are known to be different from the ones needed to produce the perception of other properties of the visual universe.

It is known that people only *see* colour when the light and the chromatic signals which arrive from the eye reach the brain. Visible light is only a small part of the electromagnetic spectrum. A great number of authors place the visible spectrum between 350 and 760 Nm (Nm = nonometrus = 10 metres) or between 400 and 700 Nm. *Blues* are near 436 Nm; *greens* are near 546 Nm and *reds* near 700 Nm.

The evocation implies a transcription of languages, which should be understood under a different perspective.
However, if an act of communication is established between the brain centre and another centre through a code, one can confirm that people are in the presence of an act of language.
The existence of communication is a neurophisiological data (Monzéglio 1979).

2.10.2 Psychological Component

In order for the perception of an unknown thing to occur, not just resuming the mere sensorial impression, the archive of known items, which are likely to evoke some similarity with the recently known, is activated.

Going back to the colours, it is obvious that each person identifies differences between colours from his own chromatic memory, which also depends on emotional state, temperaments, suggestion, attention, capacity of storage of knowledge provenient from education, surroundings, culture...(Loução 1993b).
The perception is, in this context, something personal, non-transmissible and subjective.
The principles of physiology and psychology are inextricably linked. Both are controlled by neurological processes, although the exact nature of the process which controls psychological reaction is virtually unknown. A neuroscience continuum has been proposed by Graham (1997) to outline the large knowledge gap in medical theory, as well as between networks and the neurology of psychology. What is known is that the psychological reactions originated from the limbic system within the cortex of the brain, and are the subject of much current research.

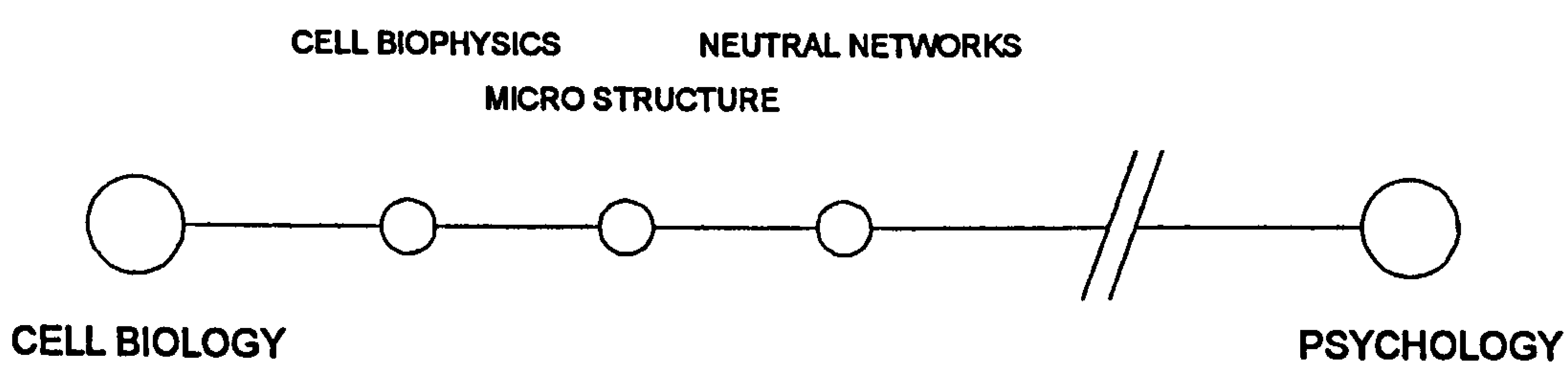


Fig 2.30 Continuum of Neuroscience Knowledge (Graham 1997)

It is the purpose of this research to develop the study of colour, in a way to demonstrate the characteristics that allow the perception of space, not only in its own structured qualities of light and chroma, but also in the links they maintain with the geometric qualities of space, reinforcing its perception.

Based on that purpose it's important to analyse the colour, through:

- The physical characteristics sensible to eyesight.
- The physical - physiological characteristics which are determi_ nants of the chromatic sensations.
- The psycho-physiological characteristics in the constitution of the chromatic visual area.
- The phenomena of the chromatic contrast in the different colours relations.

2.11 Physical Characteristics of Colour Sensible to Sight

Colour is light, which means that without the source of light we wouldn't be able to understand the colours.

"The phenomenon of colour vision includes the ability not only to discriminate between different colours, but to respond to them as a means of conveying information, stimulating emotions and practising deception"(Lancaster 1996b).

"Without the sun, or generally speaking, without a light source, we wouldn't have light and the eye would be, consequently, condemned to inactivity" (Bouma 1947).

Every light changes in form and in colour, which people is able to see, are percepted as combinations spectrally different of light energy.

Light can be described as an electromagnetic energy type which propagates itself through waves, similar to radio, TV, heat, and X-ray waves, that spread, concentrate, interact, one with the other, and react to obstacles. It can also be defined as a form of matter, because it is constituted by particles - the *photons* - which form currents. It is, therefore, *energy* and *matter*.

The most ordinary light source - sun light, a natural source - issues the *white light* from which the radiations of the chromatic spectrum are originated and from which, to a certain degree, people are able to understand.

There are other light sources, natural or produced by man, which present different characteristics of the sun's light, creating therefore other areas of perceptible radiations.
As an example, sodium light, mercury light and the light known as incandescent.

Considering that nowadays environments are constantly subjected to artificial lights it is necessary to analyse colour from its natural structure (especially because in this study the investigation is dealing with colour in exteriors) which is the one that originally touches people visual reception, because, as people are also natural beings, people are physiologically conditioned to the natural environment.

The memory method developed by Helson, Judd and Warren in 1952 (Rico et al 1995), shows that an observer has to be trained for an eight hour period in a way to be able to perfectly situate approximately 20 examples in any colour scale (for example, the Munsell scale), defining with precision their hue, value and chroma, at the day light.
Figure **2.31** shows an example of this, in which each arrow starts from hue and chroma under day light, and ends under another light source (Rico 1995).

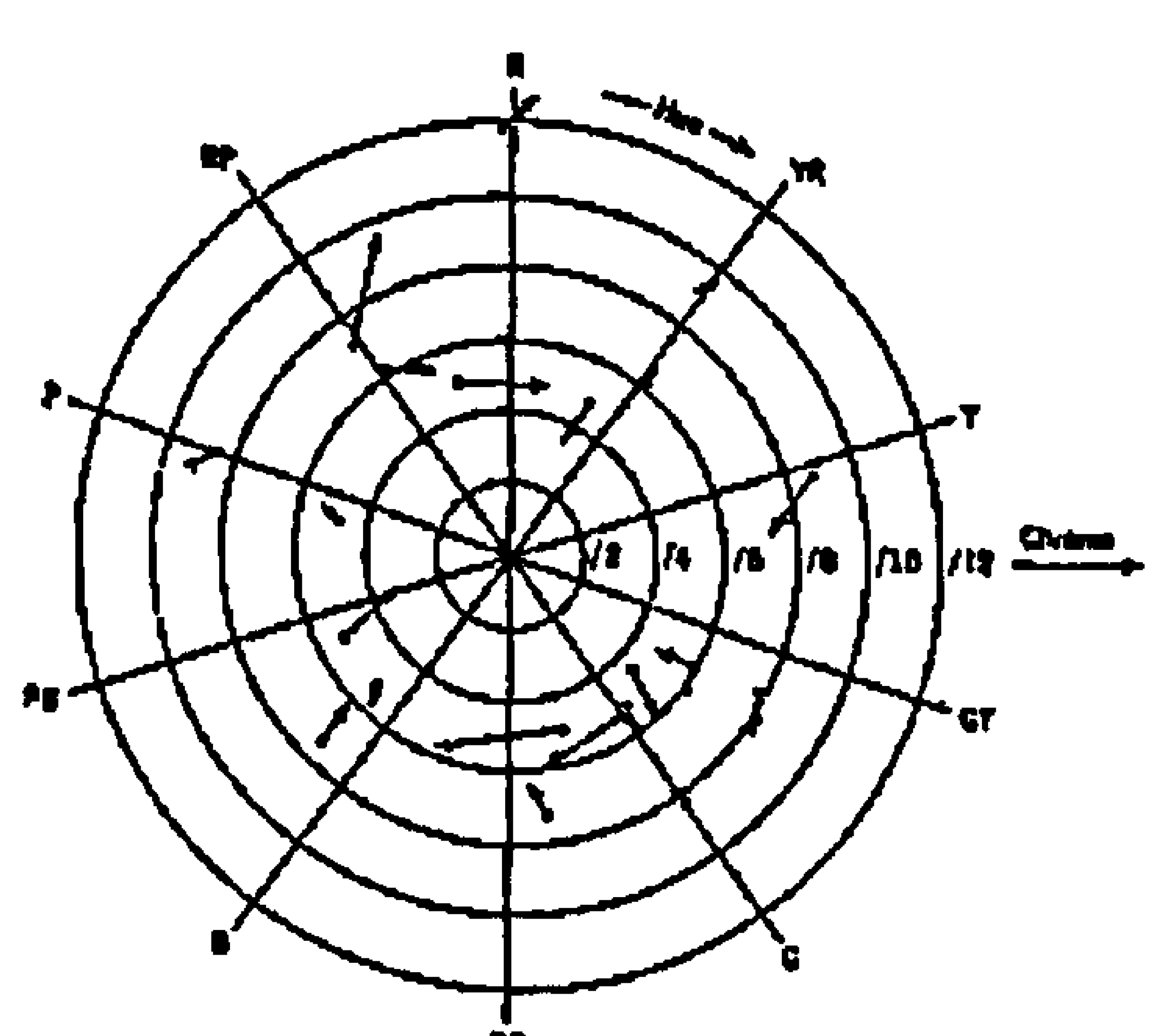


Fig 2.31 Changes in hue and chroma, when the light source passes from C to A (Rico 1995)

The *object of this study* is the *interaction between colour and space* and the *definition of structural similarities between both,* which from the perception are constants that interact in the constitution of *the unity of visual language*.

The study is concentrated on *colour* derived from the natural source of the sun, so that similarities of basic information can be determined.

As a *component of light structure*, *colour* is defined in its physical characteristics as sensitive to sight, according to its own light energy constitution.
Because of these characteristics, the stimuli that interact in the chromatic perception are discriminated in accordance with:

- Light intensity
- Colour quality (spectral)
- Colour intensity

These three different kinds of stimuli are sensible within each range of values.
Through those ranges, the limits and chromatic perceptive boundings are defined.
So, within the strict sense of differential perception (which in a basic and easier way gives people the space notion, i.e. the comparative action between a minimum of two values that defines a contrast), analysing the colour from the physical stimuli, one can build in this structural level, *the idea of space through colour.*
This idea is attached not only to the fact we have three different chromatic stimuli and, consequently, creating among themselves the perceptive differences, but also to the fact that there exist in each of them boundaries and perceptive levels, originating differences which increase in number and species.
The first notion of space one can have in terms of colour is the one of differential content order.
Sight is able to capture the stimuli from energy/light and to select attributes which, in a wider scale, total a number of three.
So, the first notion of space through colour presents a *triad* constitution which is repeated in the differential sensations, through the relations among the three attributes facing two to two (from 1 to 2, from 2 to 3, from 3 to 1).
If colour is analysed in each one of the three structural attributes it gives the notion of space in three different ways and in functions of perceptive limits and boundaries, the dimensions of which are as follows:

2.11.1 Value (light intensity)

Value, is the distinction between any colour and a lighter or a darker one (Munsell 1976).

According to Munsell, *Value* expresses itself in higher or lower value.

The value scale of the fundamental colour is the following:

Yellow, Orange, Magenta and Green, Cyan, Violet.

Goethe (1989) gives a *value* of 10 to white and 0 to black, conferring respectively:

9, yellow; 8, orange; 6, magenta; 6, green; 4, cyan; 3, violet.

From this scale of *values* one can infer that the pairs of complementaries with higher *value* of contrast are:

Yellow-Violet (9-3) followed by the pair of Orange-Cyan (8-4) and, finally, the pair of Magenta-Green (6-6).

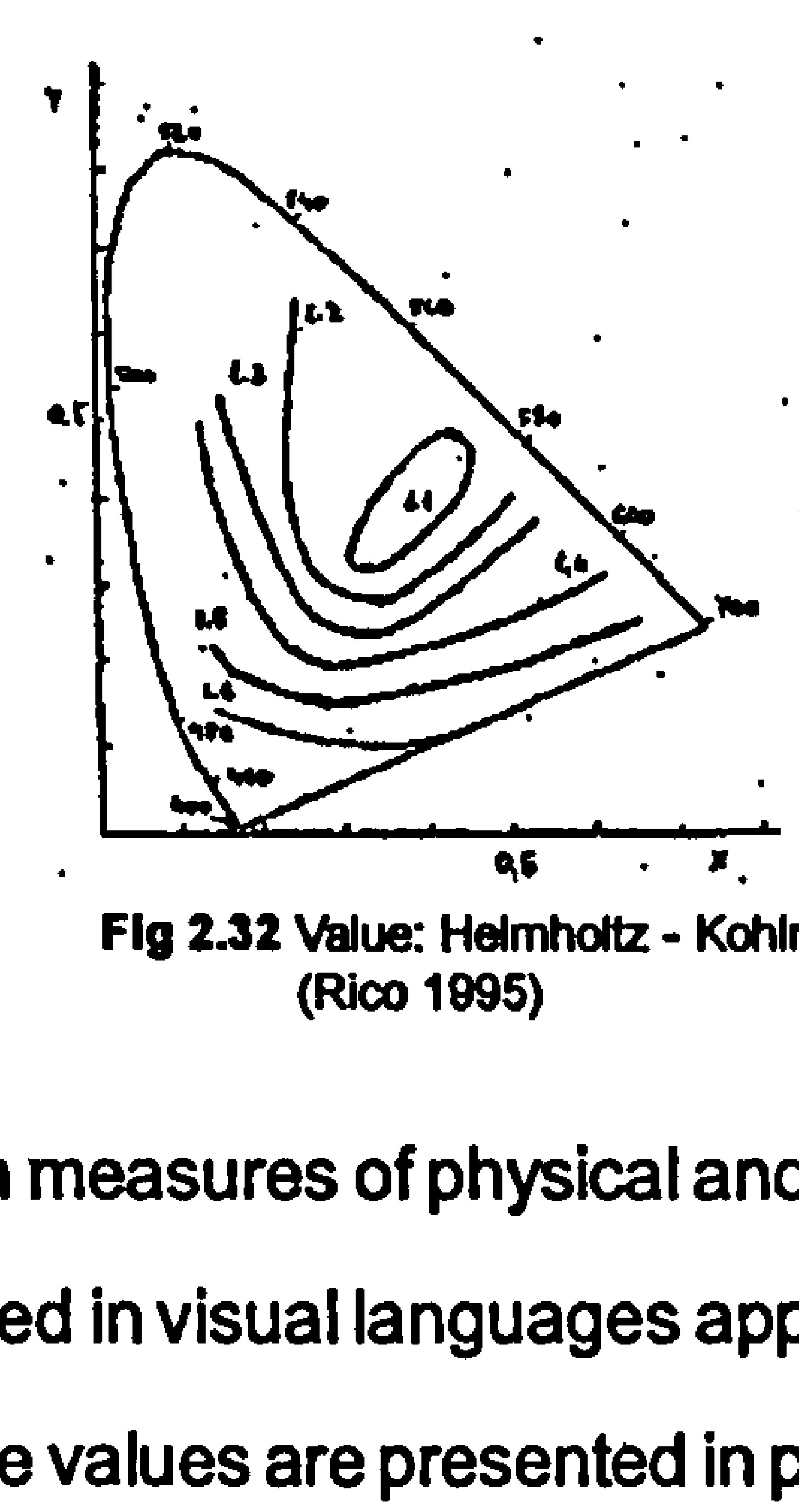


Fig 2.32 Value: Helmholtz - Kohlrausch (Rico 1995)

The values change within measures of physical and photometrical nature. In the case of colour, and as used in visual languages applied to environment, or to art and to communication, the values are presented in percentages of reflection, corresponding to:

- Sensibility boundary = 0%
- Saturation boundary = 100%
- Differential boundary = variable between 1 and 2% (the data on differential boundary are relative and depend on specific conditions of the source nature of the stimuli and the receiver.)

Indicating another kind of measurement related to the light flows from a light source, as an example, the *values* are in "light quanta", correspond approximately to:

- Sensibility boundary = 10^{-6} lumens
- Saturation boundary = 10^{-4} lumens
- Differential boundary = variable between 5 and 10% of variations regarding that "the spectrum of illuminations generally used by people in their reactions is extended between some lumens and some thousand lumens with a differential boundary in the percentage mentioned above" (Moles1971).

In this case, space is felt in terms of colour, through a differential content of light quantity, which is the result of the comparative action between brightness and darkness.

2.11.2 Hue (Shade quality)

"*Hue* is that quality which is commonly accepted as colour in defining its redness, blueness and yellowness" (Porter 1993).

For Munsell (1976) *hue* is a universal variable present in all colours. *Hue* is a variable, which informs one to which particular class one colour belongs.
And the classes are:
Red, Yellow, Green, Blue and Violet.

To these classes can be added hybrid classes such as the reddish-yellow, greenish-yellow, violet bluish and the violet reddish.
Tidying up these *hues* in an ordering and circular sequence can establish relationships between them, relationships which are not normally visible and, which produce a familiar and classical form, the chromatic circle.
However, the chromatic circle is a mere exercise if its intrinsic and natural relation is not recognised with the visible spectral.

The values are given by spectral positions, in wavelengths, which are measured in *milimicrons units* (mμ) correspond to:

- sensibility boundary = 380 mμ
- saturation boundary = 780 mμ
- differential boundary = variable between 2 and 3 mμ, resulting in a wide ramp of shades, between 130 and 300 sensitive variations.

In this structural aspect of colour, the main shade variations are defined, which are placed in the sun spectrum and that are given through the following values (Prado 1961):

Sensibility boundary	black	
		380 mμ
	violet	
		446 mμ
	indigo	
		464 mμ
	blue	
		500 mμ
	green	
		578 mμ
	yellow	
		592 mμ
	orange	
		620 mμ
Saturation Boundary	red	
		760 mμ
	black	

One should notice that in this case, in terms of colour, space is felt regarding the differential content of quality of the light radiation, i.e. monochromatic radiations, and it is defined by comparative action between one and another colouring.

Some authors compare the structural shade organisation of colour with the tonal organisation of sound.

As an example, in the analysis of information repositories, when giving the visual variables of sensorial stimulations, Abraham A. Moles (1971) defines them, in the case of spectral positions, as "corresponding to the eight level of sound and which differential boundary changes deeply with people (until 10.000 changes/tones, recognised by trained people)".

Another example is found in the book *"Color Fundamentals"* by Maitland Graves (1952), where light structure is compared to sound. He considers "the eye as a specialised instrument trained to receive and respond only to waves of resplendent energy of determined wave lengths; as well as the radio, which is directed to receive and respond only to energy waves resplendent of determined lengths, called radio waves".

In an attempt to arrive closer to comparisons and correspondences he quotes: "as well as the different colours which are produced by light waves of different lengths, the sounds of different heights are produced by sound waves of different lengths. In the same way, when a colour has exactly half of the wave length of another, we can say that it is similarly, one eighth above, which means that the violet light is one eighth above the red light...We know that the perceptive spectrum correspond and is included in a eighth".

"Our ears can hear 11 eighths of sound, but our eyes can only see one eighth of light" (Graves 1951).

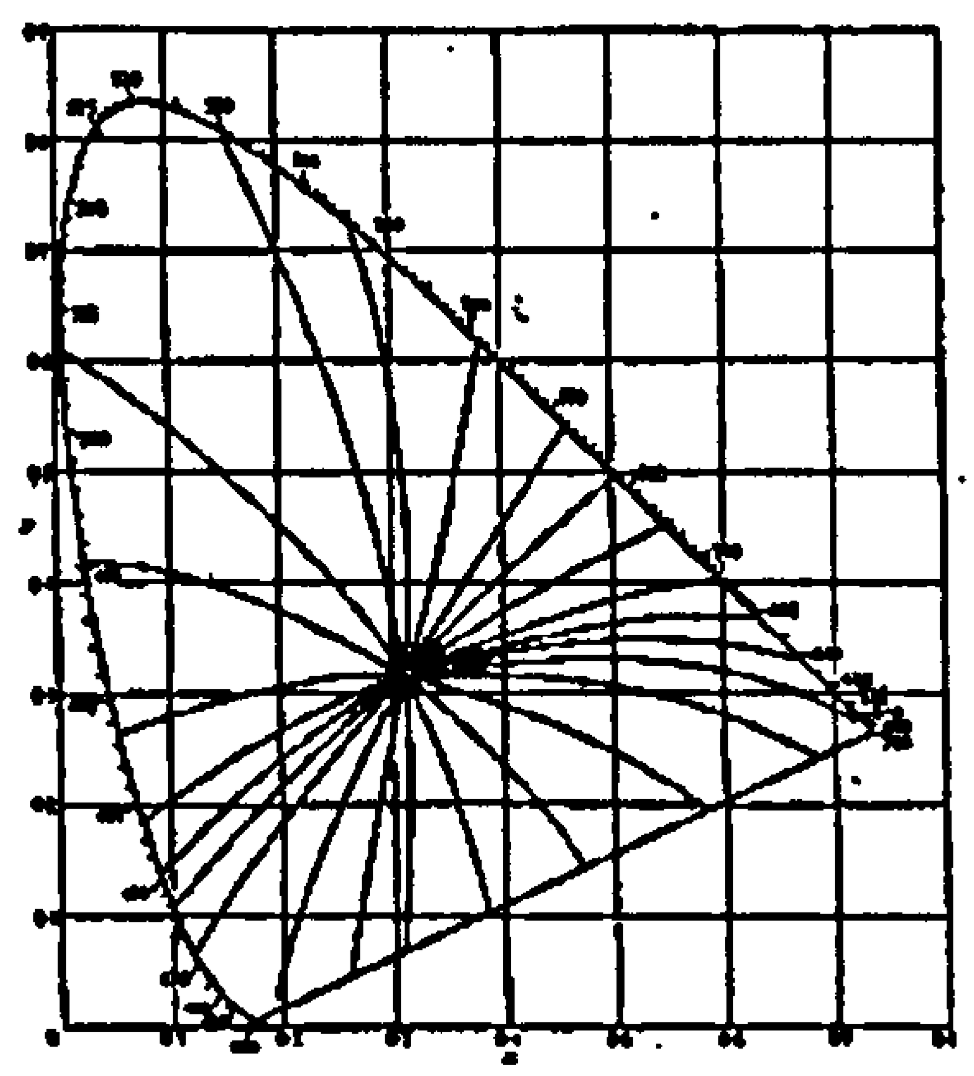


Fig 2.33 Lines with the same apparent hue (Rico 1995)

2.11.3 Chroma (Shade Intensity)

Chroma, *Intensity* or *Saturation* implies the existence of *hue* and, is the distinction between one colour and another more or less saturated.

One can say that it describes the *state of purity* of one colour.

Contrary to *hue* and *value*, which can be visualised independently from one another, the intensity cannot be visualised other than in a variable of scale in which the *hue* is systematically affected. The lower level of *saturation* is obtained when two complementary colours mix together in equal parts and, the higher level of saturation is obtained when compact paint, commercially prepared, is applied in its natural consistence, on a white surface (Loução 1993b).

The values are given by the purity dosage or by the colour vivacity corresponding to its spectral position.
The levels of purity are expressed in percentages that correspond to:

- Sensibility boundary = 0% "chroma"
- Saturation boundary = 100% "chroma"
- Differential boundary = variable between 3% and 4% "chroma"

In this case space is felt in terms of colour, in its differential content of shade quantity, and is defined by a comparative action between chromatic and achromatic.

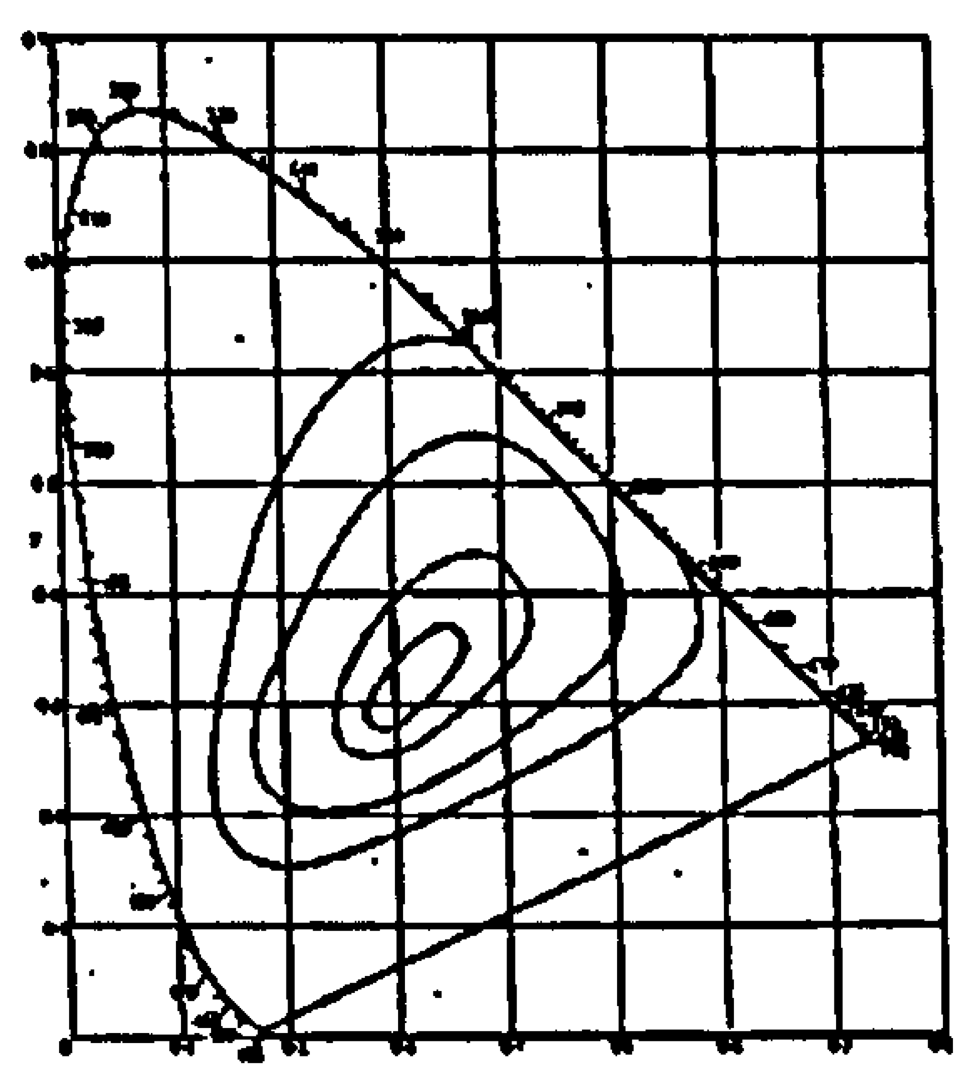


Fig 2.34 Curves of constant chroma
(Rico 1995)

2.12 The Physical-Physiological characteristics which are determinants of the chromatic sensations

"The world without colours: it would be rather difficult to imagine a world without colours, a world of white, grey and black shapes" (Sargent 1964).

"We use terms, such as pale-grey, olive-green, brick-red. We describe the colours as pale, brilliant, expressive, strong or intense. But our descriptions of colour are extremely indefinite.

In the communicative reality we hardly find achromatic atmospheres unless they are produced on purpose. Many of the languages which compose the environment can be achromatic, or tend to the neutral shades, but the complexities of direct or reflected light radiations which get into the environment and their languages, come from several different shades, therefore, fulfilling the atmosphere and the objects with such shade values.

Having as an example constructive materials applied to architecture and to the city, if in the environment we consider spaces to which belong languages such as concrete, reinforced concrete or asphalt, for all of them there is a chromatic definition, even when it starts in a higher scale of neutral and grey values which is from a visual structure of achromatic basis.

If we take another example, strictly from the graphic communicative and environmental field which is the photo and the film in "black and white": our visual sensations are conditioned to achromatic images and the stimulus of that species is relevant and prevails almost totally, even with the environmental incidence of other shade radiations.

But it is a temporary condition, they are images that are visualised and pass; or they compose constantly certain environmental spaces, but not totally. The height of a tower can be expressed in inches and feet. The weight of an atom can be given. So, why this uncertainty about colours? Is our general awareness on the subject very low? How many colours are there?" (Wissing 1966).

People need colours for their environmental well-being. Colours are part of people's visual structure and they don't represent an essential issue of communication and atmosphere except for the visually.

Then, in the natural order of sensations, colour is an element to be constantly considered, whatever the aspects of visual and environmental communication are and the languages which are their components.

Regarding the natural order of the chromatic sensations one should define clearly the sense of colour.

In accordance with the space-chromatic analysis from the physical characteristics sensitive to sight, the colour/space relationship is understood as dimensions that comprehend several structural kinds.
The chromatic sensations follow those kinds and, in physiological terms, they adapt themselves to different dimensions.
So, the sense of colour is not only restricted to what is colourful, but it comprehends all the perceptive ability of the other dimensions. Then, also in the sense of colour, the values of light intensity, or lightness, and the values of shade intensity, or saturation, are considered.
Those three physical attributes, and of physiological correspondence in the sensations, allow the idea of attributing the colour, as a sensitive element, not only to self and precise definitions in qualitative and quantitative characters, but also *to see*.
But, and what is more important, those images are temporary and they represent a reality, which is chromatic, and, by experience, one knows their shades and variations.

So, one doesn't need their colours in the total sense as one is informed of their values in one's memory.
Therefore, one can conclude that in the natural order of the sensations of colours, two issues must be considered, which are components of people's perceptive - communicative structure:

- The direct sensations which are present in the environment and in the messages that reach people, and
- The indirect sensations which are not present in the moment of observation, but still reach people, by a process of recovering the reality previously visualised.

But, considering the issue that people build up their perceptive structure through the experience of the knowledge of the reality, without which people wouldn't have any visual recovery by memory, people should therefore analyse the issues that contribute by a direct incentive to the sensitive composition of colour/space perception.

2.13 The Psycho-Physiological characteristics in the constitution of the Chromatic Visual area

When studying *colour* it is necessary to analyse its *own physical structure*, which is a contribution to the particular characteristic of the *structure of the image* in the field and, consequently, influencing the limited ability of the *visual space*.

Psycho-physiologically, the chromatic visual area is structured, regarding:

- The physical qualities of the chromatic radiations which get to the retina.
- The physiological constitution of the retina, regarding the distribution of neurones in its surface, as well as their physiological capacity, in the behaviour of capture and selection of stimulus.
- The perceptive organisation of the psycho-physiological capacity in the captured and selected stimulus.

Fig 2.35 The colour wheel (Porter 1997)

"Look carefully at the colour wheel on figure **2.35**. Focus on the white dot at the centre and allow the surrounding colours to be completely absorbed by the eye. After about a minute or so focusing intently at this figure, switch your gaze to the black dot below. You should now experience an illusion of the colour wheel" (Porter 1997).

"If you did, you experience a *negative afterimage* in which you saw colour where none existed. This demonstration is important because it clearly illustrates that the ultimate colour experience occurs not in the eye but in the brain. In other words, the colours that we see do not exist on the surface of objects but are manufactured in the mind's eye. Our experience of colour is a subjective sensation conveyed by the eye's absorption of the different energies in different wavelengths of light radiation within the visible spectrum. However, without an observer, light rays do not, in themselves, constitute colour.

As Newton explained, the rays are not coloured; in them there is nothing other than a power to stir up a sensation of this or that colour. The eye and brain of the observer interprets the meaning of these sensory messages; the resultant colour perception depends on three important factors:

- first, the conditions under which the stimulus is viewed: for example certain paint colours applied under tungsten light would appear very different from the same colours viewed in sunlight, as the two perceptions respond to two different spectral energy distributions contained in each light source.
- second, a colour perception depends on the spectral characteristics of the stimulus, the ability of its substance to absorb, reflect or transmit light: red paint, for instance, appears as red because it has the property of absorbing from white light everything except the red component of the light.
- third, our ability to perceive colours, the sensitivity of our colour-registering mechanism (the eye and the brain) to create a colour response" (Porter 1997).

People are aware that the most peripheral area of the retina hasn't got the cones, sensitive neurones to the coloured radiations and has only the sensitive neurones to the light variations.

People also know that the central area is the one that has the skill to understand all colours. There is, obviously a relationship between the *perception* between *space and colour*, depending on the *visual field* and the opposition between the *achromatic* *and chromatic.* This relationship determines the sensation of colour/space regarding concentric areas which gradually are no longer sensitive to determined chromatic radiations, according to the distance from the central area of the retina. The areas of different perimeters of the visual fields, into different colours, are defined in the following order, from the centre to the periphery area:

green, red, blue, yellow.

And they correspond, approximately, from the distance of the centre:

- green = 30°
- red = 40°
- blue = 50°
- yellow = 60°

In general, those measures are taken comparatively to the two groups of chromatic pairs:

green and yellow, and, blue and yellow.

There remains the pair of the achromatic group black and white, whose perimeter goes far behind the yellow area, to a perimeter of 70°.

By the chromatic visual field, colour/space structures the visualised image, in such a way as to give a brighter colour to the area which is coincident to the fixing point, as the chromatic characteristics are also understood with higher visual accuracy. Therefore the *sensation of space*, in the moment of the vision of the environment is captured by the co-ordination between the two visual perceptive skills, which also in terms of visual field complete themselves in structural sensitive similarities: *space/light and colour* in co-ordination with *space/configuration and colour.* So, *colour and space* find signs of image structuration, to whose colour is relevant, already in the psycho-physiological behaviour of the visualisation field (Monzéglio 1979).

2.14 The phenomena of the chromatic contrast in the different colours relations

The phenomena of the *chromatic contrast* has been explored and applied by a great number of artists, in their works and studies.

As an example, Fernand Léger (1957), talking about colour in architecture, said: " No colour is absolute. We are in a continuous relativity ".

Maitland Graves (1952), in his book " *Color Fundamentals* ", orders the chromatic contrast in six perceptive principles, which in synthesis are:

1. Light colours enlarge the image dimension; dark colours reduce it.
2. Colours over a ground seem to be darker and vice-versa.
3. Neutral colours acquire an opposite shade to the one of the ground where they are placed.
4. Colours placed over grounds with similar shade, they modify the hue which tends to the ground opposite shade.
5. Colours placed over similar grounds lose chroma; and colours placed over opposite grounds gain chroma.
6. Dark colours placed over a white ground loose chroma; if they are placed over a black ground, they gain chroma; the opposite happens with light colours over the same white and black grounds.

These principles, as a whole, formulated by Graves, define the contrast, according to the modifications in the perception of the physical reality, being the relationship of colour and space influenced:

in the dimension of the images, in the lightness, in the chroma, and in the hue of the shades that compose them.

According to another author, Johanns Itten (1961), in his book " *The Art of Color* ", contrast is interpreted in seven different ways, which are considered essential for the knowledge of the field of arts and of "design".

Types of chromatic contrasts, according to Itten:

1- of hue

2- of light/dark

3- between "hot" and "cold" shades

4- of complementary

5- of simultaneous

6- of chroma

7- of quality (extension) or area

Each one of these seven types of contrast, according to the analyses made by the author, shows the influences in the colour/space language organisation, from the structured perceptive level, to the communicational level, with variations in intensity, in communication contexts, being messages intentions, being individuals' cultural characters, or being factors of the individuals of psychological or social nature.

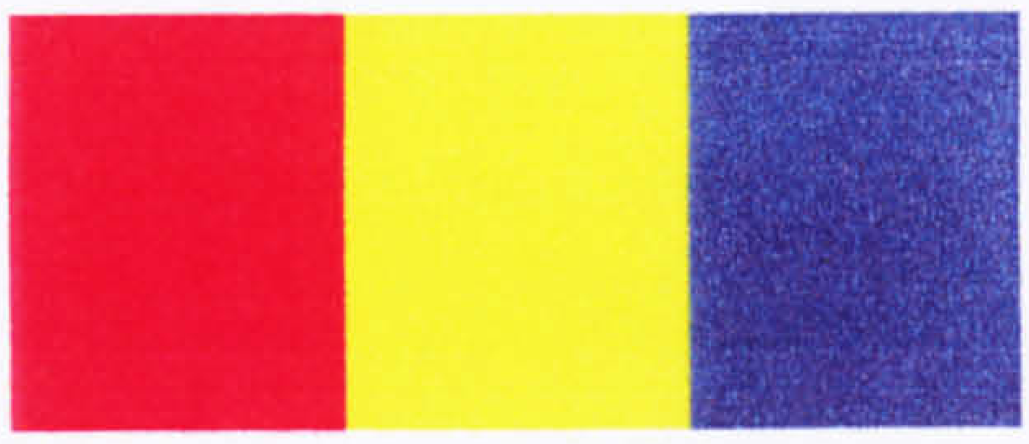


Fig 2.36 Chromatic contrast of hue

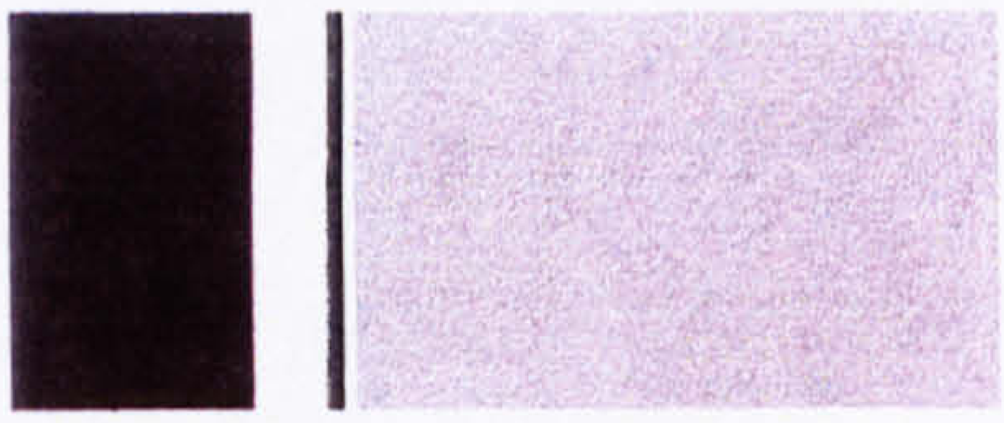


Fig 2.37 Chromatic contrast of light/dark

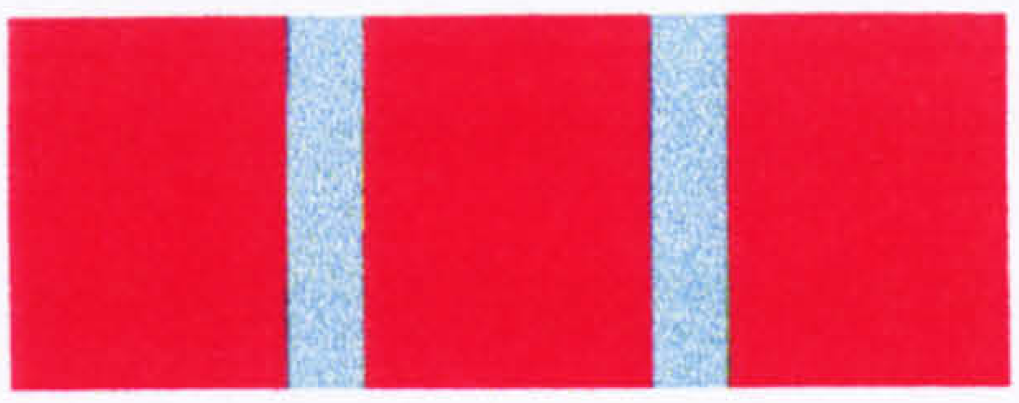


Fig 2.38 Chromatic contrast between "hot" and "cold" shades

Fig 2.39 Chromatic contrast of complementary

Fig 2.40 Chromatic contrast of simultaneous

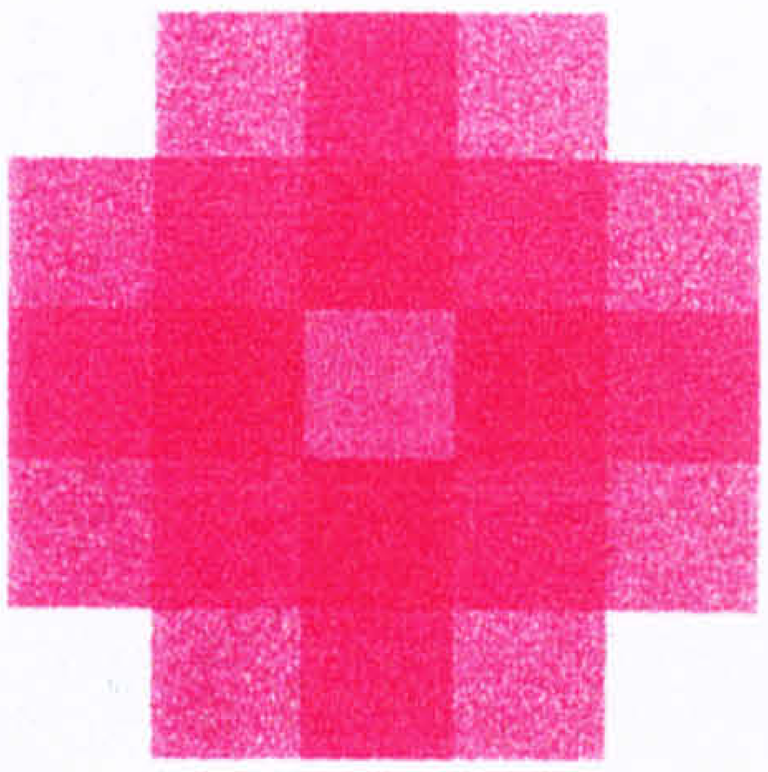


Fig 2.41 Chromatic contrast of chroma

Fig 2.42 Chromatic contrast of quality (extension) or area

It's also important to refer to an author that developed exhaustive studies about the chromatic contrast language, using it as a basis for the study of the arts, and having created didactic principles which, even now, are used by the schools of architecture and "design". The author is Josef Albers (1963), and his study is condensed in the book *" Interaction of Color "*.

The explanation of the importance of the chromatic contrast phenomenon is found in the very psycho-physiological perception of colours.

There are people who find it more psychologic and there are others that find it more physiologic, in the condition of capture of the stimulus by the neurones in the retina and the consequent saturation of the radiations, provoking the perception of the opposite radiations, in the search of an equilibrium of sensations. This criteria was followed by Hering who based his study in his tri-chromatic theory of the perception of the light stimulus: the basic understood shades originate the others, completing the range of the sun spectrum (Monzéglio 1972).

For the visual language problems, what has remained in all these investigations was the understanding of the existence of opposite shades, which, by the *law of contrast*, are opposite but also complete themselves.

Those shades receive the name of complementary colours. In the perceptive organisation order, they mean colours that in their whole have the three fundamentals of the subtractive mixtures and are therefore complementary colours:

- red and green - blue and orange - yellow and violet,

or

using the terminology of the subtractive mixtures:

- "magenta" and green - cyan and orange - yellow and violet.

The notion of complementary colour, already indicated with this terminology, was given by Chevreul in 1839 , before the middle of the XIX century, adopting the phenomenon as a criteria of the colours classification. (Chevreul 1967)
The other authors, scientists and artists, who followed him, applied in one way or another the " Complementary Colour Theory ", even more for the proven fact of the chromatic post-image formation after the fixation of the coloured shades.
By coincidence of the psycho-physiologic explanation, post-image is always of a complementary colour of the one observed.

Chevreul's book *"The Principles of Harmony and Contrast of Colours"* (1967) was outstanding for three main reasons: first it was practical, setting out the uses of colour in every imaginable field from textiles to painting and from architecture to horticulture; second, it dealt sensibly with the subject of colour harmonies; and third, it provided explanations for such peculiarities as optical mixing and simultaneous contrast. Cheveul's explanation that orange sunlight produced violet shadows offered invaluable guidance to the impressionist painters, providing an argument against those who were suspicious of the sensory approach to colour.

The use of colour harmony in painting or the built environment is founded on an understanding of simultaneous and successive contrast and of the phenomena of visual colour mixtures.
In the concept of a relationship between colour and space, the theory of the complementary colour creates the idea of imaginary space possible of being conceived in sequential instants of the image observation, i.e., post-image acting as a continuation of the informative visual stimulus, in opposite values which try to establish an equilibrium of the information itself.

With regard to the contrast problem, analysed in terms of colour and space, it is of relevance to consider the property of the colours producing sensations of depth, differing from one shade to another.

It's evident that the function of bigger or minor existent contrast in the images, are understood, closer or more distant, making the contrast an incidence in any of colour attributes.

In what concerns space/hue, there's a particular illustration. For example, if one looks to an image composed of shades correspondent to very far spectral positions, such as the case of red and blue, one gets sensations of relief, as if the red is superimposed over the blue. The explanation of the phenomenon is given by a relationship between perceptive ability and wavelength of radiations. People know, by physical principle, that for a bigger wavelength people have a minor angle of refraction, and vice-versa. In the case of the eye, the crystal-clear has behaviour of a lens, it refracts the radiations, according to the same basic principle, therefore:

- for the red colour, which possesses a bigger wavelength, there's a minor refraction;
- for the blue colour, which possesses a minor wavelength, there's a bigger refraction.

With the existence of this physical opposition, to have a coincidence between the focal point of the rays that penetrate in the eye and the central point of vision of the retina, the *"fovea"*, it's necessary to accommodate movement of the lens/crystal-clear, so:

- for the red colour, the accommodation movement happens to increase the refraction angle, provoking the sensation of approach of the image;
- for the blue colour, the accommodation movement happens to reduce the refraction angle, provoking the sensation of distance of the image.

The relationship between *Colour and Space*, therefore, in what concerns hue, presents characteristics of extension in depth, which are inherent to the perceptive structure itself, reaffirming once more the concept of colour in terms of visual space.

The colour contrasts issue will be addressed in Chapter 8, when the author, in investigating the hypothesis, will discuss colour planning.

2.15 Summary

Research supports the notion that colour in architecture has the potential to become an integrative element of the project design process.

This chapter has, firstly, defined colour and described the importance of *colour* as *a fundamental component* of the *visual message* and of the *space perception*. It has also showed that it belongs to the light structure.

In this chapter, colour was characterised through its physical, psycho and physiological characteristics in the constitution of the chromatic visual area.

It also addressed the importance of colours contrasts in the analyses of the relevant literature review about colour issues.

CHAPTER 3

SPACE

3.1 Introduction

Space is the second element of structural order in the present study.

As the author wants to prove the existence of a straight relationship between colour and space, and in this particular case of space as an area of colour in the architecture of the city, this chapter will address the subject, focussing the visual space.

3.2 Elements for perceiving space

The *notion of space* is relayed to us via our *sensory channels* which are capable of transmitting information about distances and in them, the relative position, of directional location of dimensions, proximity, volume and formal characters, of variation of light and shade characters.

The dual dimensional perception of *space* is a concept which comes before the tri-dimensional perception, which comes from its contact with nature. It is this ancient, hereditary perception which intervenes in the appreciation of forms that comprises *space* (Loução 1993a).

The sensory *channels* originate from the perceptive organs which receive information, establishing physical and psychological interrelations between ourselves and the environment.

This interrelationary procedure is in accordance with the different sensations people are able to have, and which are dependent on the variety of feelings that one encounters.

In general, one considers sense of space, amongst the other fundamental senses: vision, hearing, touch and smell, because through these senses are channelled information purporting to the nature of spatial perception.

However, this information is not of isolated content, separating each sense, but, on the contrary, there is an interrelation between the various senses.

Although one knows that there are *five essential senses* in all, one has to add one more to the ones already listed as belonging to the spatiality, that of *taste.*

The fusion of these transmitted informations is such that they can no longer be distinguished separately which allows people to group the perceptive sensations, therefore making them understand the capacity of each one.

According to the psychologist Julian E. Hochberg (1965) "there are more than the five traditional senses" and those sensations are given to us by the amalgamation of the main senses, giving a full meaning to the way we perceive the environment.

According to the same author, some other feelings arising from amalgamation can be specified thus:

- "sense of distance"
- "sense of texture"
- "sense of depth".

The first one has an interrelation between vision and hearing. The second, between touch, taste and smell; the third has an interrelation between the other senses, beside the five principal ones originating from the sensation of stability in space and appropriation of the same space, being:

- "sense of balance"
- "senses of the central organs",

corresponding in general to the sensations of position and movement of the muscles and joints.

Consequently, in terms of space, there is a new definition of fundamental senses making up another list composed also of five senses with a more intricate structure, composed senses through the link of simple senses.

In terms of space one can classify the simple senses (as systems receiving information from the environment) in two groups:

- group 1: simple senses which receive information in space far beyond us
- group 2 : simple senses receiving information in space close to us

Edward T. Hall (1966) interpreted this as "distance sense receivers are those which examine distant objects: the eyes, the ear and the nose"; and the "immediate receivers are the ones which perceive the closer world, in other words touch, the sensations we receive through the skin, the membranes and the muscles".

However, if on one hand there is the sensation of touch which gives people the feeling of hot or cold, on the other hand there is that which tells anyone about the contact people can have with objects (directly or indirectly), things and from our environment, whether they be of an organic or inorganic nature.

In this case there is a sensation of space followed by a notion of what people can do with it. By touching an object one can feel its volume, form, dimension, and have an idea of its size and the geometric qualities of its components and are also aware of its surface, if it is crumpled or smooth in texture, or not.
The confirmation is given by the interrelation with the sight which receives these stimulations in accordance to the space which is transmitted by the physical phenomenon of light.

Sight and touch are therefore two of the perceptive senses which are closely connected, complementing each other in order to define the structural quality of the objects, things or events in the environment.

Judging by the research and interpretations of various authors, such as those mentioned in this chapter, the author finds different ways of *defining space* and different groups of sensations, creating different systems of perception.

The common point which has been proven is the capacity for the five basic senses to be extended to include various possible combinations of them, or by psycho-physical reactions to which they are subject, meaning the perception answers given by the central organs of the nervous system; for instance the sense of balance or the sense of position and movement of our muscles or of our joints.

What interests this research the most is the *sensation* and the *visual perception of space*, taking into consideration the kind of *communication* it allows people to have, i.e., the *visual*.

Colour is a component of *Space* because:

- It is a property of the substance, which forms it.
- It is an attribute of the light, which makes it visible.
- It is inherent to the observer thus making him sensitive.

These three factors determine the dynamics of *colour* because they are global and simultaneous at the same time; the knowledge of the speciality implied in the chromatic phenomenon is not able to do more than recognise the limits of uncertainty in its comprehension; never to determine the pattern or pre-define the results (Loução 1993b).

Colour is a derived component of *Space*, because it is the consequence of the *interaction* between the *light, substance* and the *observer* (Loução 1993b).

It is therefore interesting to look for the relationships that other senses may maintain which are directly connected with sight in the context of perceiving space.

To find these relations one has to go through various stages, each stage determining the specific values of the performance of senses and their interaction.

One can consider three stages of procedure(s):

1. In the first instance, one considers the simple senses which bring people the sensation of space, and the possible relations of mixture which originates the compound senses that complete in the structural order the understanding of a certain type of space. Being the *searched interaction* between *man and environment*, that which one makes through *visual communication*, the type of *objective space* is the one possible to be defined as *visual space*.

2. Secondly, one considers the psycho - physiological reactions which correspond to the *sensation of space visually perceived*, determining the orders of relationship with one's own being, i.e., a person's body and what that body can physically and perceptively reach.

3. Thirdly, one considers the feelings and the groups of feelings, which correspond to the reception of information distant or close to people in space.

The author hereby defines three groups of considerations, whose study leads him to certain conclusions, in each one of the kinds.

3.2.1 Perception of visual space: simple senses and complex senses

3.2.1.1 The simple senses

Considering the simple senses, we can find the following incidences in order of importance:

- direct incidences :

  1st - one only sense, sight

- indirect incidences, mediate to judgement of complex senses:

  2nd - the sense of touch

  3rd - the sense of hearing

  4th - the sense of smell

- indirect incidences, distant in the judgement of the complex senses:

  5th- the sense of taste.

Regarding the various senses (except taste which doesn't relate to the author's referred space - space/area of colour), the relationships are more evident in a descendent sequence of affinity with the space which has been visually perceived, going from the tangible to the contents of resonant distances and waves, to the contents of awareness of things, and of beings or events, by smell.

Logically, with regard to *visual space*, sight is the real sense to be considered by structural, natural and inborn affinity, and to which all the other sensations and perceptions will be related to.

To complement the last rationalisation regarding the simple sense of sight, two theories are transcribed on the study of space by two different authors from different periods and schools of thought. The first, and most recent, is by an anthropologist, and the second, from the renaissance era, is by an artist and scientist.

"The sight was the last sense to be developed and it is in reality the most complex. Lots of data is transferred to the nervous system through the eyes with better quality than is done by touch and hearing.

The information a blind person receives from outside remains limited in a circle between seven to thirty metres. A normal person can see until the stars"... "It is normal to consider the eyes as the main way through which man receives information" (Hall 1966).

Leonardo Da Vinci wrote: "The sight through which the beauty of the universe is revealed to our contemplation is so excellent that whoever lost it would be deprived of knowledge of all fine pieces of nature, of which sight makes the soul happy inside the prison of the body and all thanks to the eyes that present the infinite variety of creation; those who lost them abandon the soul in a dark prison where all hope of seeing the sun, light and universe is lost forever.
Those to whom the darkness of night is so heavy however brief, what would they do if this darkness would remain the same throughout their lives? Who wouldn't prefer to lose their hearing and smell rather than lose their sight? With hearing one would lose the sciences transmitted by words, however not the vision of the beauty of the world that shines on the surface of the casual or natural bodies and it is reflected on the human eye" (Da Vinci 1944).

3.2.1.2 The compound senses

Concerning the compound senses, the combined sensations together with sight, of a sensation kind and following the order of analysed incidence in the simple senses, form the following compositions:

- a combination between sight and the sense of touch.

  1st) - compound sense - *vision / touch*
- a combination between sight and the sense of hearing.

  2nd) - compound sense - *vision / hearing*
- a combination of sight and the sense of smell

  3rd) - compound sense - *vision / smell*

The author doesn't consider the indirect and distant incidence in the formation of a compound sense, because it doesn't define the values with straight connections with the visual space, as has already been demonstrated above.

Regarding the first compound sense, one sees an object in space and has an idea of its shape and one understands exactly the quality of its substance by touching it.

Regarding the second compound sense, one visualises the distance between oneself and an object of which one already knows its resonant characteristic. The composition between the two senses of sight and hearing sensations give people an accurate idea of its distance.

Regarding the third compound sense, the smell of certain vegetation identifies precisely the existence of the space that surrounds people, as one recognises with more precision its structural formal characteristics in combination with the sight (Monzéglio 1997).

3.3 The vision of space and its relationship with us

- Relation of visual equilibrium

  1a) - extension of visual sense, giving one the notion of the stable condition of a body in the space where it is situated.

- Relation of visual position

  2a) - extension of visual sense, giving one a notion of localisation of one's body in space and of the function of other bodies, both organic and inorganic.

- Relation of visual movement

  3a) - extension of visual sense, giving one an idea of the articulation that one's body can keep with the space where it is situated and according to the position and the equilibrium which belong to them.

People are human beings and they belong to an environmental structure in its organic form and they are situated in it obeying its inorganic laws (forces and substances, such as gravity and earth and air). The structural affinity necessary to the live equilibrium between organic and inorganic, in this case consubstantiates itself in correspondence between forces and substances of the surrounding world, and forces and sensations of their interior world (perceptive organs of the central nervous system).

As a result, one has three relationships, making possible three kinds of extension of people's visual sense.

3.4 Relationships of close and distant perceptions: the compound senses

- Compound senses for perception of information distant from us in the visual space

  1a) - reception at distance by compound sense 1 - sight / touch

  2a) - reception at distance by compound sense 2 - sight / hearing

  3a) - reception at distance by compound sense 3 - sight / smell

- Compound senses for reception of information close to us in visual space

  1a) - and the only existent reception of information close to us by compound sense 1 - sight / touch

- Compound senses for reception of information close and distant to us in the visual space

  1a) - and the only existent dual reception, distant or close, by the compound sense 1 - sight / touch.

Touch, being the sensation which the skin experiences, being where the peripheral nervous terminals are located to pick up this sensation, is considered the sense of reception at a distance when it picks up stimulus from distant sources, such as those of thermion sensation, such as hot and cold (e.g., the heat transmitted by the sun). Yet this same sense is considered as a sense of close reception, because it is through the skin that this reception is experienced. Therefore it has a double function and the capacity of reception of those two types of stimuli.

Sight, in its capacity to perceive the space via stimuli emanating from the energy of light, as they realise themselves in geometrical qualities of objects, or in chromatic quality of light and colour, also has, like the sense of touch, a double function and capacity to receive distant or close information:

- distant, visualisation of bodies or objects by reflected light - (distant stimulus of reception).
- close, the sight of light and colour, radiation of energy-light which constitutes one of the two different qualities of visualising the space - (stimulus close to the perception).

Judging the capacity of reception of stimulus and information, by order of longer to closer distances, thus reaching the closest absolute one, which is direct by touch with the sensorial receptive organs, constitutes the group of senses which, set together with sight, define such perceptive capacities.

Three types of reception via compound senses with sight result from this judgement, one of them being the result between the other two.

The study of the relationship of sight with other senses, and other psycho-physiologic consequences related to the perception of space, demonstrates the possibility to order the scheme of reasoning according to triadic development formations (Kolb 1980).

These formations develop themselves inside a structure which comprises organisations of a more comprehensive nature and in which others are less well embraced.

The structure, connected to the process of intervention and performance of constituent elements, originates a system possible to be defined in operation according to a series of trilogies dependent amongst each other on its own order.

3.4.1 Summary of the basic sequence of formation of the system

3.4.1.1 The system in the order of higher comprehension:

Triad 1

1.1 – senses of space – *simple and composed*
1.2 – interdependency – *space/environment and space/object*
1.3 – spatial interrelation – *reception/ close and distant*

3.4.1.2 Systems in order of lesser comprehension:

Triad 2

2.1
simple sense/direct incidence
simple sense/indirect incidences
simple sense/far incidence

2.2
composed sense - sight/touch
composed sense - sight/hearing
composed sense - sight/smell

triad 3

space – *sensation/equilibrium*
space – *sensation/position*
space – *sensation/movement*

triad 4

senses – *reception/distant*
senses – *reception/near*
senses – *reception/**mixed** (distant/near)*

3.5 The visual space:

Predominance of the visual aspect in the perception of space

Despite the sensations composed by links with other senses and particularising the space in its characteristics of visual perception, a type of relationship between man and environment is created which, by predominance of those characters, is defined as visual space.

In presenting this kind of environmental relationship as a prevailing role in the perceptive - communicative process, with considerable predominance by the other perceptions and as the object of our study is space as an area of colour, being a component of the structure of light and, therefore, constituting a real visual stimulus, it is necessary to consider some data related to the vision of space.

"The experience of seeing is at the same time a spatial experience" (Mulvey 1969).

The *vision of space* is based on aspects of the relationship between man and the environment and consequently is of a physico-psychophysiologic complex nature.

"Architectural space is subjected to a whole series of perceptual overlays: day-night and seasonal cycles which cause it to be illuminated altemated by light from the sun, by its reflected light from the moon, and by artificial light sources - the degree of lightness or darkness influencing our perception of spaciousness" (Porter 1997).

According to James J. Gibson (1950), the perception of the visual space is based on the performance of functions of that nature, which determine conditions "to be able to see", therefore: it must have light, the eyes ought to be well open, the eyes must focus, the sensible eye membrane (the retina) must react to light, the optical nerve must transmit to the brain.

If one of those conditions is interrupted one becomes blind. But sight, according to this author, enables people to understand and act in accordance with the visualised things, among others: to combine colours, to create representations for things, to draw, to build environments and so many others, including also the action of contemplation.

Quoting his words, "to gaze upon the scenery is the most wonderful action of vision, because the sight we have of a house or landscape, when somebody observes it with a receptive mind, it has a great range, and at the same time it contains the smallest of details and each detail concerns a nervous process" (Gibson 1950).

3.6 The action of seeing space

The visual space particularised in its *geometric qualities (position, size, etc.)* in general can be seen in two main ways: the one of being a finite void, where other visual spaces can be situated (the involving space); or the one of being a void between existing configurations (spaces known as involved ones).

For Rudolf Arnheim (1971), the space "is experienced like a gift which precedes the objects in it, as the mean in which all things have their places".

Trying to answer the question - *"what is space?"* - he defines it as a "conception of an entity which contains itself, finite or infinite, like an empty vehicle prepared and with the capacity to be filled with things".
And in interpreting a text of Prado (1961), he defines it as "the enclosed space of all creation and in a way it is visible and sensible", or "a non-existence like an entity in the external world, like the objects it can contain and, in the absence of those objects, the space would continue its existence as an empty and unlimited receptacle".

"Our visual image of the real world embodies a complex pattern of perceptual patches; shapes that each have a colour and a tone, and that, apart from responding to the intensity and direction of the light source, each communicate textural attributes describing surface quality which, in turn, describe differently sized planes and shapes that, using different levels of brightness, pinpoint different locations in the illusion of space" (Porter 1997).

People see space when they are in front of scenery and they can feel like an object that tries to set itself in it. It can transmit to them an image of nature and the natural events are many of the characteristics amongst which the space shares its vacuous involving forms and colours. Nevertheless, people's presence, like a new object that takes possession of the scenery, makes people feel a visual emptiness, having the need of other objects which can dynamise and fill the intersected spaces, that are configurated in visual boundaries which may be closer to their reach. For example, scenery without houses or buildings can be seen as a finite void, where other visual spaces can be located. In another way, the houses and other buildings which have been located in the scenery represent the break of only one void, reducing its own size and subdividing it in to smaller ones, which condition the movement of people's view from one to the other, defining forms and identifying colours, locating so many objects, that organise the environment, trying to condition it to their visual experience.

In the same way, people judge the finite visual void, before an enclosed space, an empty room, and they visualise the possible intersected spaces in which they would like to be able to be organised: an interaction of wholes and voids, visible and sensible, suitable to their visual ambience.

For the visual space one would deduct the visual void and the visual whole, contrast which in the structural order is reduced to the geometrical qualities of the space perception. The first one is *the finite configuration which contains it*, and is therefore, judged in higher amplitude. The second one is the *finite contained configuration*, and, therefore, judged in lesser amplitude, and occupying a *place* in the one of bigger amplitude.

From the relationship between the *finite configuration* which contains it and the *finite contained configuration*, is derived another relationship, which is established between other *finite contained configurations* that can come up in other areas of the *bigger finite configuration*. This second relationship is the introduction of a third level of structural identification of space: the subdivision of *finite configuration which contains*, in a reduced scale, the beginnings of a system to which a process of continuity can be determined, with even smaller reductions.

3.7 Proprieties of the receiver in the perception of visual space

Considering the nature of the phenomena which are part of the perception of visual space and the correspondence between them; considering the nature of the stimulus which produce the sensation of visual space, and considering the basic aspects of structural order which allows the identification of visual space, the proprieties of the receiver will be analysed, in the data thought as necessary and sufficient to lead the study through the relations between *geometrical qualities* and *space / brightness* and *colour*, as structural bases in the communication languages.

One has to consider the following proprieties of the receiver:

- conditions of picking up and selection of stimulus
- limits of perception and boundaries of differentiation
- visual field and structuring of images
- field organisation, in the structural relations of figure - found.

3.8 Conditions of picking up and selecting visual stimuli of spatial nature

To have a visual understanding it is necessary that the stimulus sent from the environment would find favourable conditions for its reception. These conditions refer to the adaptation of the physical aspects and the existence of the ability to understand it, judge it, and give the corresponding reply in order to complete the balance of the perceptive act.

Considering the perceptive act, if people select the stimulus in accordance with the physico-physiological capacity for them to be able to see, people select them also in accordance to the capacity of the intellect to decide between *what one wants* and *what one doesn't want* to apprehend.

Quoting an example, based on common environmental city experience, when one passes a street or a square, from all the stimulus that reach him from different visual configurations, many of them are not recorded or kept in his memory because they are just simple sensations of something that exists, that feels the void, but nothing more than that. However, there are others which are apprehended, understood, and influence people's behaviour culminating in a reply which is not only the direct understanding of what was transmitted but what remains and expands itself, making people have certain reactions (Birren 1978).

One has to define what determines the capacity to select the events and things *one wants to see* coming from the complexity of environmental stimuli that reach him. Firstly it is important to define the meaning of the expression "*one wants to see*". The search for the reciprocation between people and the environment, which in visual perceptive terms is one of the necessities of people's life, be it personal or social, makes people want to see so that they visually know what exists, and from what exists they are able to understand what has adequate meaning to justify this visual action.
The understanding of visual meaning is a result of continuous and permanent learning which is obtained via an adequate sensorial capacity. So it stretches, increases and organises itself progressively giving form to the knowledge people can have of existence. Therefore, the visual interchange between people and the environment is not only based in the condition of *being able* to see, but also of *wanting* to see (Monzéglio 1978).

3.9 The visual boundaries of perception and threshold of spatial differentiation

Comprehending a complex structure which conjugates the physical, physiological and psychological natures, the power of seeing and wanting to see make people think about the conditions through which the stimuli are transmitted from the environment, therefore in direct relation with the visual configurations where they derive from.

Considering the restrictive visual sensorial understanding, the considerations fall back on the following judgements:

. the limited capacities of apprehension of stimuli, and

. capacities of differentiation between stimuli.

Conjugating the inorganic and organic structures, which intervene in the perceptive act, the physical stimuli are perceptive, by the physiologic nature of the receiving organs, inside a determined strip of values, which defines the *sensorial boundaries.*

Inside this strip we can perceive intermediate values among the sensorial boundaries and in a quantity which depend upon minimum perceptive difference between two stimuli, meaning, a minimum perceptive variation called the differential sensorial threshold.

According to the interpretation given by Abraham Moles (1971) on the studies dedicated to the message and its elements, boundaries and differential threshold are defined in the following way:

1 - Below a certain limit of physical excitement the receiver becomes insensitive: it is the threshold of sensibility.

2 - Above a certain limit of physical excitement, the receiving system is saturated: it is the threshold of saturation, and it doesn't understand anymore the variations of that excitement, being, therefore, considered without a specific answer.

3 - In order that the receiving organism understands the progressive development in the excitement it is important to go beyond a certain value called *differential threshold*; therefore the sensation is qualified between the *sensibility threshold* and the *saturation* one, by means of differential thresholds; concerning any changeable physical excitement, there is a finite number of perceptive elements from which the psycho-physiology prepares a repertoire.

Trying to interpret the boundaries and perceptive thresholds, together with the generic aspects of structural order of space voids and wholes, already analysed by system form of basic geometrical qualities of space, one could give them the following meanings:

- Considering the *finite and involving configuration in higher order*, as being the maximum extension in perceptive dimensions of geometrical space, it would be defined as *saturation threshold*, because above this limit there wouldn't be specific answers to perception.

- Considering the *finite involving configuration in lesser order*, as being the minimum extension in perceptive dimensions of geometrical space, it would be defined as *sensibility threshold*, because below this limit the perception would become insensible.

- Considering the *finite involved configuration*, as being an extension of perceptive dimensions of geometrical space and, being located in it, in the dependency on the number of ages and possible dimensional variations, it would be defined as *differential threshold*; it would be qualified between the first two thresholds, originating the differentiated perception, in the judgement between geometrical visual values of space.

As a first result of the explanation given before, one would have the following relationship:

- *visual space / geometrical qualities* -

saturation threshold	[Finite configuration which contains in the *bigger order*]	bigger void
sensibility threshold	[Finite configuration which contains in the *lesser order*]	less void
differential threshold	[Contained finite configuration variable in dimension and number]	wholes

Establishing the basic system in the order of relationships between the involving and involved spaces, they would acquire in the function of boundaries and thresholds, the following meanings:

- Considering the first relationship which establishes connections between space and *finite involving configuration in a higher order* and that one *of finite involved configuration*, therefore, connections between the *threshold of saturation* and the *differential threshold*, it would be a relationship of dimensional order, closer to involving spaces and involved ones, comprising a minimum number of these; so for a minimum dimensional difference between both , the minimum number of involved spaces would be of one. There is an attribution of a minimum differential threshold which results in minimum variation between the saturation threshold and the spatial dimension which would succeed it.

- Considering the second relationship which establishes connections between space of finite involved configuration and that of finite involving configurations in lesser order, consequently connections between differential threshold and sensibility threshold, it would be a relationship, which in a number of involved spaces would determine the possible dimensional variation between them. Due to this relationship people reach the conclusion by the attribution of differential threshold and inside the sensibility threshold, but not going beyond it.

- Considering the stated system of first to second relationships, a new relationship is established by which, in the dependency of behaviour in a certain moment of the processed system, the involved space can become involving, in a new higher order adapted to a moment of perception and all the thresholds (of saturation, sensibility and differential) will have relative values but not absolute ones. This means that, in the dependency of the considered field for visualisation, the absolute values will get new dimensions (Monzéglio 1979).

3.10 Visual field and construction of images

People's visual perception is structured in a way to determine till where the extensions and dimensions of the physical field (which acts as sensorial stimulus) can be visualised. This limitation of visual extent is defined by a perimeter with which a contained area constitutes the sensible *visual-field.*

The *visual-field* area is determined by structural characters, anatomical and functional, physiological of organs and perceptive visual system.

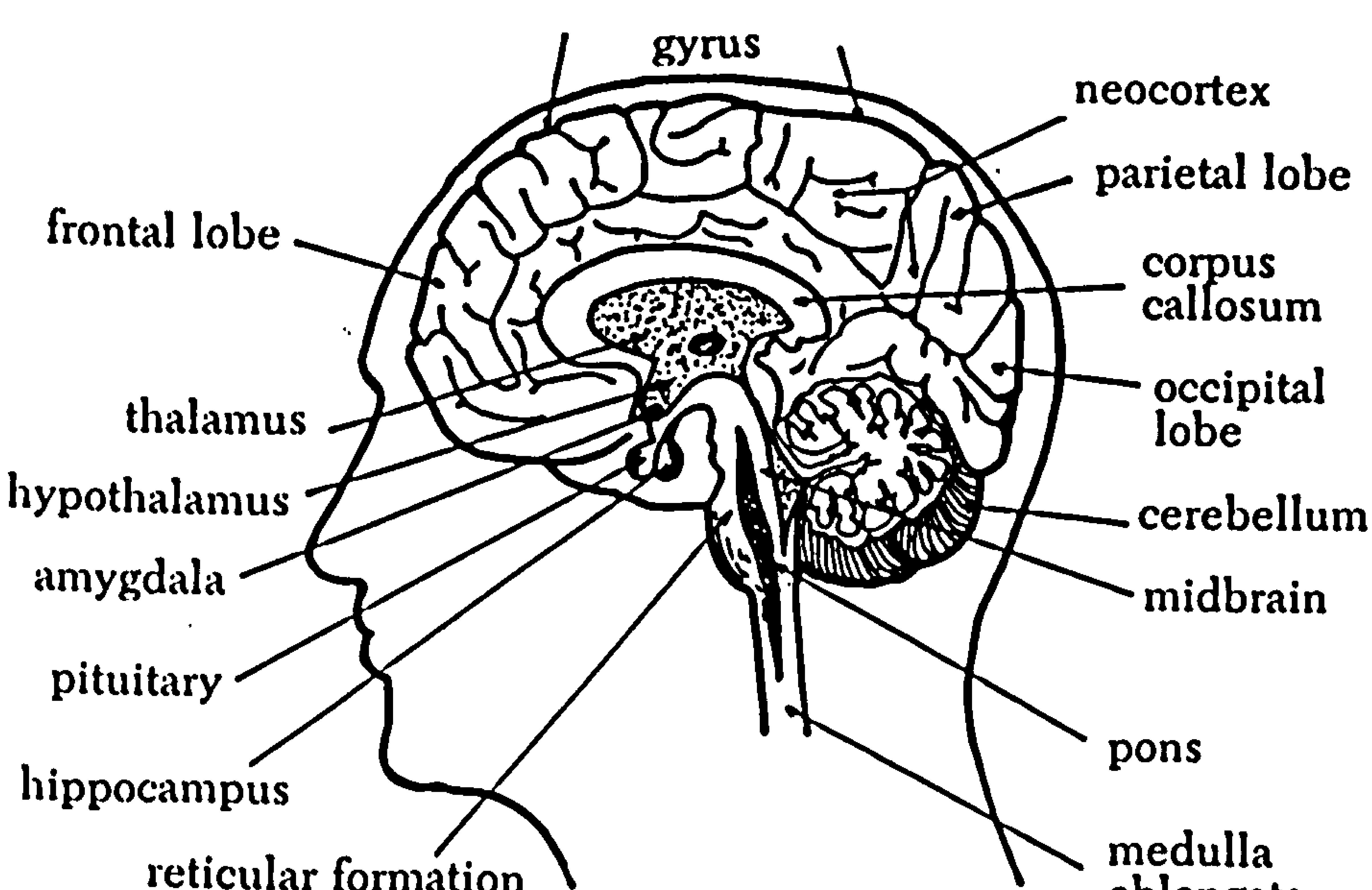


Fig 3.1 Schematic drawing of side view of the human brain (Mahnke 1993)

The anatomical composition of the eyeball allows it to receive physical stimulus which are projected against the retina, being sensibilised by the neurones which compose it, known as cones, rods and nervous cells of connection. The distribution in the retina of cones and rods is diversified. The central point which receives and focus the luminosity it is called fovea, the middle of the retina spot, and it is constituted only by cones. Progressing from the central point to the outer surface, the cones decrease in number while the rods increase their number. Cones are the neurones responsible for sensation and perception of chromatic radiations, while the rods are sensible only to the variation of luminosity. The central point which is the one that brings into focus the light beams, structures the sight of the projected image to its minimum detail, while the other outside areas structure the sight of image in accordance to general sensations, gradually losing all details. Besides, the sight of the converged image in the central point is also more complete in the chromatic sensation of hues or spectral positions of light, while the projected images to the peripheral areas gradually lose this sensation, prevailing only the variation of light (light and dark).

The receipt of stimulus-light is co-ordinated by the stimulated visual field so that complete perception is given by the central point called *visualised image point of fixation*. So, the stimulus directed to it prevails for the apprehension and perception, while the stimulus which reach the periphery region remain secondaries, terciaries and so forth, in a decreasing order, and as they direct themselves to the periphery of the retina. Around the fixation point of image consecutive and concentric areas of sensibilisation points are formed which, by comparative action between the *more visible* and the *less visible*, contribute to the sensation of space: extension, dimension, position, situation and locality of this image in its whole, in the visual field with which it structures itself.

In terms of visual field, in the structural perceptive order, the first judgement of space is given by the comprehension between the more visible and the less visible.

The visual field, in its totality, brings together a great number of stimuli. The stimulus of greater excitement at the moment of visualisation defines the image point of fixation. However, the necessity to know other points, which comprise the image, and at this first moment are less visible by the fact that they are in the peripheral area, makes a continuous renewal point of fixation. This renewal forms displacements in the direction of the look, in order to create a dynamic structure which constructs itself according to the capacity of excitement of each stimulus.

The point of fixation varies and this variation, judged in the physico-psycho-physiological conjugation (between organic and inorganic), depends on two main factors: the physical peculiarity of the stimulus being stronger or weaker in excitement, and the particularity of the receiver to perceive and select stimuli which he *can receive* and which he *wants to receive.*

So, there is a second judgement of space, which is given by structural order, intrinsic to the visual field and defined according to the importance of physical stimulus and the perceptive interest of the receiver. The displacements of points of fixation going through the image, give comprehension of geometrical relations of space.

A third judgement of space, which is given by the sum of visual possibilities of the optical field, exists in all modes that conjugate the ocular capacities and those of motor coordination linked to them, determining the appropriation of visual environmental space (González 1990).

Taking part of this study the visual communication, there is another type of visual field to analyse which is part of the structural order in communicative terms: the visual field structured by memory:

- it belongs to the combination of present field visualisation with past ones, direct, indirect, far off, enlarging the visual dimension, the apprehension of the existent, relating it to what existed before or still exists.

There are three fundamental aspects in all to have in consideration for the perception of space, in the structural order of visual field, four individual characteristics are considered, being three of them directly tied to the psycho-physiological structure of sight and, the fourth representing the complementary psychological condition, because it is not in respect the image stimulus - present, but only to image stimulus - memory of the past.

By the formation of a system with the following trilogy in the conception of visual field and structuring of images, we conclude the following:

1 - Notion of space, in accordance to the more visible and the less visible:
- visual acuity -
- point of image fixation -
- peripherical points of image sensation -

2 - Notion of space, in function of the more visible to the less visible:
- qualities of physical stimulus: with less or more excitement
- qualities of the receiver: with bigger or less interest in the perception

3 - Notion of space, in accordance with the perimeter extension of the visual field
3.1 - monocular visual field
3.2 - binocular visual field
3.3 - combined visual field with the ocular motor and body motor capacity - complementary field to 3.1, 3.2 and 3.3 - of the visual memory (Otto 1979).

3.11 The organisation of the visual field in the structural relationship figure-ground.

To study the organisation of the field of vision in the structural relations of figure-ground, it is necessary to introduce the notion of processing of special perception of depth and relief, from the capacity to receive stimuli and, conjugating with the projection area of visual field.

The spatial perception of relief and depth in the field is given according to the complex system of relations between receiving organs and conductors of physical stimuli and, the organs of the central nervous system, the *visual projection area in the brain*.

The physiological-psychological correspondence is based on the biological sense of experience in space. By the physiological capacity *one feels* space and, by the psychological *one judges* space (Thompson 1995).

a) - Locality and direction: there is a dependence of motor organs of the eye and head for the direction of a seen object, in function of a strong stimulus, which permits the calling of visual attention and produces combined movements.

b) - Locality and depth: there is a participation of the phenomenon of crystalline adjustment (eye lens) which, modifying its curvature to different distances of fixation, influences the sensation of depth. The binocular vision plays an essential role in the perception of depth by the conjugation of monocular fixation points and the ocular movements which allow the fixation of close and distant points. In the first case we have the simultaneous perception phenomena and the fusion of images, and in the second one we have the phenomenon of adaptation / convergence and of adaptation / divergence.

Relief: For this type of perception it isn't particularly considered only one point of the visualised object, as the point of image fixation, but it is considered the continuity of points forming surfaces and volumes.

In this case of the relief, the images, from one eye to the other in the binocular vision, are partially different due to the anatomic distance of both eyes, provoking

different projections of the visualised image. This binocular inequality gives the sensation of relief, and the procedure of a perceptive act of space presents the following characteristics:
Analysing according to the visual fields of each eye, the retina temporal areas are connected by the conductor nervous system, on the same side of the brain. On the opposite, the nasal areas are connected to opposite sides of the brain. Therefore, the temporal area of each retina transfer the received image stimuli according to determined conductor route, while the nasal areas transfer them through another conductor route. The result is that an image, which is on the right, reaches the left side of the brain and, the one on the left reaches the right side. Finally one proceeds to the association of the transferred visual images according to the phenomenon of visual fusion (Moles 1972).

The essential condition for the sight of depth and relief is binocular vision. The other aspects mentioned before, like the reception and selection of stimuli and the structure of visual field, can also be considered as monocular vision, not only binocular, which doesn't happen with the last analysed example of vision.

Being the relief and depth attributes of binocular vision, the visual association which happens in the brain is done in three different ways:

- Association of images by simultaneous perception - capacity to understand at the same time two images, which have been projected separately, one on each eye.
- Association of images by blending - capacity to understand in one image the two images projected separately on each eye.
- Association of images by stereoscopic vision - capacity to understand relief in the image conjugated and projected on each eye, with binocular disparity.

There is a renewal of the tripartite concept also in the phenomenon of visual association.

3.12 Visual space and theories of perception

The image of visual space on the different types of knowledge has been the subject of study and research. Some theories have arisen from it, which tried to define the phenomenon of perception as an organised whole and co-ordinated among its components (Küller 1976).

Next, a summary of various theories is presented, which was compiled in order to give a general idea of various tendencies. The criteria of choice for certain theories obeyed some interests in the present study, therefore relating the knowledge of visual language, combining colour, space and visual communication.

3.12.1 Associationists theories (structuralist point of view).

They belong to the tendency of defining perception as an association with visual values, therefore, deriving from structuralist thought, for whom these values combine themselves to constitute a perceptive one. There are laws or associationist principles.

Law of contiguity:

- two representations which are simultaneous or directly successives, remain associated and, being so, if one realises itself the following one tends to produce itself.

  examples : - idea of an object and its use
  - idea of the thing and the name or sign
  - idea of the signified thing.

Law of similarity :

- if two representations are similar, one tends to reproduce the other -

  example : - the things that are similar by shape, colour, substance,structure, function, origin, value, etc.

Law of contrast:

- one thing can imply its opposite as well as its similarity -

    example : - white makes people think of black:

    - big makes people thing of small.

From the conjugation of these laws, one has the following results:

- the contrast redounds on a similarity, meaning, two opposites are similar to each other when they belong to the same class inside which they oppose each other.

    examples : - white and black are *colours*;

    - big and small are *sizes*.

- *similarity gets close to contiguity if it exists as a common element*, therefore two things are similar to each other by function.

    example : - the object and its use.

This theory, in the sense of formation of the visual whole, tends to have the coalition of elements by proximity in the perception, in a limited sense, without any consideration for the content.

3.12.2 Globalist theories

Gestalt is the principal of these theories, adopting a *principle of perception as an organised whole.*

The scientists Max Wertheimer, Kark Koffka and Wolffgang Koehler were the ones who introduced it in 1920, proceeding the predominancy of the theory in the study of perception during the following two decades.

The general principles maintained by this theory are:

- perception is a whole whose parts belong to the unit; it is not a whole as a sum of all parts;

- there is an interdependency and organisation among the parts. A whole is perceived as an organism and there is an order in it: on a certain time and with a particular function.

Giving the same sense to the *visual field*, the following is concluded: the parts combine with each other to form the field and they possess an order and a structure which organise it; the components of the field are interdependent in shape and meaning, in the sense of individual functions, always combined for the whole. Due to this theory, the characteristics of the field elements are based in phenomenologic method, and can be defined as:

- having form
- having stability
- having perseverance
- having movement.

Analysing these characteristics, people see that the elements defined by them as essentials to the visual world are comprised in the formation of the visual whole so, colour - space - visual communication fill up, in the structural order, the mentioned characteristics the necessary interdependency which combines the parts in the visual unity, the *organised whole*.

In the order of interdependency of the field, the elements organise themselves in the perception, in accordance to other principles derived from two fundamental ones:

- there is a tendency for the perceptual organisation to acquire the biggest and possible regularity and, the biggest possible simplicity: it is the principle known as *pregnancy of form*.

  example - the bigger regularity promotes order in the system, in which the structuring points and process must be the most simple of all perception ; consequently, the system allows the visualisation of the form against its ground - field of combined elements;

- there is segregation of units according to the conditions of form-ground in the field, which is identified in the following types :
- segregation by *proximity* - tendency to visualise as a whole the elements which are closer to one another, giving less possibilities to the distant ones; this way complex units are formed, made up by groups of elements put together through physical proximity; these units become new elements, creating new visual conjugations in accordance to the existent proximity;

- segregation by *similarity* - tendency to visualise in the whole the elements which are similar in form, having less possibilities to the different ones; complex units are formed to which other complex ones with similar visual conditions can be conjugated;

- segregation by *continuity* - tendency for the proximate and similar elements to obey an order of sequence in the visualisation giving a natural visual follow up, resulting in a conjugation of them all in a visual unit;

- segregation by *closing up* - tendency to define structural order, by way of visual continuity, closing the form in a circuit ; there is the creation of units specified by a formal quality defined within the biggest possible regularity and simplicity ; it results in closure of basic geometric forms ordered in plane and space - from the point to the line, to the triangle, to the square, the rectangle, and so forth, to the tetrahedron, hexahedron, to the prism of various basis, etc.

The principles of this theory guide the perception in the formation of the visual whole in the structural order, making it possible to enlarge its sense for a more complex order, comprising visual meanings. (Hubel 1988)

3.12.3 Theories of gradient, or textures

One considers the perception of distances in accordance to textures of the visualised field, acting as potential stimuli of space perception.

James J. Gibson (1950) is the principal follower of this theory, describing *textures* as *gradients* and defining them as being the proportion in which a propriety measured in the field varies in accordance to the continuous and extended stimulus. According to this theory, if one looks at a surface :

- if it presents a uniformed texture without a variation of stimulus, the *gradient is zero*;
- if it presents a variation in the texture in density, which changes its gradual scale, from the closer one to the most distant one, there are different degrees in the *gradients*.

  example: the visualisation of a land full of stones; the variation of density is perceived depending on the distance from which it is observed; the bigger the distance the higher the density of gradient; the lesser the distance, the lower the density.

Edward T. Hall (1966), in his book *"The Hidden Dimension"*, says that the theory of *textural gradients* has the following interpretative base:

- perception of space is conditioned by the existence of the ground seen as a continuous surface;
- space perception is conditioned to visual memory, having in consideration the acquired experience and defended by a conceptual tendency of psychology;
- space perception is given in thirteen different variations for the vision of panoramic perspective.

These variations which correspond to the sensorial impressions, are analysed as being the example of what happens when different types of sounds are related to the linguistic vowels and consonants, constituting basic categories in which people can find other variations more particularised and specifics to the sight experience. This theory limits itself to the analysis and comprehension of permanent information from the present visual field, having taken into consideration what the author calls *"variations of stimuli"*; the *components of textures* as essential aspect to the *spatial structure* in order to have a necessary and *effective information of depth and distance.*

Considering the basic categories recommended by Hall and the thirteen possible variations in the experience of visual perspective, there is the following summary:

- Basic category of *"perspective of location"*:

    1 - perspective given by the texture
    (density of "grains" on the surface)
    2 - perspective given by the size
    (close objects - bigger; distant ones - smaller)
    3 - linear perspective
    (the one applied to design with geometrical bases)

- Basic category of *"perspectives of parallax"*:

    4 - binocular perspective
    (stereoscopic vision)
    5 - dynamic perspective
    (sensation of movement between the observer and object, relations)

- Basic category of *"independent perspectives of position, or movement of observer"*:

    6 - aerial perspective
    (the atmosphere as influencing the vision of close or distant objects - misty day - clear day, etc.)

7 - out of focus perspective

(clear and dim, the example of photographic focus).

8 - perspective and point of observation

(vision of the horizon and sensation of unreal heights, giving the illusion of the objects being at the same level as our eyes)

9 - perspective by change of spacing

(close small objects seem to have the same size as bigger ones, but at a distance)

10 - perspective of convergence adaptation in the binocular vision

(fixing a close object, the distant image appears to have been doubled and vice-versa, fixing a distant object it is the closer image that appears to be doubled)

11 - perspective of comparative movement

(close objects seem to move more than the distant ones)

12 - perspective by integrity of the outline

(the closer object looks like it has a more continuous outline than the distant one)

13 - perspective by contrast between light and shade

(bigger contrasts indicate more proximity, and less contrast indicates, in opposition, bigger distance).

These assumptions were explored by other authors in the past. As an example one has the studies of *light and shade and perspective* carried out by Leonardo Da Vinci (Ramos 1944), or the ones by James J. Gibson (1950).

In summing up, the research considers three tendencies for the present study about the *sight concept of space* in the organisation between *field, figure and ground.* Each one of these tendencies exists for the reason of dependency of *language content* and *structural conditions of visual image communication* which is transmitted to the receiver.

On one hand, when people perceive images as organised units in the field of figure / ground, people are inside the *globalist tendency*. On the other, one should consider that there are images succeeding one another in a continuous movement relating, therefore, to space and time. In this case people built up at the end of the succession another whole, which is not completely present, being more an association of parts even if there are various wholes of minor order in the meaning of language. Either by one or the other tendency, the image can be built on components whose variation of stimulation by textures creates a relationship figure/ground of particular information. So, the wholes visualised in the field are spaces resulting from the permanent variation of figures against a continuous ground, thus the relationship is reinforced by the prior knowledge of the phenomenon, as a consequence of past visual experience, associating values of perception.
In reality there are three tendencies which conjugate the time factor with a dimension that completes the *sense of existence of visual space* inserted in the *language of communication.* According to the reflections from the previous chapters: one considers *colour, space, and communication the essential components of the visual world*, constructing a *visual ambience* in accordance to *time*, joining the moments through the *communications of events* as being linked in *colour and space.*

3.13 Opposition aspects and contrast in perception of visual space

For a judgement of visual units co-ordinated as a whole in the field, more or less dynamic, from past experiences or not, it is necessary to consider a phenomenon as without it there wouldn't be a condition for the perception of the figure/ground relationship. This phenomenon concerns the contrast.

The perceptive organisation of visual field obeys to an action of comparative type for judging and formation of image. It is the comparative action between stimuli projected in the field that originates the sensation of contrast and, consequently, the definition of visual elements which come up from this phenomenon and have their performance in the observation field.

The first concept of contrast is given by the opposition between two types of stimuli which comprise two big categories in the sensation and perception of visual field, being :

- projection of light and colour, and
- projection of geometrical qualities, therefore, the *contrast* is determined by non geometrical qualities (light and colours) in opposition to *geometrical qualities* (configurations).

The opposition is not only given between two categories of essential stimuli but it is particularised on each one of them.
Consequently, the following concepts of contrast are formed in a sequence from the first one:

- luminosity and obscurity by opposition of light and no light;
- figure and ground by geometrical opposition - limited and unlimited.

From these *tripartite basic oppositions*, there are others at different levels and stages, creating a differential visual structure in the field.
The development of these relations originates a scheme of maintenance of visual judgement, based on comparative action, the comparative points being the unitarian elements of visual order whether simple or complex (Monzéglio 1978).

3.14 Basic interpretations of the concept of contrast, in the structural order of the visual space

The sense of opposition, which gives the idea of contrast in visual terms, may mean: opposition between visual values or objects, one of them making the other stand out.
Consequently, the idea of visual space, by contrast, is motivated by the introduction of notions, such as:

- space, a void to be filled

- space, a filled void
- space, a fullness in the void.

where values oppose one another to be able to stand out :

- whether the void which can envelope
- whether the void which envelopes
- whether the involved is fullness which is enveloped.

In this opposition game of *full-void*, the concept of *structural image of space* which is projected to people's visual field is builtand to which people project a *visual environmental field*. The new concept of the opposition is *people and environment*, in the conception of experience action field, of reciprocal relationships, of continuous interchange in the adjustment of fullness and void.

The *fullness - void* is permanent in the field organisation and, in the structural order, constitutes the more general support sustaining the other visual spatial values, in a scale that goes from the perceptive level to the communicational one. In that scale, *fullness and void complexes* identify the types of languages which compose them by the meaning they transport, receive or acquire, because they belong to a life context. In communicative terms they tend to identify themselves with this context and integrate themselves in it, establishing a visual equilibrium in the opposition *people and environment.*

The *fullness - void* opposition being an action of contrast through which the values stand out and complement themselves by the self equilibrium of the oppositions and, considering the *fullness the more direct stimulus*, and the *void the less direct stimulus*, of perceptive projection in the visual field, perceptive sensations can be defined, according to a sequence of contrasts, analysed from the perceptive act to the communicative one. This means a series of comparative actions which, in order of increasing complexity of stimulation, define opposing visual values, filling the demands of natural visual stability to the structure of languages.

Considering from the beginning the contrast in the perceptive sensation, in increasing complexity order, the following sequence of visual values in opposition could be constituted:

- interpretation of visual space in terms of possible contrast between visual field and *stimulus - light*:
  - For a uniformly constituted and uniformly illuminated field, the sensation of visual space is produced according to the existent values of luminosity, extension, continuity, perseverance, homogeneity:

    it results in the sensation of void without opposition of fullness, therefore, without any present contrast, unless one considers the two values of origin : a visual field in contrast with the stimulus - light, determining the conceptual and subjective meaning and not that of a visual and objective one.

  - For the same visual field, visualised in two different moments, and understanding that the variety of intensity of light changes from one moment to the other, by opposition that occurs in terms of visual memory, a kind of contrast is defined in what concerns the stimulus - light. The sensation of visual space is, therefore, motivated by a contrast which is produced, even if the homogeneity of the field is maintained. The comparative action in this case produces itself by established relationships according to the time factor. If other moments succeeded, with other variations of light, it would result in successive interdependent contrast / light sensations, because they belong to the same field and to the same nature of stimulus, the light, therefore, a whole which fulfils itself in successive parts, according to one variation of the system: *the differentiation of the intensity of light.*

- The interpretation of visual space in terms of contrast in the visual field between light and no-light. For a field constituted by a uniformly illuminated background, which can be moved by a dark point, the sensation of visual space produces itself according to the following comparisons:
- luminosity and darkness, extension and boundary, continuity and discontinuity, homogeneity and heterogeneity.

The result is the sensation of fullness in the void in the oppositions of: *dark in the light, the least in the bigger*, involved in the involving, creating the visual principle of the formation of the configurations.

- Interpretation of visual space in terms of contrast in the visual field of the *figure - ground organisation.*

From this interpretation, the definition of contrast according to geometrical qualities of space is consolidated, articulated between themselves and in conjugation with the stimulus - light; therefore, an entailing of contrasts produced by both the original and natural sensations of visual space (Birren 1982).

By this complexity of contrast one reaches the interpretation of *space/configuration* which originates the stereoscopic perception (of tri-dimensionality).
In *space/configuration*, the oppositions respond to comparative actions which define values in contrast of formal and differentiated qualities: *figure / ground, form and no-form.*
It results from the sensation of *fullness and void*, in the visual touchable version; it means formal structures co-ordinated to visual perception which judge them and gives an equilibrium of stimulus / action, in the contrast, with the formulation of formal signification.
By these three interpretations one has the notion of the *formation of visual space*, according to the perceptive image of a *whole in contrasts*:

- parts which oppose each other, but complement themselves.

The conceptual trilogy of contrasts is formed, supported by the following oppositions of visual space:

- *light in opposition to light itself*

  - by differentiation of one of its structural values, the intensity

- *light in opposition to no-light*

  - by extreme differentiation in its structural value, the intensity

- *form in opposition to no-form*

  - by differentiation between geometrical characters, in the outlines and limits of configuration.

From there onwards, following with the movement of stimulus in increasing order of complexity, the sequence of oppositions has continuity, which won't be the only ones in each visualised field, but in a number that will vary according to the complexity of its own stimulus in contrast.
Interpreting the unit of opposition or contrast as a component element of the field which is not in its whole, therefore, existing within other components of the same nature, a concept of bigger contrast is originated which *might happen between the units of component contrast.*

Consequently, the visual space is structured by a system of oppositions and contrasts which embrace the most different perceptive types and which, in the structuring of image, join themselves according to certain affinities by perceptive capacities, being the ones related to perception and selection of stimuli or being the ones related to the structural organisation of figure-ground. So, embracing sensorial and perceptive conditions, the contrast acts in the formation of the whole, following the natural structure of the formation of the visual space image.

It is in this sense that the images of real space which surrounds us are formed, a group of points, lines, surfaces, volumes, shades, textures, depths, distances, positions, directions, dimensions, extensions, elements, which are visualised by comparative actions, which give them sufficient levels of contrast for the visual definitions and elements with which other contrasts are produced, in conjugated and compound units, all of them being structural images of visual signification. And these, by logical structural affinities, are determined in its semantic - pragmatical level, also by comparative acts of the judgements of opposition and of contrast (Monzéglio 1979).

3.15 Summary

In this chapter the author made a review of the relevant literature about the second fundamental component of the visual message: *space*. In this particular case the space connected with colour in the architecture of the city (exteriors), which is the *visual space*.

The author investigated space through the elements for perceiving it, the simple senses and the complex senses which enter in the perception of the visual space and its theories of perception, the organisation of the visual field in the structural relationship figure-ground, and the concept of contrast in the structural order of the visual space.

In the next chapter the author will outline the main hypothesis and start its investigation through the chosen methodological approach.

CHAPTER 4

HYPOTHESIS

4.1 Introduction

In this chapter, the hypothesis for the present research is expressed.

This hypothesis has been composed as a result of the literature review, contained in the previous three chapters. The relevant theory was carefully selected and analysed, in order to locate all the available information on the research subject. It is the basis for further research which will be outlined in the subsequent chapters, which will lead to the conclusions drawn in the final chapter.

4.2 The Research Question and Hypothesis

4.2.1 Research Question

" Is it possible to define Colour / Space as a visual communicational unity, which influences directly the architectural project and, therefore, the city itself? "

From this research question the following hypothesis has been developed.

4.2.2 Hypothesis

Colour / Space is a visual communicational unity which is directly connected with architecture and the environment.

4.3 Reasoning

This hypothesis has been chosen because the effects of colour have been investigated mainly in the context of medical research and in the interiors, never in the architectural project making and, therefore, in the built environment as a whole. So it is of major importance to prove that colour is always present in our man-made world and that there must exist a consciousness of this among people, as a way to control the use of colour in the environment.

4.4 Research design

The research design was outlined as following:

. observation of the *Colour/Space unity behaviour* within the communicative system, through

- the study of *colour* and *space* (as area of colour)
- the demonstration of the existence and importance of the *Colour / Space unity*, as a perceptive-communicative relationship between colour and space
- the demonstration that *Colour / Space* is a *unity of visual communication*
- demonstration that the *Colour / Space unity* intervenes in the *visual methodological programming of the environment*, influencing directly life quality.

4.5 Investigation of the hypothesis

To investigate the *hypothesis*, the research study must cover two other areas of the relevant literature review:

. The definition of the *Colour / Space unity*, establishing the relationship between the three attributes of colour and studying the *Colour / Space behaviour* in the perceptive reality of these.

. The *visual communication*, in a way to show that *Colour / Space* is a *unity of visual communication*, studying the *Colour/Space Systems, the Visual Languages Programming* and, therefore, *the Colour Planning.*

CHAPTER 5

METHODOLOGY

5.1 Introduction

Based on the understanding that architecture deals with ordered spaces in accordance with their several functions; regarding the fact that urban planning deals with multiple spaces, co-ordinated in accordance with multiple functions and uses, the participant languages are, therefore, arranged, ordered and co-ordinated, by the designer, for perceptive-communicative sets of adequate relationships between functions and uses.

The *visual space* is a member of those spaces which, for its constitutional nature, relates man and environment by the light phenomena.

Colour, being a component element of the light structure, is also, therefore, a component of the visual space.

So, space and light languages are in a permanent dynamic relationship, which are as follows:

- essential elements of the visual environmental organisation;
- fundamental participants of the architecture message and of the city.

This research is based on a study of the perceptive-communicative relationship between *Colour* in the architecture of the city (exteriors) and *Space*, which defines the *Colour/Space unity*.

The author wants to prove not only the existence of this unity which is a visual communicational one, but also that this unity intervenes in the visual methodological programming of the environment.

The previous chapter has introduced the *hypothesis* for this dissertation, based on the preceding relevant literature review, which was carefully selected and analysed, in order to locate all the available information on the research subject.

This chapter will introduce the *method of research* used to investigate the hypothesis in order to answer the two main questions:

- Is it possible to define Colour/Space as a visual communicational unity ?
- If this unity exists, does it directly influence the architectural project (taking part in it), and therefore, the city itself ?

The author selected an *integrated research methodology*, used to fulfil the aims and specific objectives of this research, developing a *model* which comprises two research methods:

- a continuation of the literature review, trying to answer the previous two questions;

- an evaluation of the literature review findings through *survey methodology*:
- *Semi-structured interviews* with experts, as a feasibility test for the next level of the research.
- Full test response via *questionnaire*
- Return to the panel of experts for a *new round of interviews* (to revise theory)

After the survey findings it will be possible for the author:

- to draw the conclusions of the research project;
- to analyse its contribution to knowledge;
- to suggest recommendations for future research.

5.2 Colour/Space unity: a unity of visual communication

In the next chapter the author will show the existence of a perceptive-communicative unity which is the result of the relationship between Colour and Space :

- *the Colour/Space unity.*

As it is also a aim of this study to prove that this unity is a visual communicational one, which influences directly the built environment, Chapter 7 addresses the subject.

Before evaluating the findings of the survey method, in Chapter 8 the author will point out the relationship between the applied meaning of the colour/space systems to the visual languages programming, according to a methodological definition which has the orientation of the project of architecture process as main target, i. e. colour planning.

So, in the next three chapters the author will outline the interpretation of the findings as a continuation of the relevant literature review.

In chapter 9 the author will utilise the survey methodology to evaluate the literature review findings, using interviews and questionnaires.

5.3 Summary

The methodology used in this research project is set out in this chapter, as well as the approach to test the hypothesis.

The methodological approach is outlined in the next four chapters:

- Chapter 6 - Colour/Space unity
- Chapter 7 - Visual Communication
- Chapter 8 -Colour/Space Systems and Visual Languages Programming
- Chapter 9 - Survey Methodology

CHAPTER 6

COLOUR / SPACE UNITY

6.1 Introduction

In chapters 2 and 3, an analyses to Colour and Space has been undertaken, proving their importance in the built environment.

In chapter 5 the author outlined the first part of the methodological approach as a way to investigate the hypothesis : to show the existence of a relationship between Colour and Space (as area of colour) which forms an unity

Colour / Space unity.

This first part of the investigation of the hypothesis is a continuation of the literature review, with interpretations of the findings by the author.

In the previous literature review the author didn't find any scientific or pragmatic approach to the theme.

After the analyses of Colour and Space, it is possible to realise that, in the established relationships, there is a certain co-ordination of senses.

Nevertheless, in the circumstance of the space of brightness and of colour, the co-ordination remains on the theoretical level, or interpretative, differently to that of the geometric qualities, where the co-ordination can happen in a more direct and real way - (the example of the tangible and the visible, in the mixture between touch and sight).

Therefore, the research must regard the strictly visual characteristics, which leads it to the definition, among other things, of the shade qualities which are really of interest to the purpose of the language and the communication of space.

6.2 Definition of qualitative shade values in the sensation of space

The notion of shade space is given in spectre positions, because they give distinguished sensations of colours. At the informative level, these variations proceed from a repertoire of values, which are of precise discriminations and there isn't any misunderstanding or ambiguity between one and the other.
This means that at the perceptive level, the definitions should also be qualitatively exact.

The spectre shade (tonal) values cannot have an ambiguous chromatic meaning:

red - orange - yellow - green - blue - violet.

So, a total number of *six shades*, instead of seven, if indigo were to be considered as a variation of violet.
If one had to consider values of transition, the shade spaces would be double in number, because in the six spectre positions there are the intermediary central values.
It is current to indicate an intermediary value between blue and violet, because the chromatic range is wider by the physical effect of relationship between refraction and wavelength.

To understand the colour/space relationship, six chromatic contents are considered with six differential contents; as in perception, the difference between red and violet is processed on a scale of continuity, apart from the physical opposition of the wavelengths (from 1 to 2, from 2 to 3... and so on...and, from 6 to 1, until the circuit is completed).

6.3 Formation of the physical unities of Colour and of Space

One can understand that the notion of space by colour, according to the physical characteristics sensible to the sight, determines the definition of the basis of visual unities conceptualisation that can be interpreted in the following way:

6.3.1 Regarding the light intensity value, which determines the quantity of light and therefore defining values of brightness of space and colour, one reaches the complex order whose structure presents two perceptive orders:
6.3.1.1 the order of sensation of brightness values as concrete visual components of perception.
6.3.1.2 the order of sensation of brightness values, as separations between visual components.

Analysing these meanings, one can conclude that *space / light* is situated in first order which in the visual structure is the envolved light space, therefore, originating the idea of (*space / light*) *fullness*; while differential *space / light* is situated on the second order, which in the visual structure is the involving *space of light*, creating the idea of - (*space / light*) *emptiness*.

According to these two perceptive orders of fullness-light and emptiness-light, the complex bases its support in a triad formation, with the following points of activation:

(Space / light) fullness	Light / maximum intensity Light / intermediary intensity Light / minimum intensity
(Space / light) emptiness	≠ Light (maximum / intermediary) ≠ Light (intermediary / minimum) ≠ Light (minimum / maximum)

The relational procedure between both orders has the formation of space / light unity, as a result:

(space / light) fullness (space / light) emptiness	=	Space / light unity

6.3.2 Referring to the shade quality, which determines the chromatic values of the spectrum positions, therefore, defining the space and colour hue values, like the previous one, one reaches the ordination of complexity, with a structure also presenting two perceptive orders:

6.3.2.1 The order of the values of hue sensation, as concrete visual components of perception.

6.3.2.2 The order of the differential sensation between hue values, as separations between visual components.

Analysing the meanings, one realises that on the first order one can have the space / hue, which in the visual structure becomes the involved hue space, creating the idea of - (space / hue) fullness; while in the second order it is located the differential space / hue, which in the visual structure is going to be the involving space of hue, therefore, creating the idea of - (space / hue) emptiness.

The complexity, according to these two perceptive orders of fullness-hue and emptiness-hue, is supported by a sextuple formation, multiple of the triad one, and with the following points of activation:

[(space / hue) fullness]

- hue / red
- hue / orange
- hue / yellow
- hue / green
- hue / blue
- hue / violet

[(space / hue) emptiness]

≠ hue (red / orange)
≠ hue (orange / yellow)
≠ hue (yellow / green)
≠ hue (green / blue)
≠ hue (blue / violet)
≠ hue (violet / red)

The relational procedure between both orders has a formation of space / hue unity as a result:

$$\boxed{\begin{array}{l}\text{[(space / hue) fullness]}\\ \text{[(space / hue) emptiness]}\end{array}} = \boxed{\text{space / hue unity}}$$

6.3.3 As for the tonal intensity, which determines the purity level of shades, therefore defining in the hues the values of saturation, of space and colour, one reaches the complex ordination similar to the two previous ones, also presenting a structure with two perceptive orders:

6.3.3.1 The order of sensation of saturation values, as concrete visual components of perception.

6.3.3.2 The order of differential sensation between values of saturation, as separation between visual components.

Analysing the meanings, one realises that, on the first order there is the space / saturation, which in the visual structure is the evolved space of saturation, therefore creating the idea of - (space / chroma) fullness; while in the second order is located the differential space / saturation, which in the visual structure is going to be the evolving space of saturation, therefore, creating the idea of - (space / chroma) emptiness.

The complexity, regarding both perceptive orders of fullness-saturation and of emptiness-saturation, is supported by a triad composition, with the following points of activation:

saturation = chroma

[(space / chroma) fullness]
- chroma / maximum intensity
- chroma / intermediary intensity
- chroma / minimum intensity

[(space / chroma) emptiness]
- ≠ chroma (maximum / intermediary)
- ≠ chroma (intermediary / minimum)
- ≠ chroma (minimum / maximum)

The relational procedure between both orders has a formation of space / chroma unity, as a result:

(space / chroma) fullness (space / chroma) emptiness	=	space / chroma unity

Joining together the group of specific complexes of each physical characteristic of colour in the spatial structural meaning, one builds up the generic system with the following organisation:

[(space / light) fullness] [(space / light) emptiness]		
[(space / hue) fullness] [(space / hue) emptiness]	—	[(colour / space) fullness] [(colour / space) emptiness]
[(space / chroma) fullness] [(space / chroma) emptiness]		

In terms of colour one has a conception of fullness / emptiness structural impact as a first step to be considered, in terms of the visual complex colour / space.

Summing up, the conception of the system unity is composed by the inter-relation of the particular unities:
The unity colour / space is then the basic component of the visual perceptive composition which from the sensitive physical order transforms the sight into a procedure in higher orders, which from the perceptive nature, reaches those of the significant nature of the visual communication.

6.4 Colour / Space : tri-dimensional chromatic sensation

One has to consider the following issues regarding the capture of the colour / space stimuli: the three different kinds of stimuli originated from the light structure and defined as brightness (value), hue and saturation (chroma), they become sensitive characteristics in the perceptive order, and with the same differential character. So, one considers as the main three sensations those with colour characteristics (or attributes) : value, hue and chroma.
In the structural perceptive organisation of colour / space they become:

space / value, space / hue and space / chroma.

In the conception of the perceptive organisation, the three characteristics that become the different sensations of space by colour are in a specific structural order already conceptualised in spatial terms. They constitute three dimensions, therefore, with the minimum spatial geometric condition, which is the tri-dimensional organisation.

Those characteristics of space / value, space / hue and space / chroma, while creating the visual result colour / space, give it a tri-dimensional character which can be conceptualised and defined in terms of geometric space.

Colour / space, on a level of structural visual organisation, has a complete connotation of space, bringing together the qualities of space, of light and of colour, the one of confined geometric space.

It is common to represent the colour through a tri-dimensional form, known as "colours solid" and adopted by several authors, in chromatic systems used in arts and sciences, and reduced to varied geometric schemes, all of them following the fundamental relation between the three original dimensions (Munsell 1976).

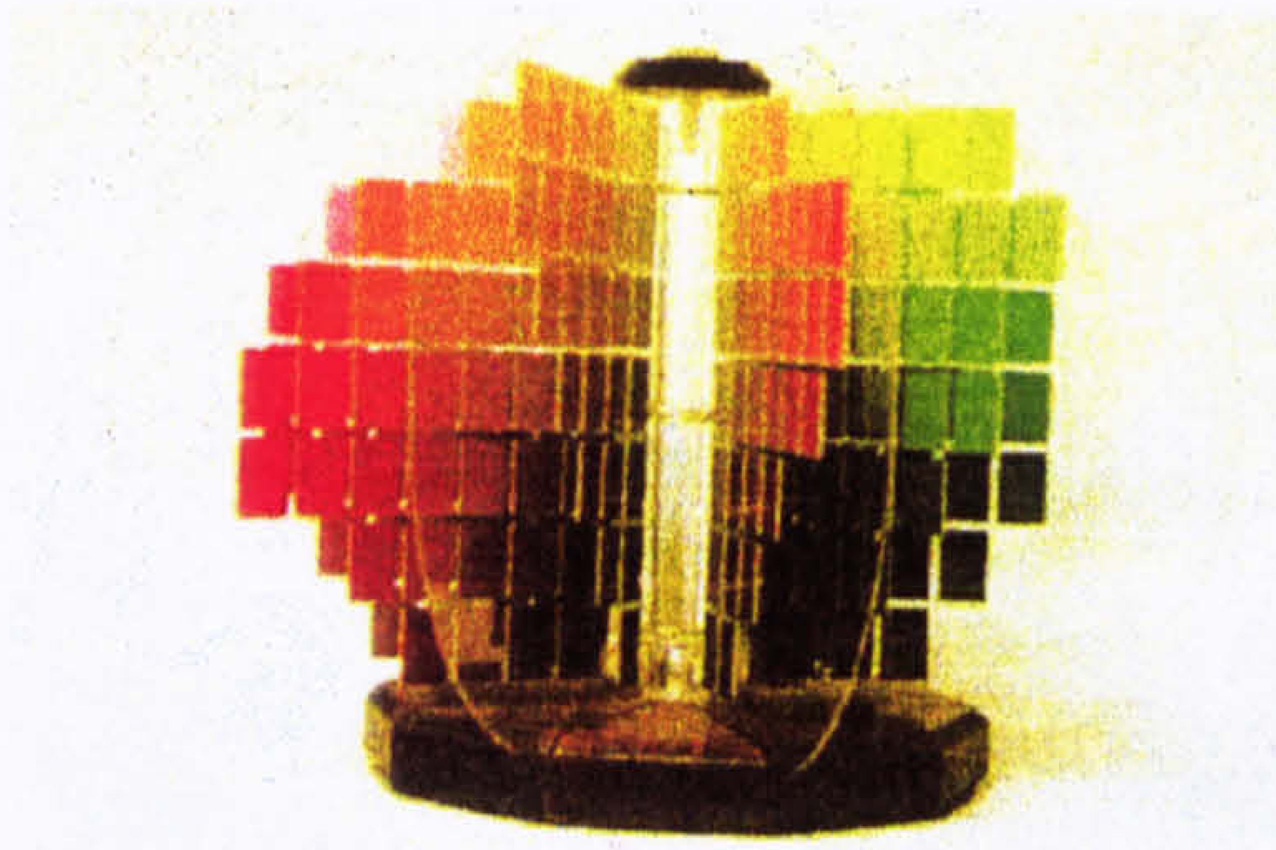


Fig. 6.1 Munsell hue, value, and chroma scales in colour / space - Munsell's solid of colours (Munsell 1976)

Judging colour in spatial issues and when comparing it with the perception of space regarding the light, one positions in first place the attribute of brightness (value). Nevertheless this attribute, in terms of chromatic definition evolves into an integrated dimension to the attribute of hue, which in terms of an informative meaning of colour is the one that characterises it the most.
So, in the tri-dimensional conception, when getting together the three attributes, the following relationship is established:

$$\textit{hue}\ \frac{\textit{value (brightness)}}{\textit{chroma}}$$

So, combined stimuli of brightness (value) and saturation (chroma) belong to a certain hue in the perceptive chromatic spatial whole.

So, the tri-dimensional relation of colour / space is represented by the following expression:

$$\textit{colour / space} = \textit{hue / space} \; \frac{\textit{value / space}}{\textit{chroma / space}}$$

which, simplified, becomes:

$$\text{colour / space} = \left[\text{hue} \; \frac{\text{value}}{\text{chroma}} \right] / \; \text{space}$$

being:

h = hue v = value c = chroma

S = space

C = colour

The expression reduced to simple signals:

$$\boxed{C/S = (h \frac{v}{c})/S}$$

This relationship, becomes the perceptive unity which is the basis for the other possible sensorial formations in colour / space.

6.5 Behaviour of Colour / Space unity

As a next issue one should analyse the behaviour of the unity $(h \frac{v}{c})/S$ regarding the co-ordination of hue stimuli captured by the nerve cells of the retina, the cones, and what is the relationship established between those attributes of brightness (value) and saturation (chroma).

The monochromatic radiations are captured by certain groups of cones, specifically to select certain wavelengths.
There are several theories about this selection process but the one that until now has a more logical and suitable explanation according to the whole visual perceptive phenomena, is the one that establishes the existence of three groups of cones (Teevan 1961). Each group captures as a main radiation one of the three, which have a physical structure to add colour and not to subtract colour: the radiations whose structure allows a combination with another in "phase concordance" of wavelength, therefore, increasing its amplitude, and not in "phase discordance", which results in the reduction of the wavelength amplitude (Ovio 1927).

6.6 The "tri-stimuli" values in the Colour / Space unity

Under radiations which allow the summing up of colours (red, green and blue), therefore through the quantitative relation of each one of them, the sensation of colour results in chromatic values, which include the whole variety of the spectre. These fundamental radiations are the so called "chromatic tri-stimuli", which are determined by a certain percentage of each one of the radiations and they are graphically represented by a system of co-ordinates x, y, z, which places in a diagram all diverted shades from the spectral positions. It is known as "diagram - spectrum locus". All these values are scientifically determined, including all the physical variations and are known as "tri-stimuli" values - "C.I.E." (the initials for Commission Internationale de L'Éclairage - Light International Commission) (Bouma 1947).
Consequently, in the perceptive judgement of colour / space one has a co-ordination of tri-stimuli, which results in the value of hue which, on its turn, co-ordinates the $(h\frac{v}{c})/S$ unity.

Once again the triad composition is repeated, in the structural order of colour, with the three hues considered as fundamentals in the spectral radiations as points of activation:

"tri-stimuli" - red radiation

- green radiation $= \left[h_x / h_y / h_z \right]$

- blue radiation

Composing with the $(h \frac{v}{c})/S$ unity, the whole of the two triads creates the following expression:

$$C/S = \left[(h_x/h_y/h_z) \right] /S$$

Regarding the presence of the other two attributes, v and c in the "tri-stimuli", that of v value (brightness) is brought into evidence by the sum of radiations which, by increasing its amplitude, add light tending to white. The Chroma c (saturation) is brought into evidence because the scale of hue in the neutral white prevents the sight of the coloured sense.

6.7 Behaviour of the Colour / Space unity in the relationship between physical and perceptive realities

At this stage of this study, it is necessary to remember that the physical reality is not always entirely correspondent to the perceptive reality. It is the case of the "tri-stimuli" and the diverted perception of the three shades that comprise them.

Our organ of sight is able to capture and select radiations, to co-ordinate its comprehension, giving response to this or that colouring. However, it is not able to distinguish which are the composing radiations of each "tri-stimuli".

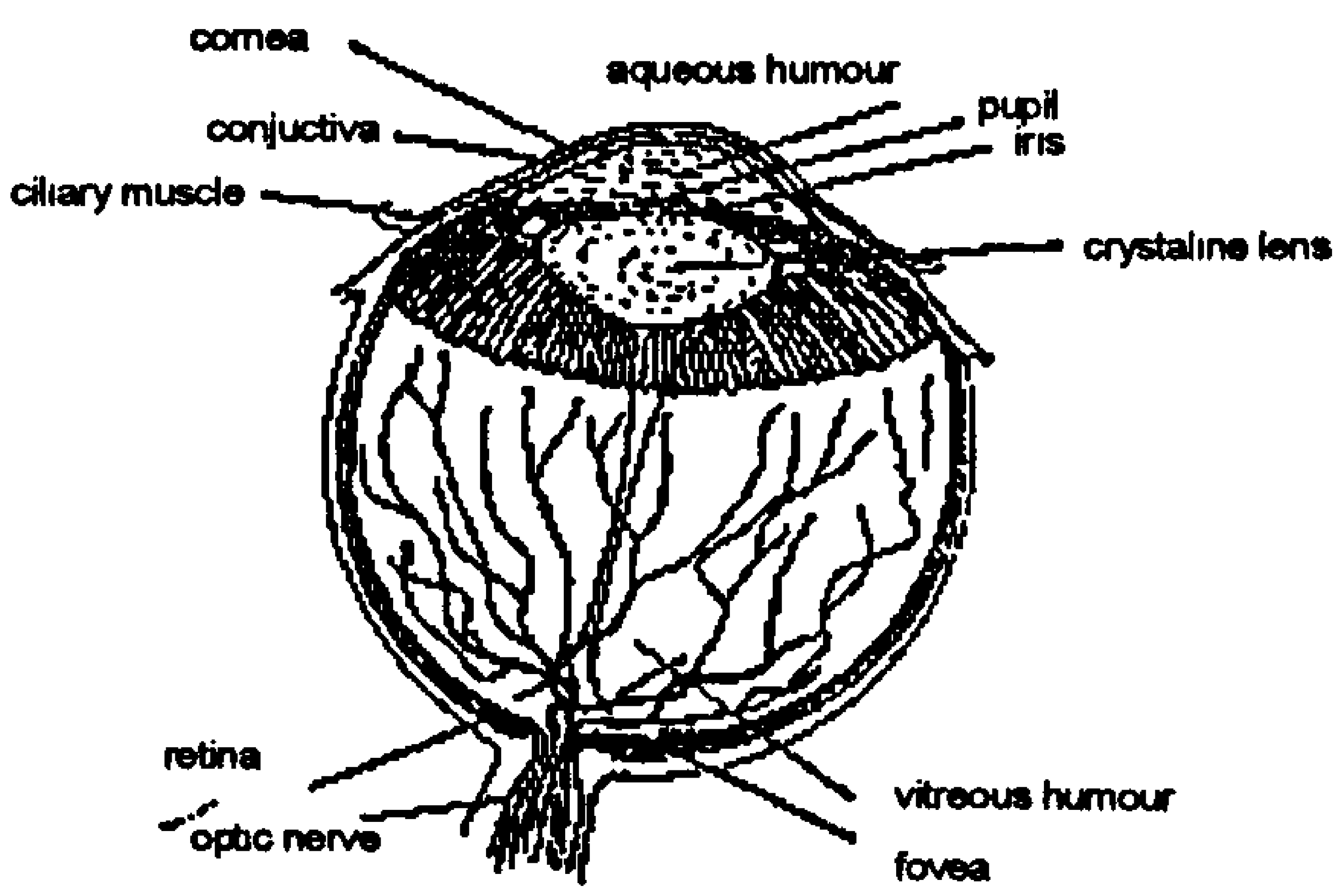


Fig.6.2 Schematic drawing of human eye (Mahnke 1993)

"We are able to appreciate a polyphonic symphony played by an orchestra, sung by a group, and we are not able to understand why there was a time when the charm of the music was nothing but a note from a cithara or one or two notes from a flute. The hearing has been educated and nowadays we no longer pay attention to such simple and poor sounds, unless when we recall the innocent but insipid pleasure of listening to a child blowing a cornet or shaking a rattle. Obviously, a sole note from the harp, echoing isolated after a sudden silence of the orchestra, can still shake our nerve fibres; but this happens because at that exact moment a preparation of the hearing and the mind, which is in a position of anxiety, leads us into a point, and that sole note means the desired and sequential conclusion after the rest; something different from the sole note of the primitive music which pleased our ancestors.

The eye also became educated, while in the ancient times it already appreciated the complex and perfect beautiful as we do, nowadays it appreciates the colour by itself, the simple colour, the same way it also appreciates the complex harmonies of the colours in nature and in works of art...

The sensation is adequate to the power that produces it, producing a relationship between cause and effect. We can feel the weight of a body when supported on our skin and we also feel its heat, shape and size.

The hearing has a determined sensation for each sound; if we mix several sounds we have the sensation which corresponds to the sum of all of them. Also for the eye, and with regard to the light, there also exists a correspondence between cause and effect. It distinguishes the intensity of light, the shape, the levels of colour saturation... In what concerns colour, this correspondence doesn't seem to exist any longer. We see the orange or green colour the same way whether they are projected by orange lights or green ones, or if they come from the addition of radiations (red and yellow to the orange, or blue and yellow to the green), the effect is the same. The eye cannot distinguish which one of them is the result of the mixture of the other colours" (Ovio 1927).

Therefore, one can conclude that:

- for the space of geometrical qualities, the sensation diverted by chromatic attributes is valid in each $(h \frac{v}{c})/S$ unity;
- for the space of brightness and colour, the sensation diverted between the com posing attributes is also valid for the same unity;

- for the space of brightness and colour, the sensation diverted in the "tri-stimuli" is not valid, which means that the composed expression

$\left[(h_x/h_y/h_z) \frac{v}{c}\right]$ / S has no sense.

So, the "tri-stimuli" have interest in the production of hues, by mixing up radiations, $h_x/h_y/h_z$ on the physical level and in the production of coloured shades which result into ***h*** hues in the visual chromatic sensation.

6.8 Behaviour of the Colour / Space unity into the physical mixtures of shades

Upon definition of the visual unity to be considered for the perception of colour / space, one arrives to the analysis of the possibilities of getting different shades through the mixture between the components of the unity and between diverted unities.

Considering the unity $(h \frac{v}{c})/S$, the first analysis is on the hue component, which is the attribute which characterises colour most in terms of informative language (Munsell 1976).

The hues, from existing shades in spectral positions, present two possibilities of mixtures: the so called additive mixtures and the subtractive ones (already referred in the literature review about colour).

6.8.1 Additive mixtures in the colour / space unity

These are mixtures processed between pure monochromatic radiations, and which are considered for the formation of the "tri-stimuli" values, meaning, red radiation, green radiation and blue radiation.

The additive mixture, called that way because the comprised radiations tend to add light, only becomes effective among coloured lights from a direct emission of the light source.

Three is the number of fundamental hues from that mixture, corresponding to the spectral radiations which originate them.

Three other derived shades can be obtained from these three fundamental shades if summed in twos, as follows:

$$\left[\begin{array}{l}\text{Red light + green light = yellow light}\\ \text{Red light + blue light = magenta light}\\ \text{Blue light + green light = cyan light}\end{array}\right]$$

The three resulting hues, if summed in twos, tend to the white light, once it contains the three fundamental ones.

In this case, colour / space has its expression as a differential content in space / hue, and the whole of the obtained colours has the total number of chromatic radiations with similar shade qualities:

$$C / S = \left[(\text{red / blue / green}) \ \frac{v}{c} \right] / S$$

or

$$C / S = \left[(+h) \ \frac{v}{c} \right] / S$$

6.8.2 Subtractive mixtures in colour / space

These are mixtures processed between radiations from the light filters, which subtract light, tending to black.

The subtractive mixture regards coloured filters, and therefore pigments also, which are used to colour objects. The number of fundamental hues of those mixtures is also three, corresponding to the ones resulting from the fundamental shades (tones) of the additive mixtures, and which are:

yellow, magenta and cyan.

Through the mixture of these colours, in twos, one can obtain the derived shades:

$$\begin{bmatrix} \text{Yellow + magenta = red} \\ \text{Yellow + cyan = green} \\ \text{Magenta + cyan = blue} \end{bmatrix}$$

The resulting shades if mixed up tend to black, because they contain in twos the three fundamental subtractive shades.
Colour / space in this case has also, as in the additive mixtures, its expression as a differential content in space / hue and the whole obtained shade has a total number which corresponds to the spectral positions with similar shade qualities. The difference is, regarding space / hue of the additive shades, that while one is hue / light source, the other is hue / reflected light.

Colour / Space of the subtractive mixtures:

$$C / S = \left[\text{magenta / yellow / cyan)}\ \frac{v}{c}\right] / S$$

or

$$C / S = \left[(-h)\ \frac{v}{c}\right] / S$$

Comparing colour / space through the two types of mixtures, one can verify that in the whole, one always obtains the same range of shades:

red / yellow / green / cyan / blue / magenta

- only, through the unity $\left[(+h)\ \frac{v}{c} \right]$ / S space visualisation is essentially of light, while through the unity $\left[(-h)\ \frac{v}{c} \right]$ / S space visualisation comes from the sensation of coloured configuration.

Therefore, both types of mixtures complete in the space / hue attribute, the meaning between:

- colour and brightness / space and geometric configuration / space.

Colour / space unity is formed, by space / hue attribute, according to a system of two triads:

$$\boxed{\left[\left[+h\ (x/y/z) \right]\ \frac{v}{c} \right] / S} \qquad \boxed{\left[\left[-h\ (x'/y'/z') \right] \frac{v}{c} \right] / S}$$

In what refers the other attributes, ***v*** and ***c***, the relations of mixtures happen between $(h\ \frac{v}{c})$ / S unities, since inside the unity itself, each one of the values belong directly to the radiation structure, or colour, which defines the hue ***h***.

As a last analysis about the conditions for perceiving colour / space stimuli, one has to mention the different ways in which $(h\ \frac{v}{c})$ / S unities are found in the environmental reality.

There are two ways, which are directly related with the kinds of chromatic mixtures:

- light over the environmental space;
- reflected light of the environmental space, which determines the colour of the objects.

So, space and environment have their own structure attached to colour / space perception, through those two ways:

- Space and environment in the issues of: colour and brightness / space.
- Space and environment in the issues of: colour and configuration / space.

Therefore, the analysis of the visual unity colour / space is completed with the constant and integrated presence to the environmental visual language.

As a conclusion, $(h\frac{v}{c})/S$ unity takes part of the visual field structure, according to a system that puts together three main groups of relations of colour / space and from which derive the others:

- Chromatic group in the relation green / red.
- Chromatic group in the relation blue / yellow.
- Achromatic group in the relation white / black.

According to this triad, one can build up the image which in the field gives an idea of the nearest and furthest space perception, either in amplitude of the opening of the field, or in the amplitude of distance and depth.

6.9 Colour behaviour in the organisation of Space in figure - ground.

The problem of figure-ground visual relation is strictly linked to the geometric qualities of the visual space. Its organisation is valid when these are taken in co-ordination with chromatic contents.

So, there is an integration of values between form / space and colour / space, which is permanent in every organisation of visual image. In the organisation of figure-ground, colour has a role of definition of contrast measure between shades, which determines the visualisation of the figure against the ground, in more or less favourable conditions.

The theories of perception analysed within the structural study of space, are applied to colour / space as an integral unit of colour / form, whose performance can be processed in the construction of the languages, either by "gestalt" characters of the global theories, or by those structuralists of the associated theories, involving time as an element which sets in motion the visual unity of colour and space.

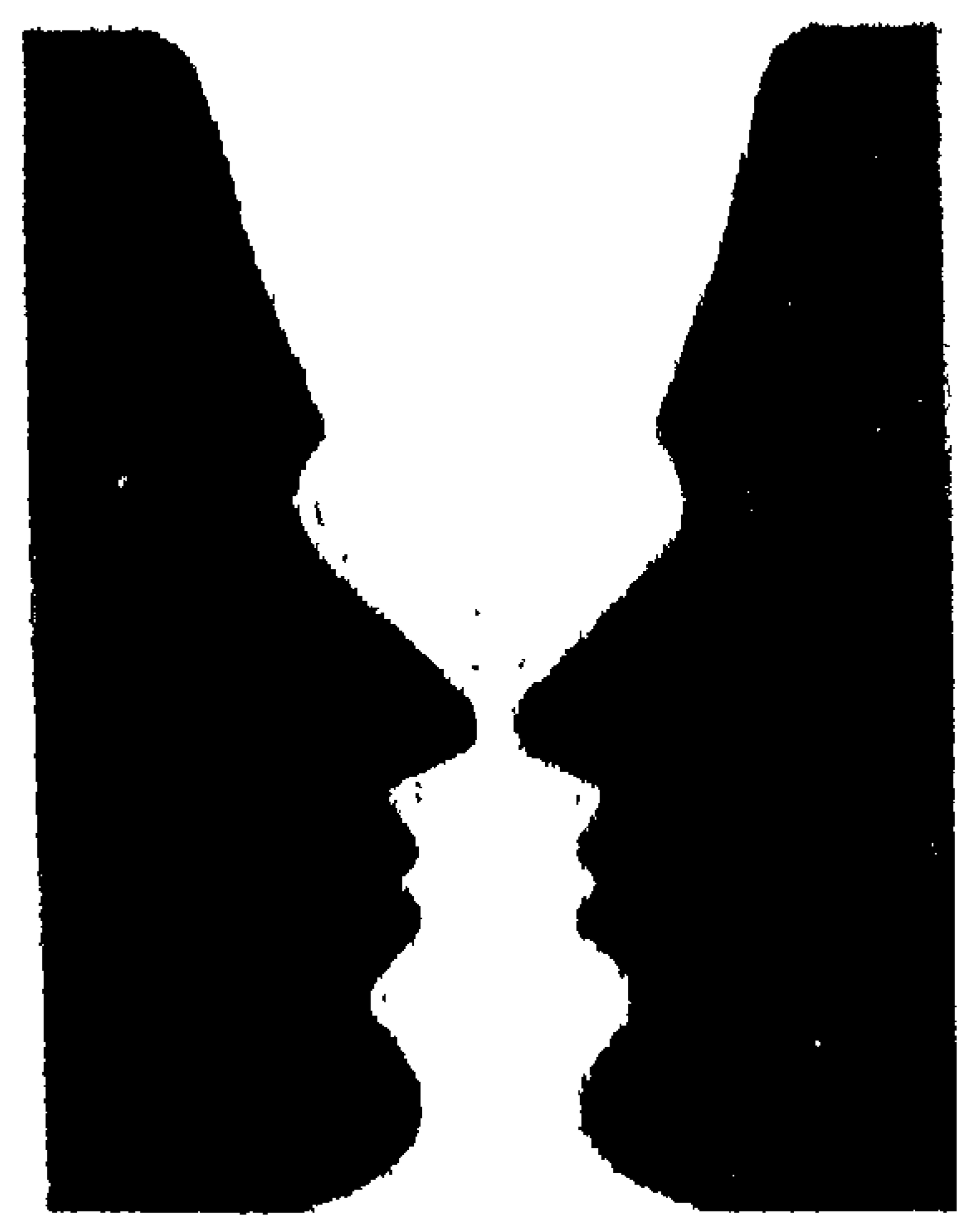


Fig. 6.3 Figure-ground model: the ambiguity of this reversible figure underlines the concept of space as a dynamic presence (Porter 1997)

One should also mention the theory of the "gradients" (Gibson 1950), as it deals with textures it is directly related with colour structural language, specially concerning the optical mixtures.
No matter what relationships the attributes have in the $(h\,\frac{V}{C})$ / S unity, the optical vibrations caused by its values in a textured organisation promotes the visual unity by additive sums among the repetitive chromatic stimuli released by the "gradients". In these circumstances, the organisation of the image in colour / space is processed according to the distance of the observation point, giving differentiated visual results in the grain of the texture, in the dependence of that distance. So, it goes along with the basic idea of formation of spatial perception, by the theory of "gradients", proposed by James J. Gibson (1950).

A typical example of space by chromatic "gradient" is given by the painting technique known as "pointillist" during the impressionist period. When you view these works closely you can see small pictorial pieces, ordering the configuration of the images according to analytical subdivisions of colour and form, reduced into small points scales in relation to the original dimension of the images represented in the pictures. The vision of these in distance cancel the point scheme, which results as the emission of colour / reflected light points, and with the final result of a visual information in colour / space language according to drawings which become a new organisation of figure-ground.

Another example is found in the graphic art known as "giantography": the applied technique to street advertising or "outdoors". The graphic reticule of printing is structured in accordance with chromatic points built up by the four colours of the graphic "four-chromatic", which allow the optical mixtures in the colouring of the images - (magenta, cyan, yellow, black). A close view of an advertisement "giantposter" is nearly the same one given by a "pointillist" picture, only with one point order in colour and space planned to the order of the mechanic process of printing; and according to the level of close observation, one hardly manages to visualise the structures of the advertisement planned image; the organisation figure - ground is, at this precise moment, the one of points in colour and space, gradients in a chromatic macro-texture. Nevertheless, the vision at a distance diminishes the gradients, as it is proved by all the posters and advertisements everybody sees in the cities.

So, colour / space is an essential component of figure-ground organisation, with a high performance in the structure of the whole visual informative language according to $(h \frac{v}{c}) / S$ unity, which acts in an individual and relational way in the construction of visual meanings of the messages.

In the system formation according to principles of perception, colour / space has support in the three points of activation given by the three considered theories;

through its chromatic characteristic, the fundamental support is given by the "textured gradients" theory:

- visual unity in figure-ground of colour/space, by the dynamic organisation of the visual variation defining movements in the interdependence of the parts;

- visual unity in figure-ground of colour / space by the structural organisation of a whole, defined according to the natural interdependency of the parts;

- visual unity in figure-ground of colour / space, by the association of the parts, whose composition is in the interdependency of differentiated times, in visuali sation sequences.

6.10 The phenomenon of chromatic contrast in the Colour / Space shade relations

In the analysis of the structural order of visual space, the concept of opposition and contrast represented one of the most important aspects for the creation of the idea of space, because it deals directly with the process of comparative action, which is the basis for all judgement of visual images which exist in the environment (Monzéglio 1966).

In the colour field, this aspect is also of great importance, especially in the relationship with the formation of the idea of visual space.

The first notion of space is given by the activation of a continuous and homogeneous ground, by a differentiated point which destroys the homogeneity, building up a new information source which moves the visualisation field according to the creation of the idea of distance, extension, limit, configuration, light and colour: the idea of a point in space or of space proceeding from a point, in opposition to an infinitive field of light.

The contrast factor acts in the $(h\ \frac{v}{c})\ /\ S$ unity according to its attributes, defining three basic orders of comparison of values which oppose one another:

6.10.1 Contrast in colour / space by the attribute ***h,*** of hue.

6.10.2 Contrast of colour / space by the attribute **v**, of value.

6.10.3 Contrast in colour / space by the attribute ***c***, of chroma.

These basic oppositions, on their turn, compose themselves origination a series of seven variations, as :

)(= contrast

6.10.1 Establishing the contrast constant in hue

6.10.1.1 $\left[ )h(\ \frac{v}{c} \right] \Big/ S$

6.10.1.2 $\left[ )h(\ \frac{)v(}{c} \right] \Big/ S$

6.10.1.3 $\left[ )h(\ \frac{v}{)c(} \right] \Big/ S$

6.10.1.4 $\left[ )h(\ \frac{)v(}{)c(} \right] \Big/ S$

6.10.2 Establishing the contrast constant in value (brightness)

6.10.2.1 $\left[h\ \frac{)v(}{c} \right] \Big/ S$

6.10.2.2 $\left[h\ \frac{)v(}{)c(} \right] \Big/ S$

6.10.2.3 $\left[ )h(\quad \frac{)v(}{c} \right] \Big/ S$

6.10.2.4 $\left[ )h(\quad \frac{)v(}{)c(} \right] \Big/ S$

6.10.3 Establishing the contrast constant of in chroma (saturation)

6.10.3.1 $\left[h \quad \frac{v}{)c(} \right] \Big/ S$

6.10.3.2 $\left[h \quad \frac{)v(}{)c(} \right] \Big/ S$

6.10.3.3 $\left[ )h(\quad \frac{v}{)c(} \right] \Big/ S$

6.10.3.4 $\left[ )h(\quad \frac{)v(}{c} \right] \Big/ S$

On the whole, taking away the super-positions, the result are the seven contrasts indicated by:

6.10.1.1 - 6.10.1.2 - 6.10.1.3 - 6.10.1.4 - 6.10.2.1 - 6.10.2.2 - 6.10.3.1

As a visual expression by contrast of brightness (value), the structural order of space is defined in light / dark ; by contrast of saturation (chroma), the structural order of space is defined in chromatic / achromatic ; by contrast of hue the structural order of space is defined in spectral position / spectral position.

The spatial organisations in light and colour happen with these contrasts, which ones along with the geometric qualities acquire other specific characters of visual structure.

Between geometrical space and space/light and colour, there are two alternatives as a result:

- the chromatic contrast values the differential content of form, increasing the sensation of space;

- the chromatic contrast undervalues the differential content of form, decreasing the sensation of space.

Considering the attribute of hue as the one which characterises colour in the different languages, the contrast between hues is the most accentuated as sensation and, therefore, between $(h \frac{v}{c}) / S$ unities is the one which gives a better indication of space. This happens because the contrast in dimension h is the one that best produces the differentiated chromatic sensation, because varying the shades change the radiations. With the other two attributes, v and c, the contrast varies the shades but it doesn't change the radiation.

Considering two oppositions, one in formal contrast and the other in chromatic contrast, and this last one being very intensive, as in the case of space / hue, there is an interference which changes the original formal character, giving origin to another one produced by the predominance of colour.

This doesn't happen with the other two attributes, the space / brightness (value) and the space / chroma (saturation), because they don't interfere in the changing of the form, unless special conditions are created, but they contribute to configure limits of surfaces, or shadows (Munsell 1976).

For example: a cube

- if each face has one colour of spectral radiations, there is an interference in the visualisation of the form, because the strong stimuli destroy its spatial continuity;

- if all faces have the same hue, varying the degree of brightness (value) or satura tion (chroma) of each of them, there is reinforcement in the visualisation of form, because the stimuli emphasise those already configured (Itten 1961).

There are some aspects to consider in the chromatic contrast, which contribute more to the sensation of space in terms of colour:

- considering the contrasts in any of the attributes, one can define three types forming three groups of chromatic oppositions in colour / space:

6.10.4 Opposition by simultaneous contrast

6.10.5 Opposition by successive contrast

6.10.6 Opposition by binocular contrast.

6.10.4 Simultaneous contrast

In the opposition by simultaneous contrast, colour / space gets characteristics of changing of shade values, by the influence of opposite radiations which comprise the figure-ground as a whole. It is called simultaneous because the visualisation of the images happen at the same time.

Example: two cubes with the same shade of grey but against grounds with different shades, one against a white ground, the other against a black one; the whole seen simultaneously gives us the sensation of two different shades of grey: the cube which is against the black ground seems lighter, and the one against the white ground seems darker.

If placed against different chromatic grounds, the same grey cube gets a shade slightly tinted, but always with the opposite hue of the ground and, if the whole is seen simultaneously we get six different shades of grey seen at the same time.

6.10.5 Successive contrast

In the opposition by successive contrast, colour / space gets changes of shade values, but in successive moments of observation.

Example: a black cube against a white ground observed during a period of time and, after the stare is directed to another white ground; a post-image lighter than the white ground is seen.

If the images are coloured, the phenomenon repeats itself, always with post-images with opposite hues.

6.10.6 Binocular contrast

In the opposition by binocular contrast, colour / space gets a differentiated value, also in successive moments but by binocular separation of the image.

Example: observing a white cube with a coloured filter covering one of the eyes, after a while taking away the filter, the eye which had it perceives a post-image of the cube with a shade opposite to that one of the filter, while the other eye which observed without the filter, perceives the post-image with the filter shade.

These phenomena are of great importance in colour / space languages organisation, since our vision is constantly receiving chromatic stimuli, the oppositions and post-images are also constantly processed, creating, therefore, a concept of constant relativity in the chromatic visual structure.

6.11 The ordination of classes of shades and the formation of chromatic image

Having as a basis the contents of contrast, colour / space classes of shades organise themselves between $(h \frac{v}{c})/S$ unities and according to three aspects:

- dimensions of the attributes
- relations between attributes
- mixture of shades.

The contents of contrast are indicated in accordance with perceptive limits and differential thresholds, by its maximum, minimum and intermediary values.
The classes of shade extensions are given considering the least differential content, obtaining the biggest number of shades. In this way, the values express

extreme contents, meaning that the limits of possibilities and capacities determine variations of shades. In practice, such contents are reduced to proper scales to be applied to the project, depending on the types of languages and messages being programmed.

Analytical-theoretical study on the ordination of colour / space classes of shades: shade classes of colour / space defined in accordance with the chromatic / achromatic opposition.

In these tonal (shade) classes $(h \frac{v}{c})/S$ unities are classified in two main categories: the achromatic category, dealing only with the attribute of brightness (value), being the one of hue and of saturation (chroma) equal to zero; the chromatic category dealing with all three attributes.

6.11.1 Achromatic category

It is a tonal class of variation in neutral shades, being colour/space defined in function of space/brightness.

The tonal class which changes brightness (value) and saturation (chroma) is ordered in function of the contrast factor between these two attributes.

This type of contrast received in **6.10.3.2** the indication $\left[h \ \frac{)v(}{)c(}\right]/S$

6.11.2 Chromatic category

It is a tonal class of space/hue in composition with space/chroma and space/value. This shade class brings together the whole of all possible colour/space variations. Considering that each space/hue has a combined variation between chroma and value, the programming of this shade class considers space/hue the whole of variables for each one of the hues.

The author arrived to this expression which rules the formation of all colour / space programme charts, seen as a whole unity of :

$$\boxed{\left[\text{hue}\ \frac{\text{value}}{\text{chroma}}\right] / \text{Space}}$$

6.12 Summary

This chapter proved the existence of a straight relationship between colour and space, forming a perceptive-communicative unity : the colour/space unity.

This first part of the methodological approach model was done by relevant literature review and the author's personal experience and background, arriving at the expression $(h\ \frac{v}{c})\,/\,S$ through the study of the physical unities of colour and space formation and their tri-dimensional chromatic sensations.

The behaviour of the colour/space unity was also addressed in this chapter, as well as the phenomenon of chromatic contrast in the colour/space shade relations.

Finally, the research study continued through the ordenation of classes of shades and the formation of chromatic image.

So, in this chapter, the first part of the Hypothesis was shown by the author. In the next chapter, the author will continue the study with visual communication, because he wants to show that the existing colour/space unity is a visual communicational one.

CHAPTER 7

VISUAL COMMUNICATION

7.1 Introduction

The previous chapter has demonstrated the existence of a close relationship between colour and space, forming a unity: the Colour / Space unity. It also studied the behaviour of this unity which can be represented by the expression $(h\frac{v}{c})$ / S. In this chapter the author will provide evidence that Colour / Space unity is a unity of visual communication.

7.2 Communicational structural relationships with Colour / Space

From the world of perception one goes to the world of communication. In order to accomplish an informative act it is not enough to be in touch with the surrounding environment through sensorial reactions. At that point perception becomes the channel through which the signals are transmitted and transformed into signs which are more than simple responses to physical stimuli; they are the basis of meaning, having in one unit the signals' physical support and the references to the objects and images which are connected to them.

According to Rudolf Arnheim (1971), things and events wouldn't be worth anything if there was no information: events simply can't occupy the mind only as sensorial reflexes "without the information of what is happening in space and time, the brain cannot act", they are the natural relationships between perception and thought.

One talks about information in a general sense. However, in a strict sense, according to the science of communication, "information theory represents a method of computing the units, the transmissible and transmitted signals", not interfering in the field of significance: "it doesn't represent a method of computing the significants units, semiotics being the study of meanings" (Eco 1967).

"That colour can play an enhancing role in the communication of visual messages is readily apparent. It can serve to attract attention, as to increase the readership of an object" (Tannenbaum 1966).

As this study turned towards languages of colour / space, in the search for equilibrium between the sensible knowledge and the scientific knowledge, the message structural level doesn't restrict itself to definitions of physical computations of the colour / space unity, in order to have a perceptive psycho-physiological relationship. It is essential to establish a link between this level and the other one, in which the computation of unities is of a subjective nature; the judgement of expression and contents goes beyond the simple quantification of information, which only has a meaning after a semantic-aesthetic qualification.

Therefore, there must exist an equilibrium between the information transmitted by a group of computable signals and the meaning given by judgement of sensible values, so that the language of colour / space unity can effectively constitute a communicative basis for the transmitter / receiver relationship.

As previously mentioned, in terms of colour/space there is a visual communication because it relates to specific perceptive channels for the chromatic sensations of sight.
Conjugated with space, colour, even if physically present in all kinds of perception inherent to the sensation of space, participates in them only in the theoretical sense of the meaning, because it isn't susceptible to information content through other sensorial channels. Consequently, space, characteristically defined by colour, belongs to the visual communicative structure.

Therefore, all characteristics which are peculiar to it in the structural formation, have correspondence in the visual meaningful formation.

In communicative terms there is an interest in analysing such correspondences, according to:

. the relationship between perceptive structure and communicative structure in the definition of colour / space unity.

. the definition of a significant unity of colour / space.

. the levels of articulation of the message according to the significations of colour / space.

. the contrast factor in the relation of qualification / quantification, in the colour / space language.

7.3 Relationship between perceptive and communicative structure in the definition of Colour / Space unity.

"Signal is the physical concreteness of a message" (Cherry 1957).

The physical stimuli of the perceptive structure are the signals from the emitting source in the communicative structure.

In the language of colour / space, the basic stimuli of perception are considered signals:

space / hue, space / value, space / chroma, conjugated to space / configuration.

Considering that in the perceptive reality the visual unity of colour is defined by the relationship between the three characteristics (or attributes), the complex $h\frac{v}{c}$, this one becomes the chromatic / signal of the light and colour source, exclusively in these characters. Also considering that the complex $h\frac{v}{c}$ is the visual sensation that corresponds to spatial definitions in terms of differential contents, which conjugated to those of geometrical configuration complement the whole of the spatial sensation; in the communicative structure, the unit which must be considered as signal - colour / space is the complex $(h\frac{v}{c}) / S$.

This unitarian complex constitutes the basic element of the system of shade classes of colour / space, programmed for the selection of shades which comprise the languages, either in the process of analyses or in the project of architecture process.

The selection of shades is dependent on a certain message, in the analyses or in the project.

The programming of the system of shade classes of colour / space, presents a flexible organisation in order to determine, according to the language demands, which one is the appropriated colour / key and which are the shades boundaries, the degree of differentiation between shades or the contrast grades.

In the communicative structure, the signals are selected in order to compose repertoires inherent to each message.

The system of colour / space shade classes becomes, therefore, a system of signal repertoires of colour / space.

Depending on the component languages, or in composing the language being studied, according to its environmental and intentional characters, the colour / key is determined and which becomes the signal / key of colour / space in the repertoires system, with the indication $\left[(h\frac{v}{c})/S\right]$ / key.

The repertoires system of colour / space signals, established in accordance to the flexibility of selection of tonal classes and of the component shades, constitutes the bases for the formation of specific repertoires of application to the languages.

Procedure for the organisation of specific repertoire of colour / space language:

7.3.1 Definition of signal $\left[(h\frac{v}{c})/S\right]$ / key :

- the definition is done by the judgement of tonal predominance in language;
- the predominance can happen in one shade only or in more than one.

7.3.1.1 Predominance of one shade only:

signal / key = $\left[(h\frac{v}{c})/S\right]$

which will correspond to one of the values in the table of tonal classes system.

7.3.1.2 Predominance of more than one shade:

signal / key = group of $\left[(h\frac{v}{c})/S\right]$

the group is defined in accordance to the number of predominant shades and the correspondence with the values of the tables of the shade (tonal) classes system:

group of signals / key = $\left[(h\frac{v}{c})/S\right]$ x_1 to x_n

7.3.2 Definition of shades boundaries and of shade differentiation degrees

7.3.2.1 Definition of shades boundaries:

. the shade extension of the repertoire is given by the maximum contrast which exists between values h $\frac{v}{c}$

. shades boundaries for a single signal / key =

$$\left[\left[\left(h\frac{v}{c}\right)/S\right]_x\right] \text{)(limits}_{1\,a\,n}$$

shades boundaries for a group of signals / key =

$$\left[\left[\left(h\frac{v}{c}\right)/S\right]_{x1\,a\,n}\right] \text{)(}n\text{ limits}_{1\,a\,n}$$

7.3.2.2 Definition of shade differentiation degrees:

. the intermediary shade dimensions of the repertoire are given by the minimum contrast existent between values $h\frac{v}{c}$ and its multiples, since comprised in the limits)(1 a n

. shade differentiation according to unique signal / key =

$$\text{limit}_1 \quad \left[\left[\left(h\frac{v}{c}\right)/S\right]_1)\left(\left[\left(h\frac{v}{c}\right)/S\right]_2)\left(\left[\left(h\frac{v}{c}\right)/S\right]_n\right]_x \quad \text{limit}_n$$

. shade differentiation in accordance to a group of signals / key =

$$\text{limit}_1 \quad \begin{bmatrix} \left[\left[\left(h\frac{v}{c}\right)/S\right]_1)\left(\left[\left(h\frac{v}{c}\right)/S\right]_2)(\cdots\left[\left(h\frac{v}{c}\right)/S\right]_n\right]_{x_1} \\ \left[\left[\left(h\frac{v}{c}\right)/S\right]_1)\left(\left[\left(h\frac{v}{c}\right)/S\right]_2)(\cdots\left[\left(h\frac{v}{c}\right)/S\right]_n\right]_{x_2} \\ \vdots \\ \left[\left[\left(h\frac{v}{c}\right)/S\right]_1)\left(\left[\left(h\frac{v}{c}\right)/S\right]_2)(\cdots\left[\left(h\frac{v}{c}\right)/S\right]_n\right]_{x_n} \end{bmatrix} \quad \text{limit}_n$$

7.3.3 The specific repertoires are dependent on :

7.3.3.1 types of colour / space languages which are components of environmental messages, in the case of the analytic process of visual reading;

7.3.3.2 intentional determinations of colour / space messages, in the case of the project of architecture process.

7.4 Definition of a significative unity of Colour / Space

The significative contents result from an action between:

. a physical support, or information support,

. an idea or thought indicating a meaning and giving sense to something physical and

. a behaviour between thought and physical support, creating a significative reality.

Summarising, this triad of communicative elements define what in science of communication is called a sign (Cherry 1957; Pignatari 1976).

"... A sign is a stimulus - i.e. a sensitive substance - whose mental image is, in our mind, associated to another stimulus, bringing the other about for a communication to take place..." (Giraud 1973).

Significant + Signification = Sign

Sign is, therefore, comprised by a significant and by a meaning. The plan of significations constitutes the plan of expression, and the plan of meanings constitutes the one of content.

The signification can be conceived as a process, as an act which joins together the significant and signification, the result of the act is, consequently, the sign. This way, the signification is not a "thing", but the psychic representation of the "thing" (Afonso 1983).

Sign is used to transmit information, to tell someone something that another one knows and what one wants the others to know, too. It comprises the following communicational process:

origin - sender - channel - message - receiver (Eco 1973).

Sign, is a result between a significant, a physical instrument which carries a meaning, and the meaning itself which gives it a communicative sense.

In colour / space language, the physical structure composed by chromatic signals supports a significative charge in accordance to the colour itself.
The sign language derives from the relationship between structure and meaning (Pignatari 1976).

Being a sign a basic element of the significant organisation, its interpretation is based in the unity definition, i.e., the sign is the unity of signification.
The group of signs articulated among themselves creates the language, a sign means that the message be invoked.

As it is possible to interpret sign as a unity in the colour / space language, the sign - colour / space, is created by the relationship of the signal $(h \frac{v}{c}) / S$, to which a meaning of colour behaviour is connected, according to a specific thought or idea.

From it results the chromatic sign triad, with support from the following points of activation:

- $(h \frac{v}{c}) / S$ unity
- thought or idea of colour behaviour
- colour / space sign.

The whole group of colour / space signs articulated among themselves creates the language, a sign means for the chromatic realisation of the message.
In colour/space language, considering the two ways of perception of space integrated into it, it is necessary to question what is the sign interpretation of this visual integration.

According to the analysis of Abraham Moles (1971) in his studies about art and computer, "a piece correspond to a great number of communication systems, which in principle can be separated objectively by an observer, and even subjectively by the receiver if he is paying attention". He quotes as an example: "In a real message between human beings, the receiver and the sender distinguish spontaneously a hierarchy of levels correspondent to repertoires of different signs. Therefore: spots of light, alphabet letters, words, expressions, constitute syntactical elements which correspond in the written language to overlaid levels.
The signs of a certain level join themselves in a stereotyped way to become the supersigns, for example, the words which are elementary signs in a following superior level".

According to such thought people have for the colour / space language, a superposition of signs with its differentiated repertoires:
. the signs of space / configuration repertoire;
. the signs of space / light and colour repertoire.

But in visual communicative reality we never see the form separated from the colour nor the colour separated from the form. Only in special conditions could one visualise a mental image (and not the real one), with both languages separated (Moles 1971).

However, in its concept there exists the distinction, and in practical terms one talks about form, triangular, square, circular, spherical, cubic form, etc., and one talks in colour, blue, red, brown, grey, etc., a sign association happens naturally. The form has stronger links with reasoning, the reason to relate configured structures: there is a mental construction in geometrical language. Colour has stronger links with emotion, the feeling to relate lights and shades: there is a mental harmony in chromatic language. Both of them complement each other by reason and emotion, because one constructs the other, one brings the other into harmony, in a sensible whole which can be translated as a unified language of form and colour, thereby, a group of unities: colour / space - signs.

Kandinsky (1926) gives each form a specific colour, which would permit an interpretation of superposition of sign repertoires, like Abraham Moles (1971) proposes. One can find the following relations of form and colour given by Wassily Kandinsky (1926): "Correlations Line - Plan - Colour".

lines		*forms*		*colours*
angulars		primaries		primaries
- acute angle	<———>	triangle	<—————>	yellow
- right angle	<———>	square	<—————>	red
- obtuse angle	<———>	circle	<—————>	blue

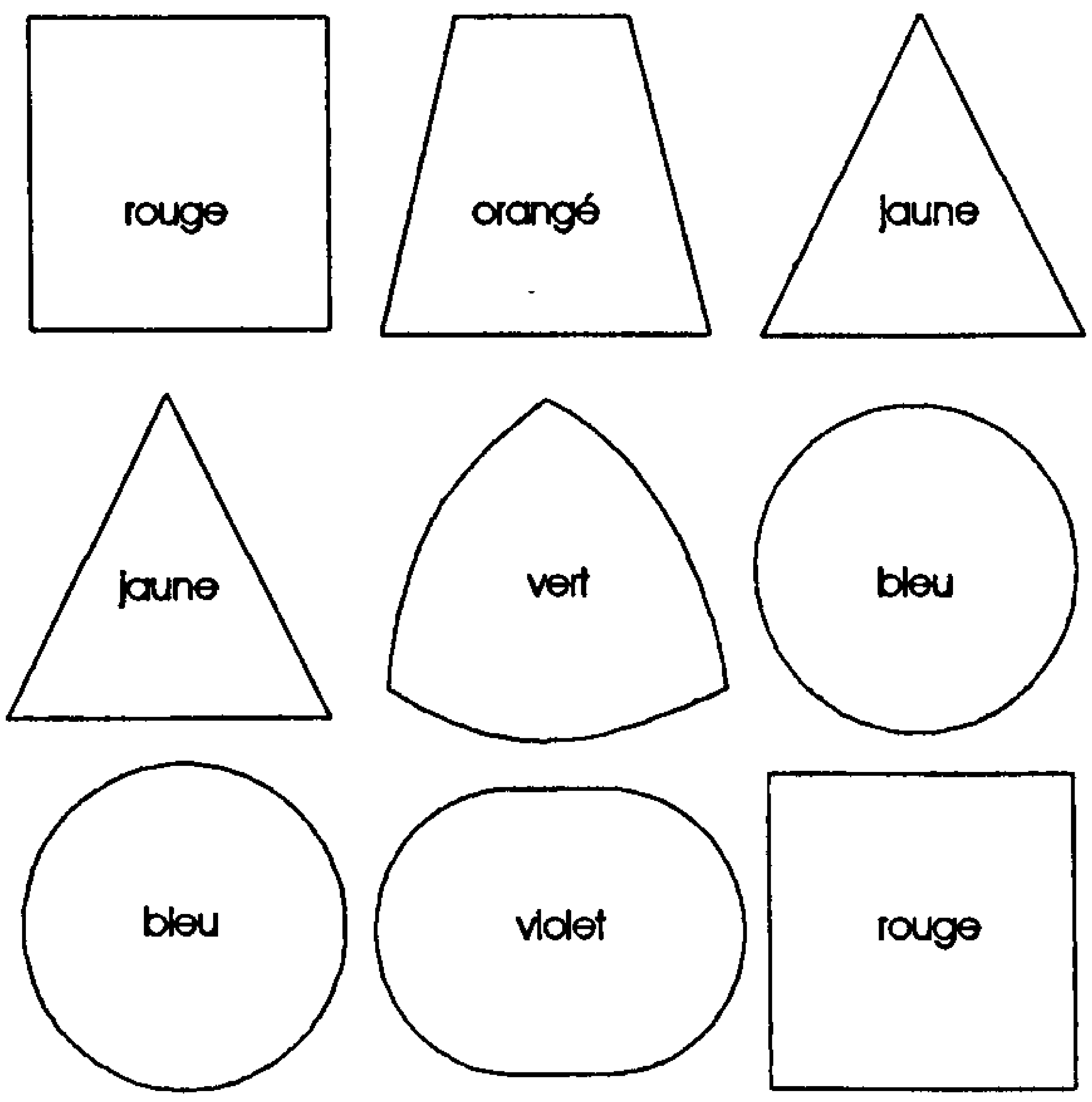


Fig 7.1 Colours corresponding different shapes (Itten 1961)

After analysing the correlations given by Kandinsky, Faber Birren (1961b) explains : " Red suggests a cubic form, because it is hot, dry and opaque, qualitatively. It is heavy, solid and substantial and offers a strong visual attraction.

Because it is very well focused by the eye it suits structured plans and rigid angles. Yellow, implies a triangle form or a pyramid form with its vertices turned to the bottom. It is the colour of bigger visibility in the spectre and, qualitatively, it is acute, angular and crisp. It is more light than substance because it doesn't have much weight, it is more space than volume. Blue implies a form of a circle or of a sphere. It is cold, wet, transparent, atmospherical. It is the one with less focus in the sight and, normally, it produces a smudged image, particularly distant. Because it is extense it doesn't give harsh details". .

The same author illustrates the correlations with secondary colours, the ones obtained by the mixture of two primary colours (in filters and pigments); sequentially it sets up the correlations according to the same scheme of primary colours and with the following interpretation :

lines		*forms*		*colours*
angulars		geometricals		secondaries
- right angle	<——————>	rectangle	<——————>	orange
- acute angle	<——————>	hexagonal	<——————>	green
- obtuse angle	<——————>	ellipse	<——————>	violet and purple

For these correlations, Faber Birren (1969), makes intermediary interpretations, in accordance with component colours, i.e. between red and yellow for orange, between blue and yellow for green, and between blue and red for purple.

In conclusion, transcribing words from Goethe (1989), "since colour occupies a very important place in the series of elementary phenomena designated to it in a more complete variety, filling in like the limited circle does, we shouldn't be surprised to verify that its effects are always determined and significative, and are promptly associated to the mind's emotions. We shouldn't be surprised in observing that when presented by itself, acting on the mind, the combinations which creates harmonies and disharmonies, impresses us even in its more elementary characters, without a relation with nature, form or the object whose appearance is deposited on its surfaces".

7.5 Levels of articulation of the message according to Colour / Space significations

Considering colour / space language as deriving from the superposition of two repertoires bringing together sign unities of colour and form, it is important to analyse the behaviour of these signs in what concems the chromatic communication.

Colour / space sign being a integrating unity resulting from this basic structural superposition, one has to verify which are its own types of communication.
In principle, there are two big chromatic sign categories:
. visual languages category which are a means of colour communication
. visual languages category which are a means of communication by colour.
In the first category, signs are real unities of colour / space, in harmony of forms / shades.
In the second one, signs are unities whose physical support is the $(h \frac{v}{c})$ / S unity but which carry communicative significations strange to colour / space unity itself.

In the first category one can find environmental, natural or produced languages, of objects, of arts or things in general, which colourings belong to them: or simply identifying colour, or identifying its own real existence.

Examples: From a rainbow we see its colours, and they identify themselves as such - red, orange, yellow, green, blue, violet; by its turn, exactly these colours identify the rainbow. From flowers and leaves we see their colours, which identify themselves as yellow, or red, or violet, or blue, or orange, or green; the flowers and leaves, in their turn, are identified by their colours. From concrete people see its grey shade, and the grey identifies itself as colour; as well as certain constructions identify themselves by the apparent greyness of that same material.

The languages created to designate something which is different in meaning to the one that is its natural, or the right one, take part of the second category. Examples: Symbology in general. Some colours are signs of a certain era. Even the grey of concrete, identifies a technological era in architecture. The green of the leaves identifies an alertness to ecological problems, of destruction of natural reserves of forests and jungles. Colour, as a code of information, is used to identify urban zones. Colours, as symbols of various expressions, were explored during all times.

About colour symbology:
Juan Eduardo Cirlot (1958) in the "Dictionary of Traditional Symbols" presents a summary of various symbolic images of colour in the human communication - "the colour symbology is the most universally known and used consciently, in liturgy, in heraldry, in alchemy, in art and in literature". He also quotes as examples : "the generic division established by the optical and experimental psychology in two groups of colours, the hot and spare ones, which correspond to processes of assimilation, activity and intensity (red, orange, yellow and, by extension, the white), and the cold and re-entrant ones which correspond to processes of disassimilation, passivity and debilitation (blue, indigo, violet and, by extension, black), having green as an intermediary hue of transition and of communication between the two groups" ... "The co-ordination of colours with psychical functions, changes from one culture to another, from society to society and also from individual to individual. However, as general rule:

- blue, the colour of space and the light sky, is the colour of thought;
- yellow, the colour of the sun which comes from afar, comes through the

darkness as a messenger of light and disappears again into the dusk, is the colour of intuition, i.e.,of a function which illuminates the origins and tendencies of events;

- red, the colour of the palpitating blood and of the fire, is the colour of life and fiery senses;

- green, the colour of the directly perceptive vegetations, is the colour which represents the perceptive functions" ... "The positive colour and the negative colour: Frequently in symbols, the opposition of black and white, as being positive and negative, either as a simultaneous polarity or as a successive and alternated mutation".

Wolfgang Goethe (1989), interpreted the colours according to expressions and symbolisms creating a language which, according to his view, should be applied to the use of colour:

- "red - indicates force (power) : the higher manifestation of colour; it expresses the ideal satisfaction.

- green - indicates weakness: the colour of simplicity; it expresses real satisfaction".

Between green and red, which set them as poles, he defines two groups of variations:

- "hot colours, indicating : active, agile, vigorous, ambitious
  . yellow / red : the vigorous, the convulsive
  . red / yellow : the splendid, the pleasant, the happy, the lively
  . yellow : light
- cold and dark colours, indicating : passive, turbulent, soft and distant
  . blue / red : the turbulent
  . red / blue : the vigour, the joy, the gloomy, the shady, the dichotomy open / closed
  . blue : the cold

- hot colours give grace and enchantment, cold colours are an incentive to sterness and dignity ".

Summarising, the superposition of signs in the formation of the colour / space sign, comprises the following reasoning, having in consideration both chromatic sign categories:

7.5.1 Formation of the colour / space sign for the communicative language of colour category.

In this case, the superposition of signs constitutes a system which, based on that one of structural physical-perceptive order, joins the triads of space / configuration and of space / brightness and colour:

7.5.1.1 Sign relation for space / configuration:

. formal structural signal

. thought or idea of formal behaviour

. formal sign

7.5.1.2 Sign relation for space / luminosity and colour:

. structural signal $h \frac{v}{c}$

. thought or idea of chromatic behaviour

. chromatic sign

7.5.1.3 Sign relation for principal and first colour / space:

. $(h \frac{v}{c})$ / S structural signal.

. thought or idea of chromatic spatial behaviour

. first sign - colour / space

7.5.2 Formation of the colour / space sign, for the category of communicative languages by the colour.

In this case, the superposition of signs constitutes a system which joins to the triad of the colour / space system principal and first, the one related to intentional signification of the message.

7.5.2.1 Sign reference by colour / space.

7.5.2.2 Sign referent by thought or intentional idea.

7.5.2.3 Designative symbol by colour / space.

In this triad is expressed a procedure of signification system by colour which defines it as a construction in itself; trying to generalise the process, which would be extensive to any type of message, whose physical or information support was colour.

Establishing, by hypothesis, the continuity of sign superpositions, this system which constructs a significative unity, it becomes an activation point of a new sign construction. In this case it has given to colour / space a new designation which makes it an even less signification of colour and a more intentional symbol of a communicative situation. According to the analysis done by Décio Pignatari (1971) in his book - "Semiotics and Literature", "a sign is originated from the sign itself". In the case of colour / space, through colour, a sign is originated which is the colour / space sign itself.

In nature one can find the substance: it has its own colour, its own language in colour /space, original and first in the sequence of the communicative manifestations. The materials that serve for application in other created and produced spaces, are extracted from the substance; colour starts having a language by signs of

colour / space overlaid to the first one, because its references are already other than the nature itself.
Objects, utensils, products are constructed from the produced materials, having with the language of colour a new derivation for its colour / space signs, giving continuity to the sequence of communicative manifestations.

The products, objects, utensils are joined together to form a construction which receives the transformed colour of nature; the colour / space signs, which referred before to a strong and stable message in its own natural equilibrium, they now designate another message with other visual characteristics of strength and stability, which in itself comprises an association of other messages, manifestations of a course of communicative situations.

The edification requires a harmonic reorganisation for these derived colour / space languages, and acquires a renewed concept of the sign which is first, because it designates simple syntactical relations of colour/space. It restarts a new sequence from another already finished in the course of moments which originated it.
There are the functions appointed to the edification and there is an intention for its use; the colour and space language superimposes again its signs.
The architecture of a building becomes through its conception to be a landmark in the historical course of human knowledge, of its capacity, of the sociability between men: colour / space restates its sign imposition in an evolutionary scale of the meaning itself.

However, architecture is a colour / space sign of a bigger organisation, the city... and, therefore, in a continuous chain originated by colour, signs of the sign itself are originated by colour.

But it also happens that besides these languages supersigns are, nearly always, joined with natural colour / space signs, originals and primaries in the sequence of communicative manifestations. Side by side with the wood which became a constructed shelter, there is the live and natural wood of trees and vegetation; a natural sequence of equilibrium search between programmed control and sensible expression, between artificial and natural, between machine and man.

In the communicative languages which are the result of experience and renovation of information, for new environments and new intentions, the continuity of significative superpositions is natural to its own process structure. Therefore, it is valid that the notion of significative system is in sequence of recreation. The continuity of sign revitalisation itself determines the order of the sequence which, by force of circumstance of context, may unfold itself originating a plot of significative origins, which characterise these contexts in time. It is the case of visual language and traditional culture which in the chromatic manifestation presents an intricate and strong symbolic mark: in costumes, traditions, arts, beliefs and religions, customs such as clothes and objects, manifestations such as folklore, and so forth.

Confronting communication and perception, primary colour / space sign could be defined as a spontaneous and natural manifestation in the man / environment relationship. For the colour / space sign in superposition of symbolic significations, an intuitive manifestation of the image, which natural and original signification are no longer satisfying, or it is a signal that goes beyond its proper meaning, by force or stimulation.
Therefore, the conclusion is that the present perception, which allows the construction of visual unity in colour / space, in its inherent significations of communication, where the parts have a natural interdependency, is a sign, a global unity. This one, associates itself to other signs in a process of derivation whose unity is in the interdependency of differentiated times of communicative situations they belong to.

The different theories of perception conjugate themselves in sign language, reconfirming communication as a process of relationship amongst themselves which, in the dependency of its dimensions in space and time, selects the visual perceptive principles which by nature integrate the process.

The significative language, which reaches a more elaborated level in the message than the syntactic one, deals with selected repertoires in order to have a co-relation between the sender and the receiver. The repertoires of signals, which are adequated to each type of message, and which also in the colour / space language are ordinated according to unities of $(h \frac{v}{c})$ / S, and according to categories of shade classes in the sign process, have a re-ordination according to the demands of the message and the co-relation sender / receiver.

In the definition of repertoires of signs, the programming obeys a procedure which fits them in character and extension to the applicable objectives. These same objectives meet in the significative level, though with the compromise of becoming useful to the context, in space and time when the message is in action.

As the necessary values are judged to satisfy the communicative solicitations, one proceeds to the organisation of the system of signs which acquires the particular characteristic of visual code of colour / space signs, because it is subjected to rules of behaviour.

"Code is a system of principles which grants a certain value to certain signals. Value is mentioned and not signification, in order to give a more general character, because signification is only used in respect to the communication between human beings; however, a communication system can be operated between machines. The relationship between machines is done by codes of values because they don't understand the meaning of signals.

In human communication, the receiver has a voluntary act of comparison between message and code and decodifies the message" (Eco 1967).

The message one deals with is a visual one and the signs must correspond to one's own perceptive necessities, which belong to human beings. Therefore, the system of principles must grant a certain value to certain signals to become a code and this certain value has a significative basis.

In terms of colour, particularly of colour / space language, the organisation of codes obeys general rules which are strictly connected to the possibility of manipulation of the language of colour, to the boundaries and differential thresholds of perceptive capacity in general, be that of signals, be it of the visual field, and to the categories of signification which are embraced by the language of colour, as analysed before, according to colour / space signs which are communication of colour, and those which communicate by colour, or with characters of simple signs, of superimposed signs or of supersigns.

Therefore, the chromatic codes are organised as having the repertoires of colour / space signals as a basis, programmed according to categories and shade classes, and they are dependent on the range of repertoires of signs of the individuals who participate in the communicative process, in consideration of the environment and common experience context.

The primary and principle codes of colour / space are organised according to solicitations of types of harmonic shades, extension of boundaries and levels of differentiation between shades.

By these codes, which are applicable to the programming of languages to all project fields, one can define the chromatic harmonisation types which, from a group of colour / space signs constitute a new sign indicator of a certain communicative situation which is characterised as a message by the tonal quality and by the quantity of visual vibrations between shades that it transmits.

Having as a base the formation of sign repertoires, the codes of superimposed colour / space signs, for designation of communicational intentions of something more than colour / space, are defined according to the solicitation of the context. These codes follow the common communicational structure of the languages being applied to them, beyond the chromatic reference given by the previous code, the qualification established by the communicative structure.

Selections of unities of interest in the codification are applied to the sign repertoires and for the whole a system of rules for the message transmission is established.

7.6 The contrast in the relationship between qualification / quantification, in Colour / Space language

Considering the levels of structure of the language, there are qualitative and quantitative relationships of contrast in colour / space, which embrace two types of people's capacity to perceive the message and to analyse it in the judgement of values. These types of relationships fall into the interpretations of objective and subjective character.

For the interpretations of objective character, the qualification / quantification of contrast relationship reduces itself to the syntactic level of the language, thus, the level in which the relationships between colour / space signs are exclusively established. In this level the measurements of visual dimensions and extensions are feasible, because of the reduction to simple signals of the languages, classified by the systems of organisation of colour. Furthermore, the visual relationships in optical practice and according to tests done with physical equipment of light and colour measurement, allow satisfactory approaches.

For the interpretation of subjective character, the consideration fits better in the following levels: semantic level, which conjugates the sign and its signification; pragmatical level, which relates the sign and its signification with the receiver's behaviour.

In these two levels, the measurement of information becomes complex, more abstract than concrete, even if registered with proper instruments in a research laboratory, because the language of art has a quality of feeling which goes beyond its own sensible and emotional content, which is difficult to be experimented and felt in the same way by another individual, apart from the one who created the expression. For the differential contents of contrast, one can apply Weber and Fechner's rule (Moles 1971), by which: - "in what concerns an unsteady physical excitement, it exists a finite number of perceptive elements, from which the psycho-physiology gives a repertoire. The differential thresholds, considering a constant K, imply a logarithmic variation of sensation according to the excitement:

$$E = K \log S \qquad S = \text{sensation}$$
$$E = \text{excitement}$$

which role is essential, being always considered the variations of differential threshold as deviations in the logarithmic relation".

In other order words: "the visual perception of an arithmetical progression depends on the physical geometrical progression". Therefore, the sensation ***S*** increases or decreases in arithmetical progression, if the physical excitement ***E*** increases or decreases in geometrical progression.
This law is valid for the acquisition of differential contents, by means of chromatic mixtures, calculating the dosage of shades and the foresight of the results.

The process mentioned before concerns unities, the colour / space sign language, and particularly the ones of colour communication, or primaries and principles, as called before.

Regarding more complex organisations of the superimposed signs or supersigns, the respective languages or messages to which they belong, it is important to consider qualitative / quantitative judgements based in the informative dialectics.

The definition and classification of messages according to qualitative / quantitative contents, and in spatial and temporary terms, have for a basis comparative relationships between the more informative and the less informative.
By this dialectic, oppositions are appraised which join together in two poles the contrasting aspects of messages.
More precisely, this system is known as "dialectic bi-poles of the theory of information" (Monzéglio 1966).

They are considered principal oppositions (Moles 1971):

. *the more informative*	. *the less informative*
- originality	- triviality
- information	- redundancy
- informative output	- intelligibility
- lack of regularity	- order and periodicity
- unexpected	- previsibility

As an example, one can consider visual languages of expressive content, as being the more informative, the ones in which sign unities are unexpected and ambiguous, therefore, without periodical order, presenting an informative output which depends in a relationship between what is transmitted and what is received, having an indefinite and original nature because it is not known. On the other hand, the languages considered less informative would have previsible sign unities, therefore, with periodical order in space and time, intelligible, having a redundant and trivial content.

For the sign chromatic unities, the following interpretations can be given:

- For the languages exclusively with chromatic special content, it is the one that is more informative that presents bigger tonal contrast and it is the one that is less informative that presents less tonal contrast. Therefore, for this category of language, the perceptive relationships between colour / space signs, are the ones which determine in which of the two poles they are situated and which are, by consequence, the informative definitions and classifications.

- For the other languages, from the category which communicates something more than just colour, the judgement of more informative and less informative, it is in the dependency of how the superimposed sign values are situated in the opposite poles.

7.6.1 Analytical conclusions :

- considering the existence of two poles which condense opposite aspects of informative content,
- considering that the comparative action is done between two values, for the result of a third one which is the expression of the established relationship,
- considering that the visual languages result from an equilibrium of physical, significative and communicative tensions, results
- a qualitative / quantitative interpretation of visual images is a triad which points of activation are three poles:
    - the pole of more informative content
    - the pole of less informative content
    - the pole of communicative content, expression of the equilibrium of the visual strengths and tensions.

For the language of colour, regarding its spatial and temporary interpretation, the same analysis is valid, considering its particular and special characteristics.

7.7 Summary

In continuation of the investigation of the hypothesis and through an analytical approach to relevant theory by literature review, the author showed that colour/space unity is an unity of visual communication.

In this chapter the author investigated the communicational structural relationships with the colour/space unity, the relationship between perceptive and communicative structure in the definition of a significative colour/space unity, the levels of articulation of the message according to colour/space significations and the contrast in the relationship between qualification/quantification in colour/space language.

Chapter 8 will address the colour/space systems and the visual languages programming, for colour planning.

CHAPTER 8

COLOUR / SPACE SYSTEMS
VISUAL LANGUAGES PROGRAMMING

8.1 Introduction

In the last two chapters the investigation showed not only the existence of the colour/space unity (as a straight relationship between colour and space), but also that that unity is a visual communicative one; which means that the author has been investigating the first part of the hypothesis through a continuation of the existent relevant literature review on the subject.

In this chapter the study will continue with the applied meaning of the colour/space systems to the visual languages programming which has the orientation of the architectural project process as its main target; i. e. the author will address the dimensional exploration and the kinetic aspects of the colour/space systems in the urban colour planning.

It is the purpose of this study to order the system of colour / space classes of shades, useful to the visual and environmental planning.

Theoretically, the system will cover all known possible tones in the physical-perceptive relation.

The values considered as basic for programming the practical system are extracted from this content.

The aim is the introduction of the process of flexibility in the system structure, in order to allow specific adaptations for the different types of languages required by the architectural project; which is, for each message there is a particular system of colour / space classes of shades.

The chromatic system applied to the visual planning shouldn't only serve the colour / space programmed orientation, but must also constitute in itself a basic definition of the chromatic character of the message being studied.
A practical system of this type allows the study of visual languages, which embrace not only the aims of planning and projection of messages, but also those of analytical visual and environmental readings, especially those of visual research in their various types.

This way, the degree of contrast between shades becomes the programming control factor which, connected to key/colour, determines the structural characteristics of the language. Thus the application in the messages analytical field in study through visual or environmental readings, is the application in the creative field of the project and drawing of the message.
For a whole definition of direction lines of this system organisation, it is necessary to link the elements of structural order in communication.

8.2 Environmental Colour/Space and Intentional Colour/Space

The colour / space systems are seen as organisations which take part in the structure of visual messages.
The visual messages are unities of the communicative process. They are also systems in the minor order, by its constitution. The languages in the scale of structural components also constitute systems by themselves, in an order which intervenes in the whole communicative process, because they constitute the means of expression and communication of messages.

Colour linked to the visual space has the peculiarity of realising itself communicatively in two ways: it is language and message at the same time.
When colour / space is supposed to communicate only colour, it is a language because it is the expressive and representative means of the formal and tonal harmonies which comprise the environment and the elements that participate in it;

but it is also a message because it constitutes in itself the meaning of the environment and its components, in the constant visual communicative relation - expression and content.

Colour / space unity is a language when dimensioned to serve as a support of overlapped meanings; only that in this case it is a structural support of another expressive and representative means which deals with intentional harmonies, images which stand out with other languages that have other intrinsic meanings. Therefore, in this instance, it is not the message as it stands alone but it is only a constituent part of its transmission.

Considering the means of communication: the one of environmental events and that of intentional events, both of them are subjected to the dimension of communicative range of colour / space.

Language is a system, which in a bigger order, becomes a unity of message. The message being a system of languages/systems, is a unity of communicative system in a larger order. Colour/space unity, being at the same time language and message, is a system of the visual communicative system.
Colour / space, being two dimensions of communicative range, is a system of communicative system of dual formation.
Colour / space system as a language is, therefore, a unity of visual message; and as a message it is a unity of the communicative system.
Because it has dual formation, the system of colour / space as a unity has an informative means of transmission of dual operative dimension.

Both ways of communication, the environmental and the intentional, are in a constant relationship because they belong to a vaster system, that of communication in generic order.

Because of this relationship, the message of intentional events is inserted in the environmental context and the message of environmental events requires for the behavioural rules of life, a movement of a system by the dynamic of the intentional messages.

In reality both ways complement each other constituting a single system, from which they are unities in a constant process of integration.

The environmental message gives information of existing natural and common facts in the environment and, therefore, in terms of human communication is unilateral, i.e., coming from the environment to man.

The intentional message informs facts which aim to change situations taking part in the natural and common existing system and, therefore, is bilateral in terms of human communication, going from man to man, as the environment is a channel to all communicational transmissions.

So, there is a bi-univocal action which conjugates both types of messages, giving a kinetic character to the communicative system, which in turn contributes to the formation of the concept of communicative unity, reached by the constant and continuous interdependency between environmental and intentional events.

Considering the environment produced by architecture, the existing buildings perform an environmental type of communication. They are relations of spatial structures supporting certain functions and aimed as a whole at certain uses by the inhabitants who receive the respective environmental information.

But, before being built, the environment was conceived, and for this reason, it was submitted to an intentional process, to become something that influences the behaviour of a user, whom, by environmental living necessities, wants to be influenced by affinity.

So, at this moment, architecture carries out an intentional act between individuals.

However, the environment produced by architecture, by the behaviour of its users, gives continuity to an intentional process, consequently all meanings of the elements which comprise it and the objects which are integrated in it, promote the communication between individuals. There is always the intention to activate a communicative cohabitation.

Furthermore, the environmental communication of architecture exists as an image of an era, of a style, of a society, of a culture. Images which persevere more as intentional communication; messages conceived and created to pass on the knowledge of the meanings of a life which existed, the capacity to appraise, the discovered technique to construct, the sensible values of a way to express oneself.

But, architecture is made of space and colour, as a language and as a message. As environmental communication and as intentional communication, it has its visual support in the expression of space and colour. Sometimes space and colour constitute expression and significant content; at the same time, and in other times, they constitute only expression with superimposed or diversified meanings.

Therefore, colour / space unity, which is a system of a communicative system, has its participation in both fundamental types of communication and, by its characteristics of dual formation of systems and of dual operative dimension of unities, constitutes an essential factor in the visual interdependency of the environmental message and of the intentional message.

In conclusion, it is therefore an essential factor to be considered in the formation of the communicative visual system unity.

8.3 Communicative System of the Colour/Space unity.

Colour/space, as a communicative system, presents the characterised formation of the unities.

Having taken into consideration the environmental / intentional interdependency relation in the system, the unities acquire different and complex aspects.

In terms of full communication it is, therefore, necessary to analyse the characteristics of differentiation between the unities increased by those values.

Because they depend on the visual perceptive structure, the levels of differentiation between unities are based on the limits and different thresholds of perceptive order. In the communicative level one interprets the communicative limits and different communicative thresholds, in the environmental / intentional relationship of messages which integrate the colour / space system. Starting from the concepts of limits and differential thresholds in the perceptive order, an analysis in this more complex level of communication, has the following as a basis:

· the behaviour of colour / space signs, as unities of limits and as to differential relationship between unities of repertoires;

· the behaviour of repertoires of colour / space signs, according to the range of communicative boundaries and, as to the communicative differentiated range from one message to another.

8.3.1 Communicative limits of colour / space.

8.3.1.1 Sign limits in the colour/space communication

In what concerns the behaviour of signs, the limits are determined according to more or less information available to be visually computable in the expression / content relationship of the message.

Considering the message in the complex environmental / intentional sense, in the dependency in which of the two types predominate in the system, the limits are computable qualitatively / quantitatively.

So, the following probabilities are defined:

· colour / space signs of environmental messages with intentional relationships, and

· Colour / space signs of intentional messages in the environmental relationships.

The communicative limits conferred to both probabilities are:

· minimum limit = communicative sensibility threshold of colour / space;

· maximum limit = communicative saturation threshold of colour / space.

If one selects the stimuli for the perceptive act according to the physico-psychophysiological capacity to be able to see what they transmit and to discern between them what one wants or doesn't want to see, for the communicative act, the transmitted signals are selected to receive and decode them. The signals constitute the physical support to the meanings, so, the selection and decodification takes into consideration the similarity of the perceptive act, the capacity to be able to understand the signs, linked to the interest of wanting to be communicated to according to those signs. Therefore, the qualitative / quantitative limit dimensions are defined according to the capacity of the knowledge one has and wants to have of the signs comprising message structure.

The limits of saturation and sensibility are interpreted in the communicative level as a complexity of limits in which participate the following:

- the perceptive limits of colour / space in stimuli order;
- the informative limits of colour / space in the signals order;
- the limits of the capacity of knowledge of colour / space meanings, in the signs order.

Having a relationship in continuity of phases, one can conceive a primary bi-univocal action between perceptive limit and informative limit and a second one between informative limit and limit of signification, originating a third action between the first two, defining the communicative limit:

[(perceptive ⇆ informative) limits]

[(informative ⇆ of signification) limits]

[perceptive / informative limit ⇅ informative / of signification limit] ⇄ [communicative limit]

Considering both categories of colour / space languages, there is a difference in the definition of signs limits.

For the category of colour / space communication to be valid, the triad of limits is represented above. For the category of colour / space communication with overlapped meanings not belonging to the colour, the determination of limits happen in opposite order, from the communicative to the perceptive ones: the communicative capacity of decodification is the one which determines the limits, from which the other significative, informative and perceptive participants are judged as a whole.

One can conclude that the definition of the sign limits in the colour / space communication depends on the range of the receiver repertoire.

8.3.1.2 Interpretation of the communicative limits in colour/space sign repertoires.

Regarding the behaviour of repertoires, the limits are determined according to the limits of signs, minimum and maximum, therefore the reasoning of the previous item is valuable, considering only that between the limits of dimensions there are other intermediary ones and those are the ones which are in constant relation. The definition of all participant sign units completes the repertoire meaning, depending on the concept of communicative differential threshold of colour / space.

8.3.2 Communicative differential indexes of colour / space.

8.3.2.1 Communicative differential threshold in the scale of the colour/ space signs

The interpretation of differential threshold in the signs' behaviour is done according to the repertoire itself, for they are the result of the composition between signs. Considering the colour/space language as such and the environmental / intentional solicitation of the message, the differential thresholds are determined from the chromatic character of the message, being therefore subject to the grades of difference of the contrast.

Considering the language of superimposed signs, the thresholds are determined according to the sequence of determined phases for the communicative limits of the colour / space sign.

8.3.2.2 Communicative differential threshold in the scale of the repertoires of the colour/space signs

In the behaviour of repertoires, according to differentiated range from message to message, the different indexes are determined in the dependency of the contents of the messages in relation to the context they belong to.
As the environmental / intentional communicative act is a relation of equilibrium in the interchange between man and context, the repertoires and their indexes of differentiation are defined by characteristics of the receiver co-ordinated with the environmental proprieties in which it is situated.

Trying to show the sign participation in the repertoire and its characterisation, the author gives an interpretation of the saturation threshold and of the sensibility threshold, with environmental examples.
Saturation threshold is interpreted as the quantitative/qualitative relationship of the signs, which reach such a complexity and dimension, making its reception and decodification impossible. As an example, the quantity of languages which happen in the urban centres overload uses and functions. These languages are concentrated in certain places, saturating the limits of the perceptive visual conditions as well as those limits of informative capture causing visual discomfort and an incorrect atmosphere.

In terms of colour / space, the thresholds of communicative saturation are in respect to:
· surplus of quantity of (h $\frac{v}{c}$) / S signs emitted;
· surplus in the scope of accentuated contrasts, and many times of extreme oppositions between the (h $\frac{v}{c}$) / S unities

· surplus of sign heterogeneities, i.e., of visual meaning connected to colour
· surplus of visual dynamic produced by the continuous and uncontrolled movement of mobile signs.

The sensibility threshold is interpreted as a sign qualitative/quantitative relationship, which didn't reach the minimum level of communicative signification and dimension, essential for its reception and decodification. The signals affect people's visual sensation, but they are not apprehended because of an emission fault. It's what happens with a built environment without any sign interests, therefore without visual stimuli, also causing discomfort by the excessive monotony, provoking an apathetic behaviour, which also is an incorrect visual atmosphere.

In terms of colour / space, the thresholds of communicative sensibility are according to:
· accentuated lack of (h $\frac{v}{c}$) / S signs emitted ;
· reduced incidences of contrast, being those always in minimum opposition, sometimes nulls, tending towards an excessive similarity between (h $\frac{v}{c}$) / S unities;
· constant sign homogeneity, which is, repetitive visual meanings connected to colour / space signs;
· an almost lack of visual dynamic, prevailing the static signs.
The visualisation of a landscape where the relationship of colour / space gives information of visual continuities without interruption, a whole sign of always equal and constant incidence, doesn't stimulate the communication disinteresting apprehension and decodification.

In conclusion, the communicative unities of colour / space are therefore determined by codes, which are the real activators of the dimensions of messages and, in terms of significance, it is through them that the limits and the differential communicative indexes are defined.

In the unitarian interdependency of environmental and intentional messages, the unities, as minimal or lesser expressions, are also interdependent, forming the integral unity. The codes are constituted through these unities which, by affinity, can be called integrals.

The qualitative / quantitative indexes of limits and of the dimensional differentiation fall upon these integral codes, using time as a factor. For each moment there is one message and its corresponding code of environmental / intentional colour / space.

The communicative interdependency between moments leads to the formation of the unity by a succession of temporal dimensions, which maintain connective links, by its own structural nature of human evolution. There is a mutation, which manifests itself by relative transformations; the essential points of their visual communicative character remain connected to the resultant messages.

8.4 Dimensional exploration in the articulation of colour/space repertoires

The analysis of the dimensional articulations in repertoires requires firstly the analysis of the component unities.

Belonging the unities to a whole, therefore alike in structure and meanings, the definition of articulations and orders of its development must have fundamental characters which are present in all unities of the whole, as invariables of the system.

Consequently, the analysis rests upon the unity considered as standard, from which the components derive, regulating the dynamic of the system.

8.4.1 Standard communicative unity of colour / space: a conception of possible articulations.

· Understanding the colour / space unity as a $(h \frac{v}{c})$ / S signal, according to the meaning which determined it as a sign content, giving it the sense of a minimum component of the visual communicative system;

· Understanding the languages categories which participate as a minimum component of the system;

· Considering it as being a unity in the expression content relationship of the environmental / intentional communicative relationship;

in its formation in the system, it is possible to consider the following orders of articulation:

· formation of sign order

· formation of contextual order

· formation of organic order

· formation of temporal order

8.4.1.1 Formation of sign order

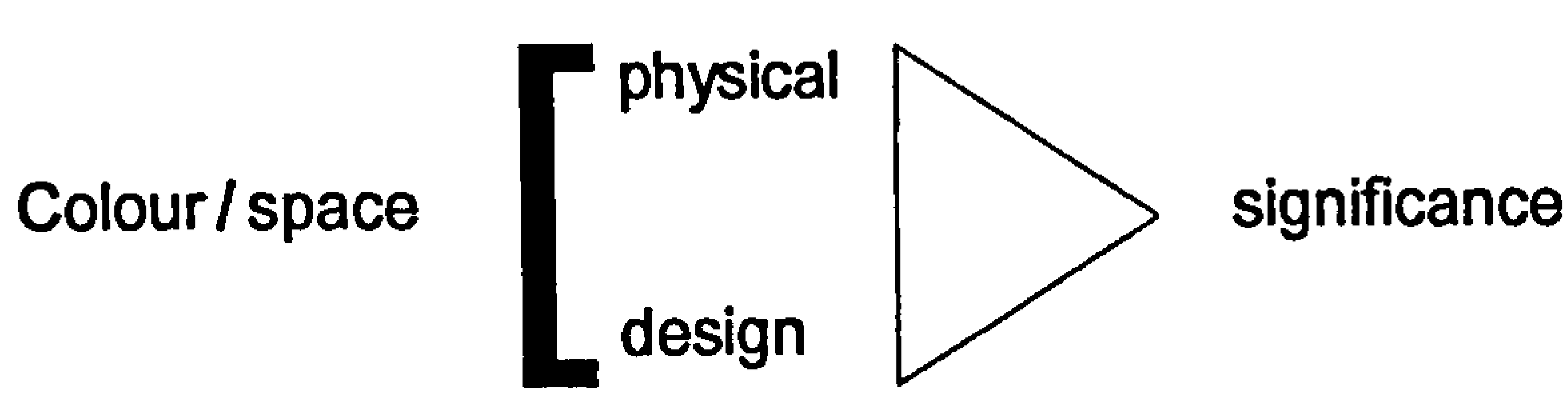
Having as a basis the analysis carried out in the formation of the sign unity, the component elements are the following:

· Elements of physical order of colour / space

· Elements of indicative order of colour / space

· Elements of sign order of colour / space

Constituting the triad of sign order:



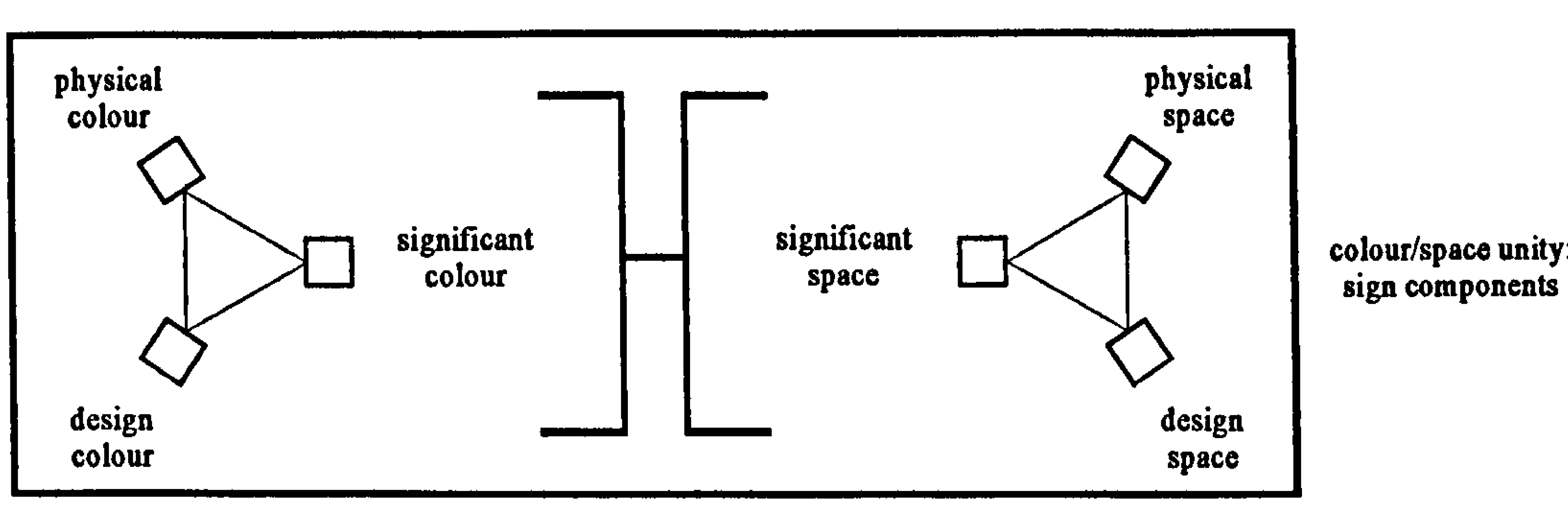


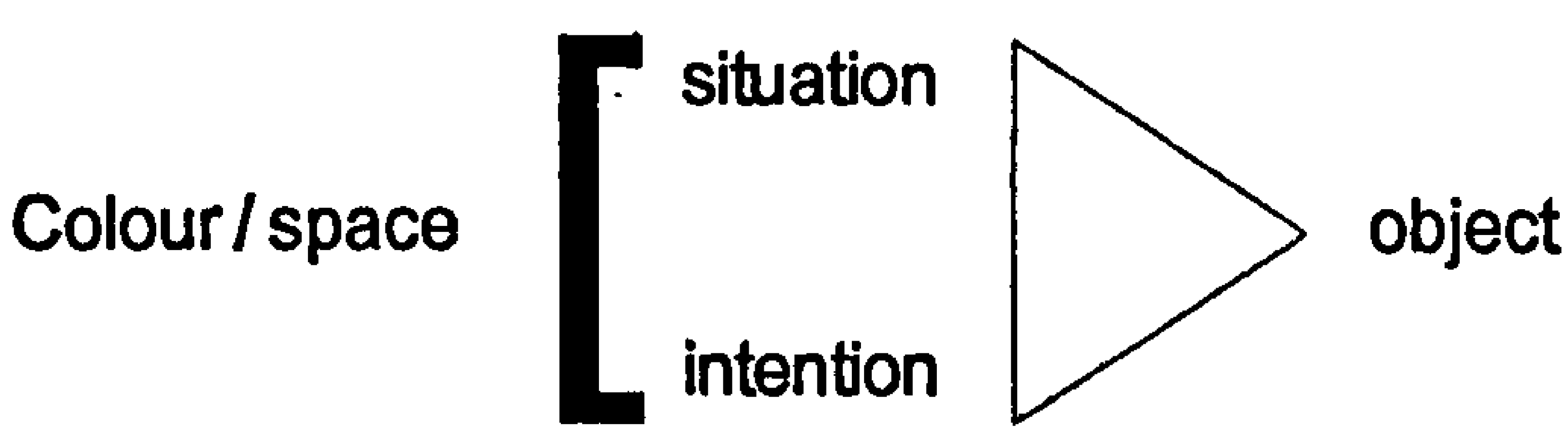
Fig 8.1 Formation of sign order

8.4.1.2 Formation of contextual order

Linking the sign order to the context of its acting, the component elements are the following:

- Elements of situation order of colour / space
- Elements of intentional order of colour / space
- Elements of object order of colour / space

Constituting the triad of contextual order:



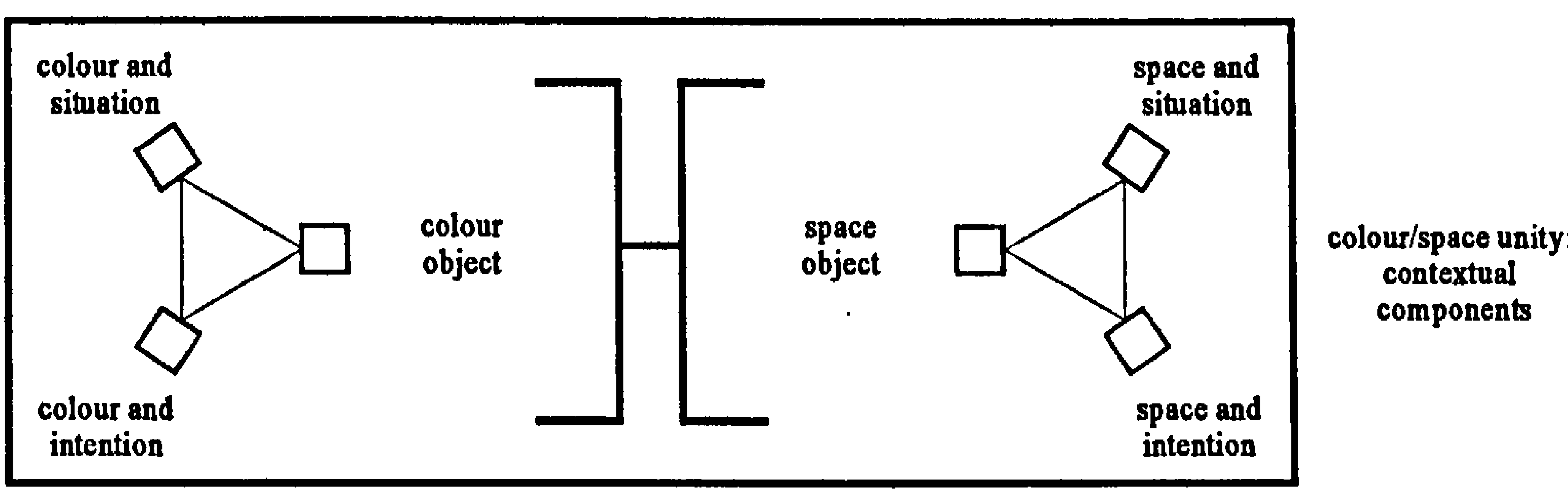


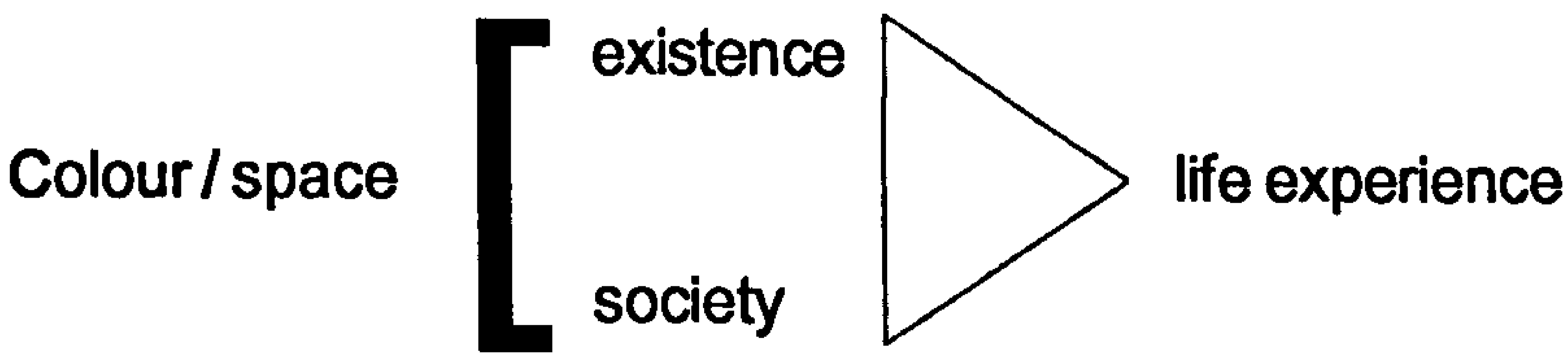
Fig 8.2 Formation of contextual order

8.4.1.3 Formation of organic order

The colour / space - sign in acting context, in its situation, intention and object, becomes an organism of human communicative life, and the component elements are the following:

- Elements of existential order in colour / space
- Elements of social order of colour / space
- Elements of life experience order by colour / space

Constituting the triad of organical order:



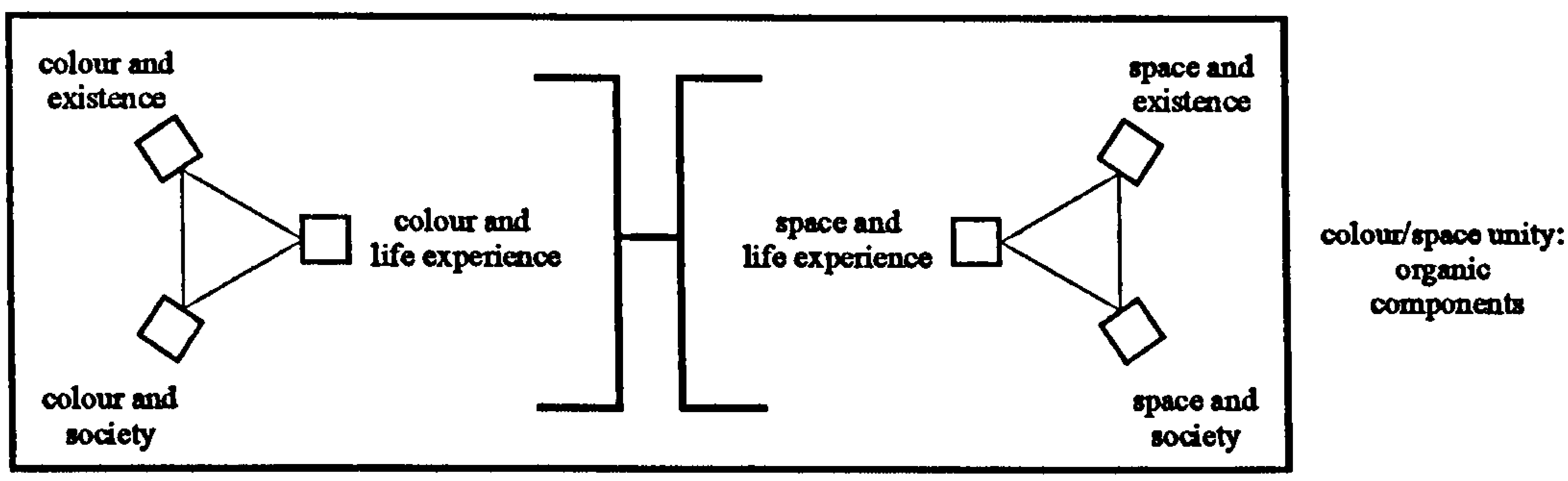
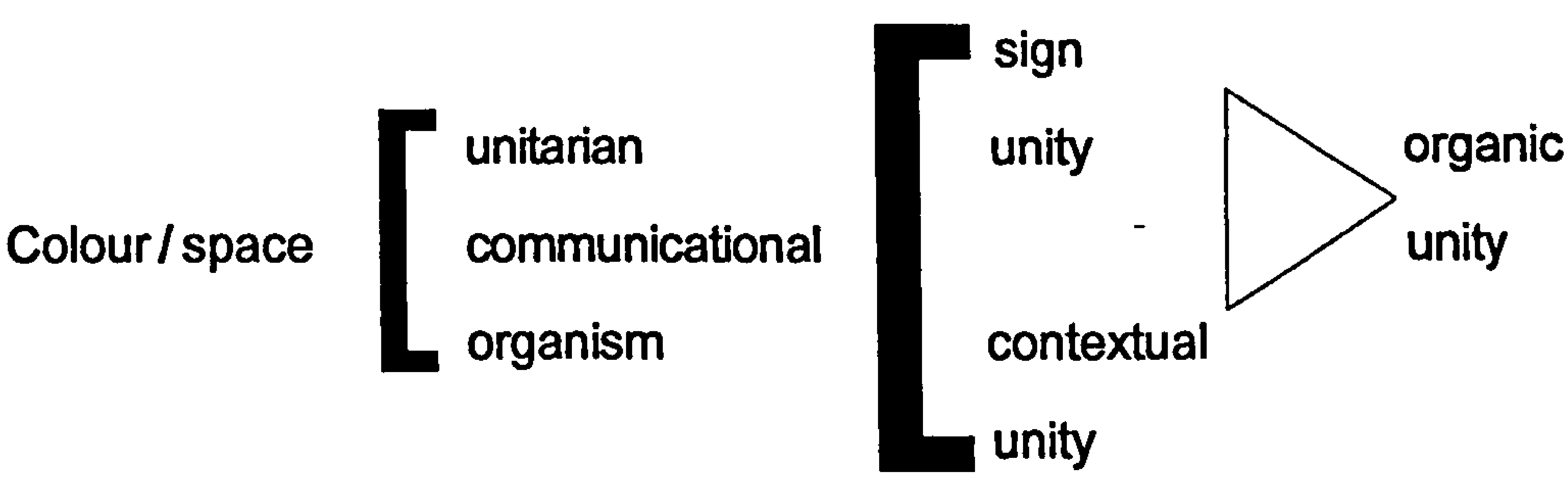


Fig 8.3 Formation of organic order

The joining of the three groups results in the sign-contextual-organic colour / space unity interpretation meaning, the communicational unitarian organism of the system:



The communicational unitarian organism of colour / space in its three orders integrates formations which are conjugations of participant minor formations within the same characteristics of meaning, that is, that one is related to space / visual configuration (Bouma 1947) and that one is related to colour / space light (Moles 1971).

Therefore, going back to the analysis in which the concept of colour/ space is founded, the three articulations of its communicational unitarian organism present in integration the partial component elements, in either both minor formations:

colour / space

colour		space
. sign unit	⟷	sign unit .
. contextual unit	⟷	• contextual unit .
. organic unit	⟷	organic unit .

communicational unitarian organism

The relationships are established for the three formations, as the value for each one of them is the integration between the partial components.

1 -	colour	[. physical	⟷	physical .]	space
		. intention	⟷	intention .	
		. signification	⟷	signification .	

2 -	colour	[. situation	⟷	situation .]	space
		. intention	⟷	intention .	
		. object	⟷	object .	

3 -	colour	[. existence	⟷	existence .]	space
		. society	⟷	society .	
		. life experience	⟷	life experience .	

The three groups of formations are also linked with time, according to the environmental/intentional of the interest and necessity of the communicational moment, creating the temporary order formation.

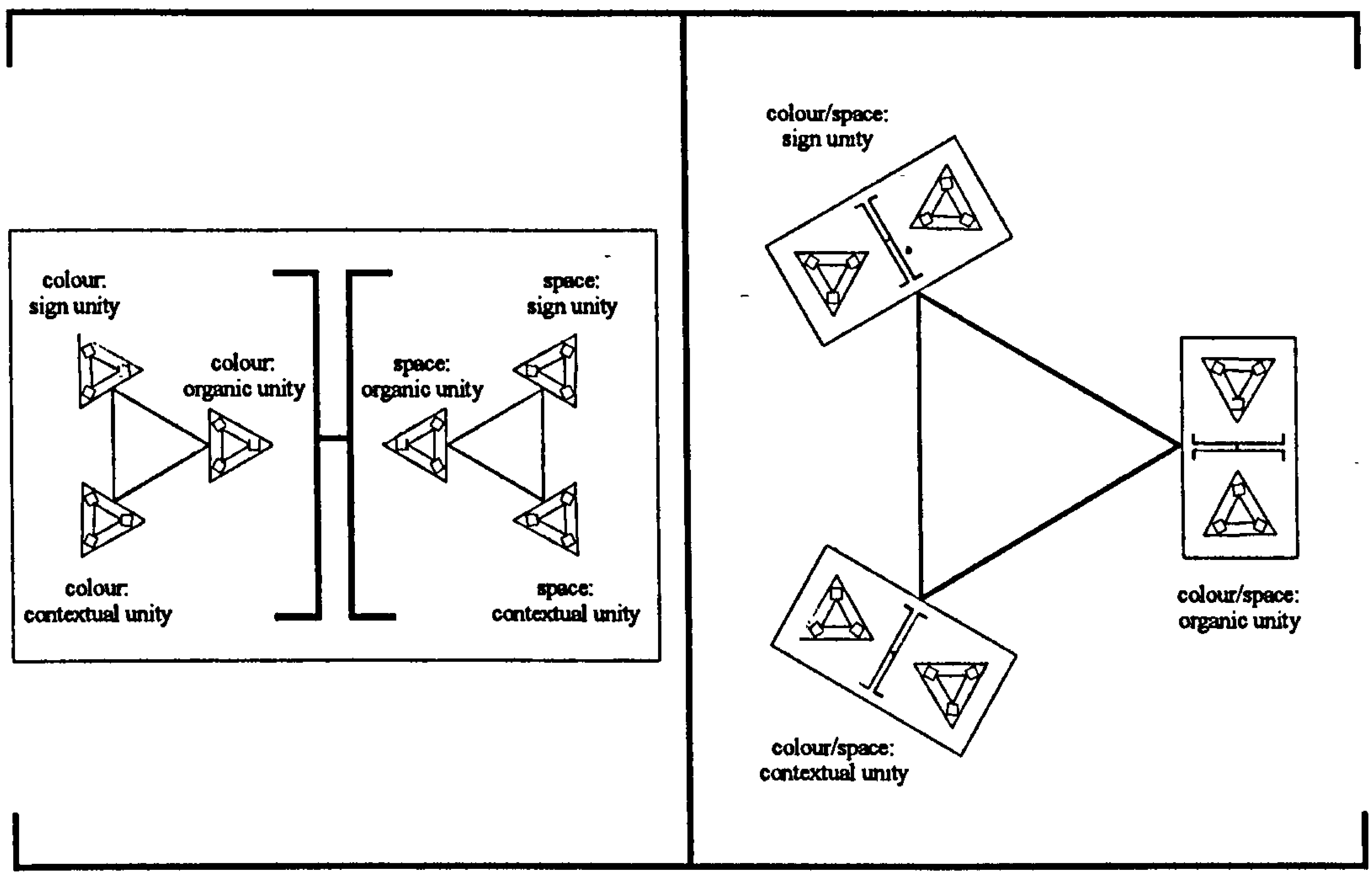


Fig 8.4 Colour/Space unity communicational unitarian organism and communicational components

8.4.1.4 Formation of temporary order

In being related to the communicational moment, the component elements are the following:

- Elements of performance order in colour / space
- Elements of demanding order of colour / space
- Elements of time / moment order in colour / space

Constituting the triad of temporal order:

Colour / space [performance / demand] ▷ time / moment

And having as partial integrated components the following:

4 - colour [. performance ⟷ performance .
. demand ⟷ demand .
. time / moment ⟷ time / moment .] space

In conclusion, then, by its three formation orders linked to the fourth one, time, the communicational unitarian organism of colour / space, is the result of four interdependent dimensions.

The triad is constituted in four movements:

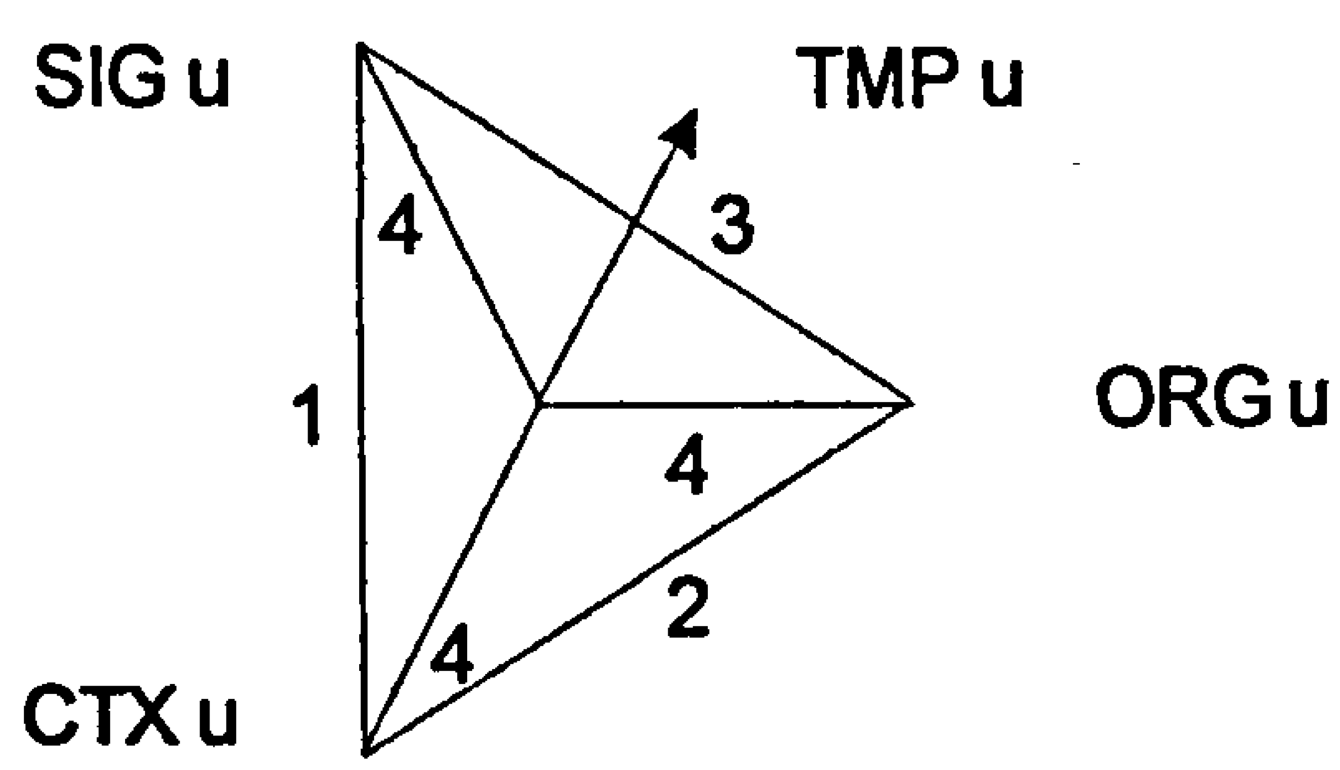
u = unit SIG = sign CTX = contextual

ORG = organic TMP = temporal

communicational

unitarian organism of

[(colour / space) time]



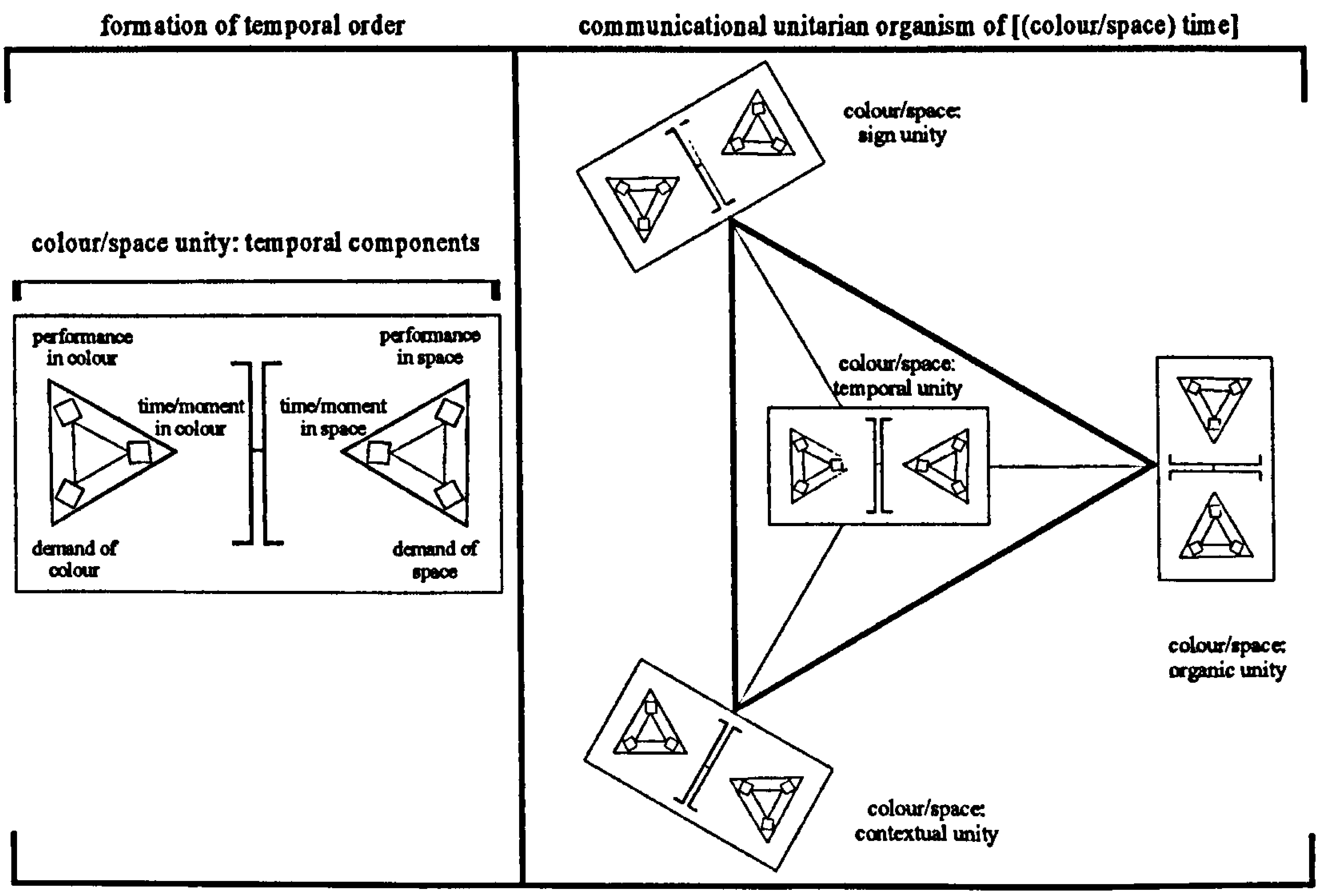


Fig 8.5 Formation of temporal order

8.4.2 Colour / Space unity and the formation orders of the repertoires

The standard component unity constitutes, by its formation, the basis for the articulation of repertoires within which it participates.

This way, together with the others that compose them, on a bigger scale, it gives the repertoires the same characteristics of formation and communicative articulation.

Considering that the repertoires have their first constitution at the perceptive level, completed by the significative-informative relations, as a pack of colour / space signs and signals, the communicative formations and articulations happen in accordance with the $(h\frac{v}{c})$ / S unity, with all the values acquired in the system as a communicational unitarian organism.

The repertoires articulated in sign, contextual, organic and temporal formation orders are constituted according to the definition of shade classes (Graves 1951), programmed systems for the selection of colour / space values adequate to the languages and messages of interest, or of visual reading, or of the project of architecture.

8.4.3 The process of organisation of colour/space repertoires according to the communicative orders of formation.

8.4.3.1 Colour/space sign: key-unity of articulation of repertoires

Having as a basis the organisation of repertoires of shade classes (Graves 1951), the key / signal of colour / space is determined. This shade, which is dependent on the communicative characteristics of the languages and messages, is selected, if it is a project of architecture, and is determined, if it is a visual reading, according to the order of communicative articulation of languages and messages.

The key / signal assumes the characteristics of the communicational unitarian organism of colour / space, in sign, contextual, organical and temporal order.

$$\left[\text{Signal } \left(h\,\frac{v}{c}\right)/S\right]\left[\begin{array}{l}\text{SIG u}\\ \text{CTX u}\\ \text{ORG u}\end{array} \Big\rangle \text{ TMP u}\right] = \left[\left(h\,\frac{v}{c}\right)/S \quad \begin{array}{r}\text{communi-}\\ \text{cational}\\ \text{unitarian}\\ \text{organism}\end{array}\right]$$

From the key / unity of colour / space, shade variables are determined, in number and in varying degrees of differentiation, by the dependency of the specific extension for each language. All unities are also defined in accordance with the four orders of formation. As a result the repertoires of communicative articulation are constituted, which become a system for the whole of the defined unities:

1 - Sign order of formation of colour / space repertoire

$$\begin{array}{l}\text{colour}\\ \textit{repertoire}\end{array}\left[\text{n unities}\left[\begin{array}{c}\text{- physical -}\\ \text{- indicative -}\\ \text{- significative -}\end{array}\right]\text{n unities}\right]\begin{array}{l}\text{space}\\ \textit{repertoire}\end{array}$$

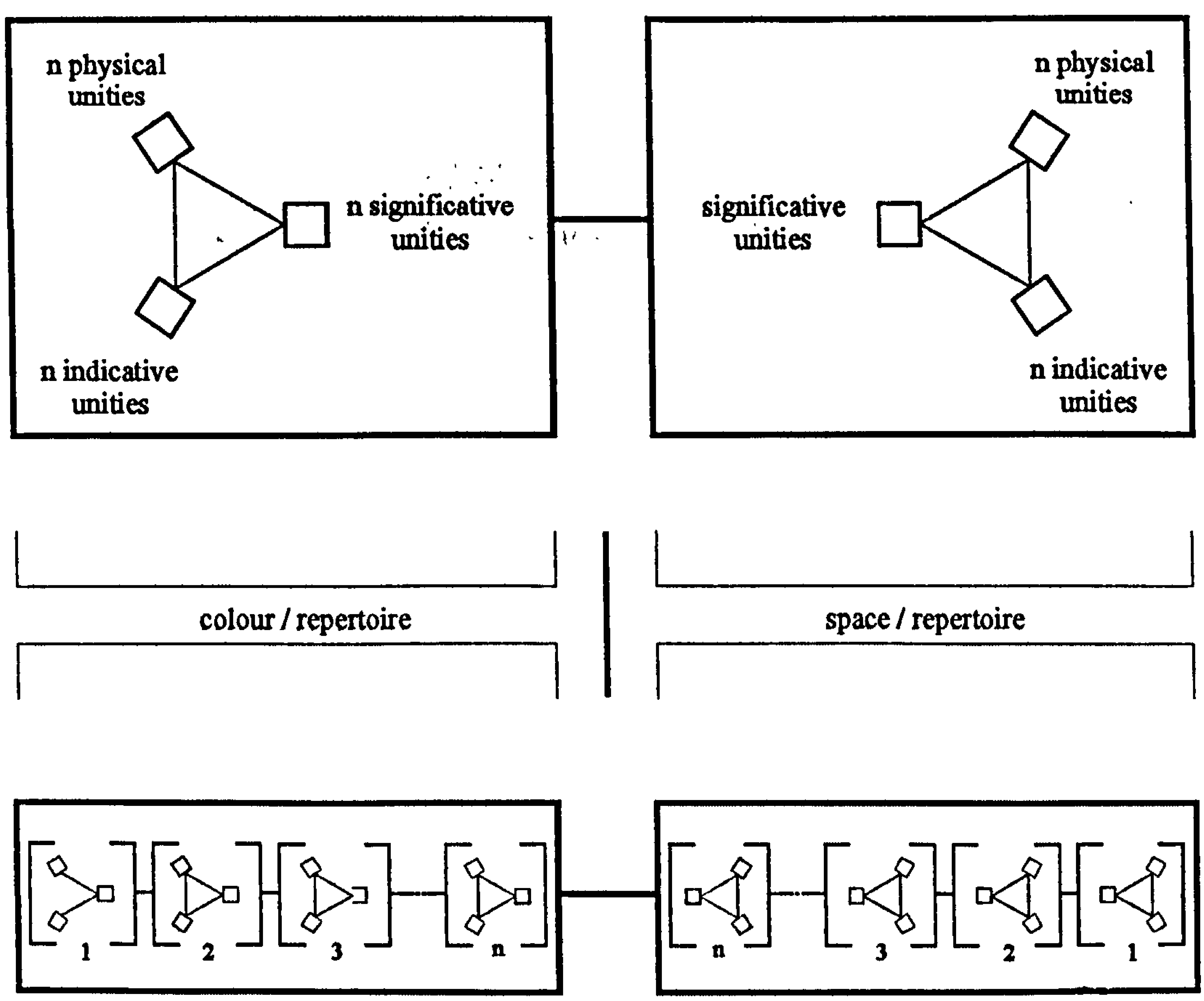


Fig. 8.6 Articulation of sign order

2 - Contextual order of formation of colour / space repertoire

colour *repertoire* [n unities [- situation - / - intentional - / *- object -*] n unities] space *repertoire*

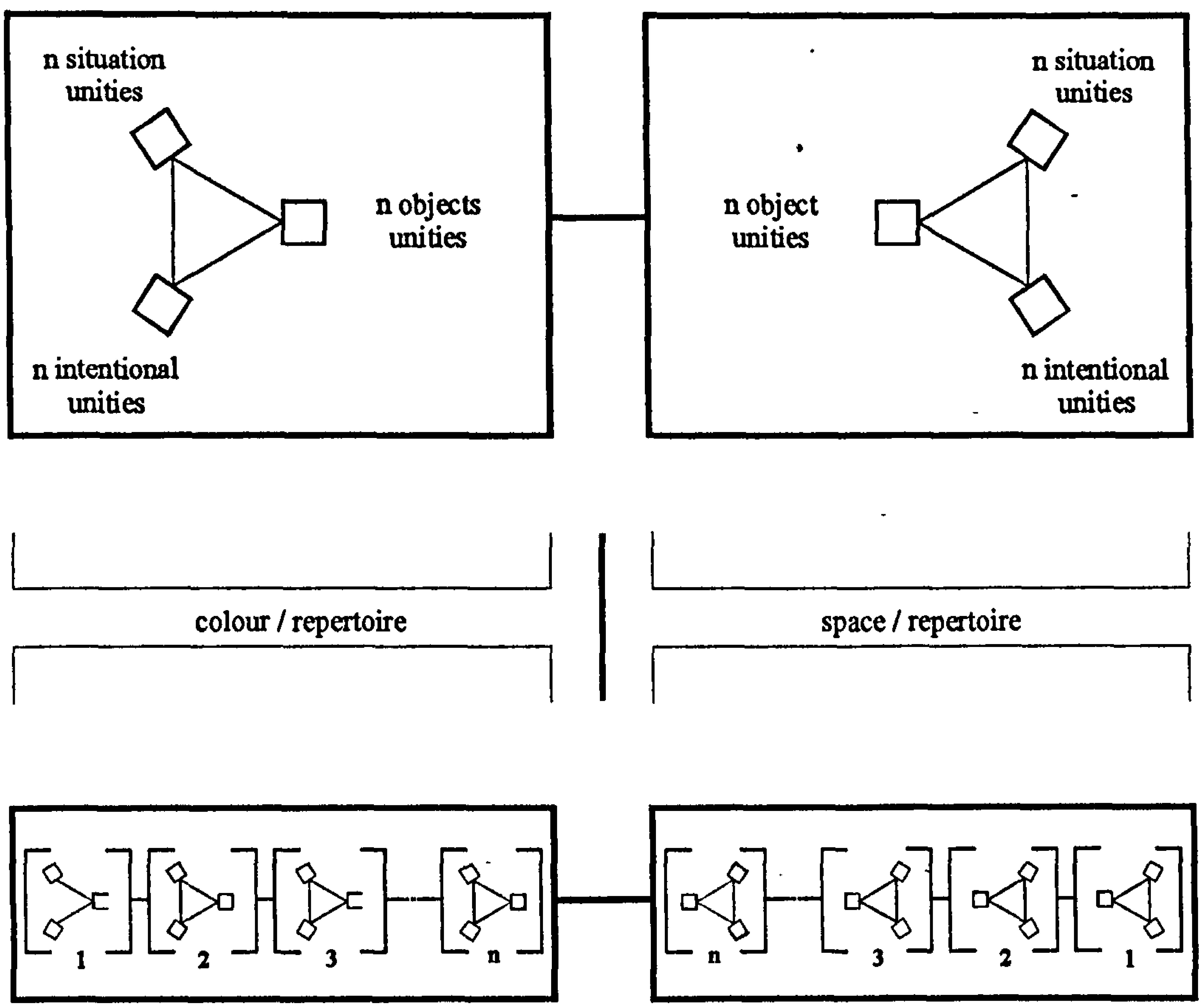


Fig. 8.7 Articulation of contextual order

3 - Organical order of formation of colour / space repertoire

colour *repertoire* [n unities [- existential - / - social - / *- life experience -*] n unities] space *repertoire*

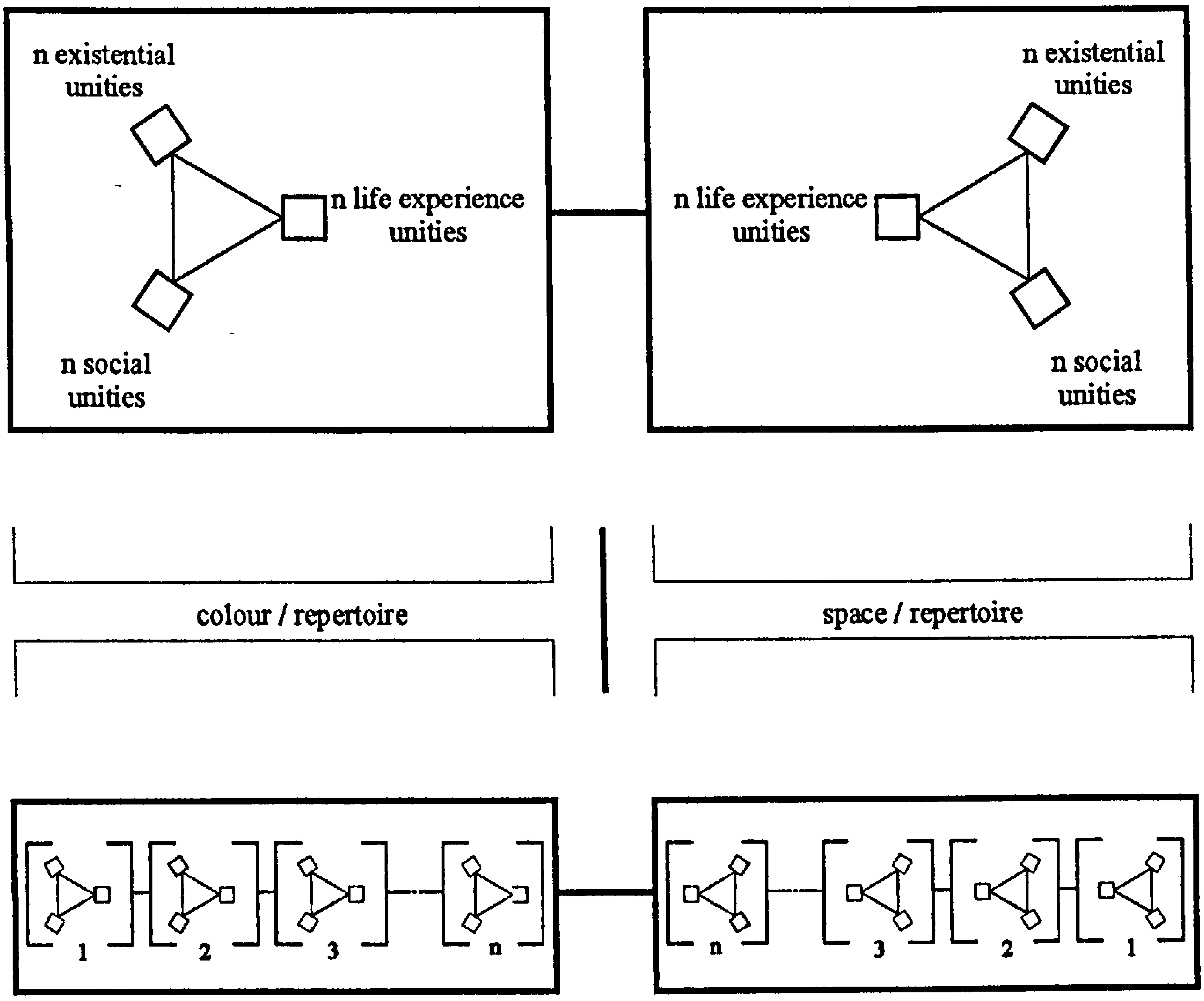


Fig. 8.8 Articulation of organic order

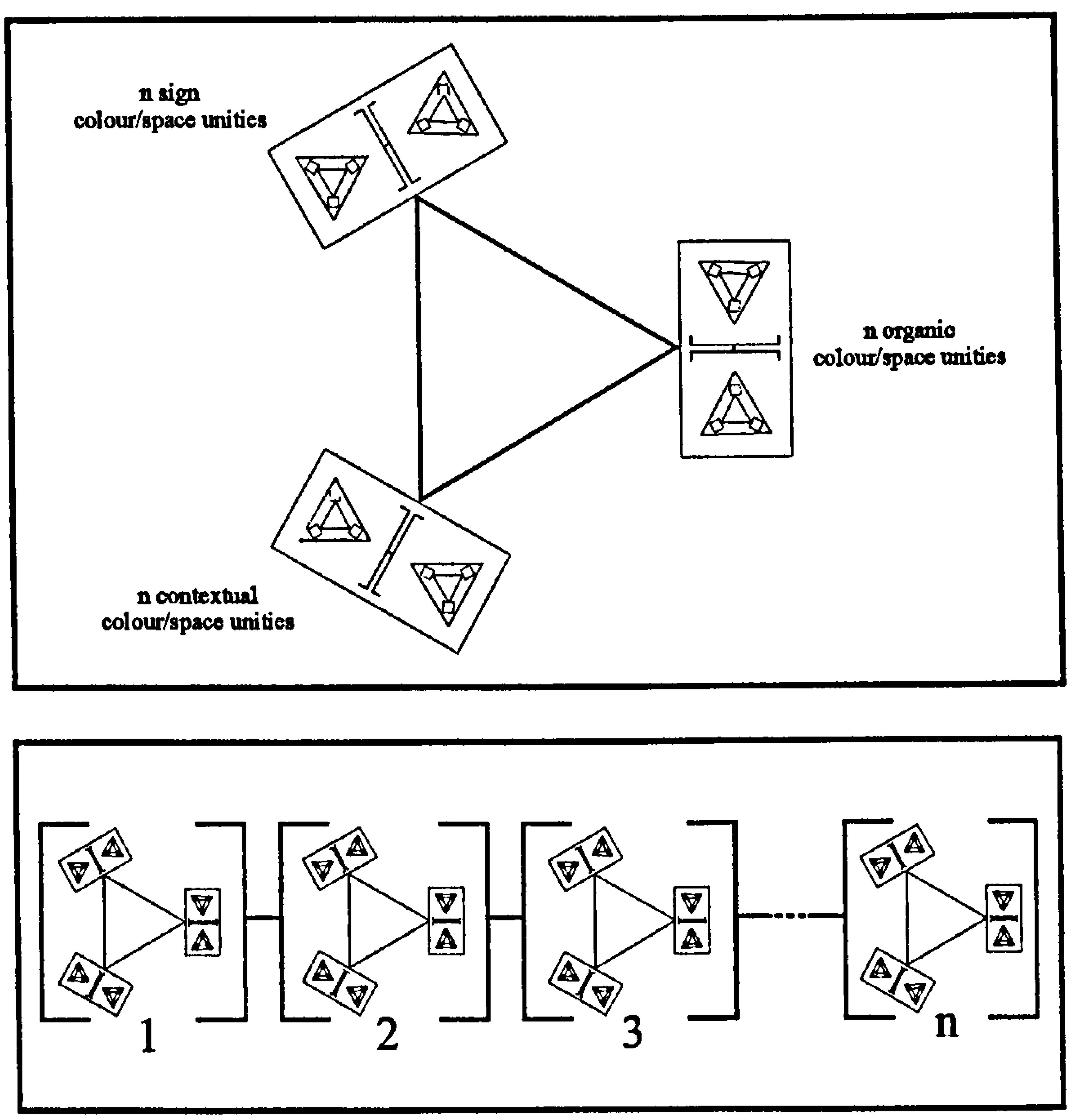


Fig. 8.9 Repertoires system of [(colour / space) time] communicative unities (1)

4 – Temporal order in the formation of *colour / space* repertoire

colour repertoire [*n unities* [*- performing - / - of demanding - / - in time / moment -*] *n unities*] *space repertoire*

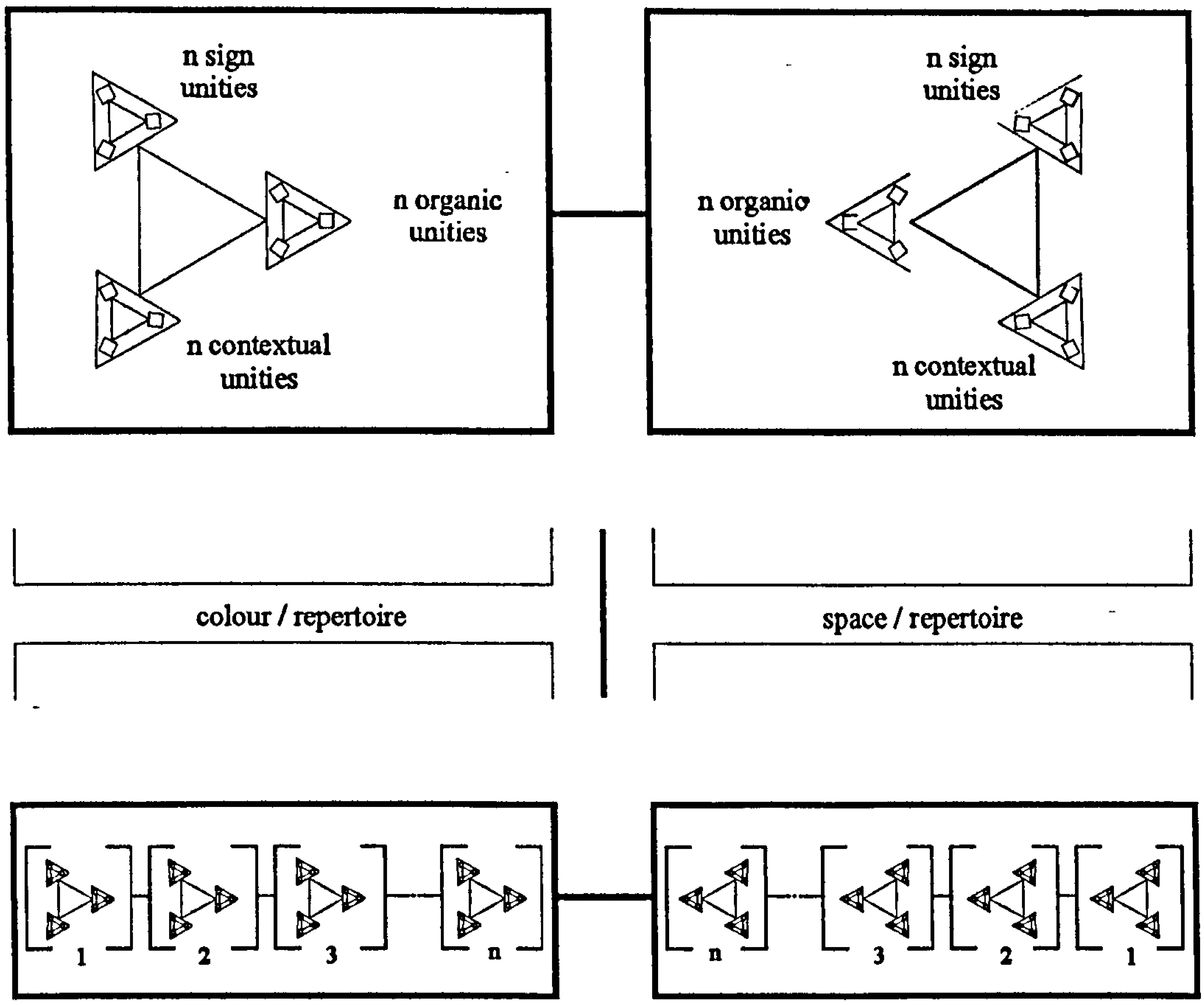


Fig. 8.10 Repertoires system of [(colour/space) time] communicative unities (2)

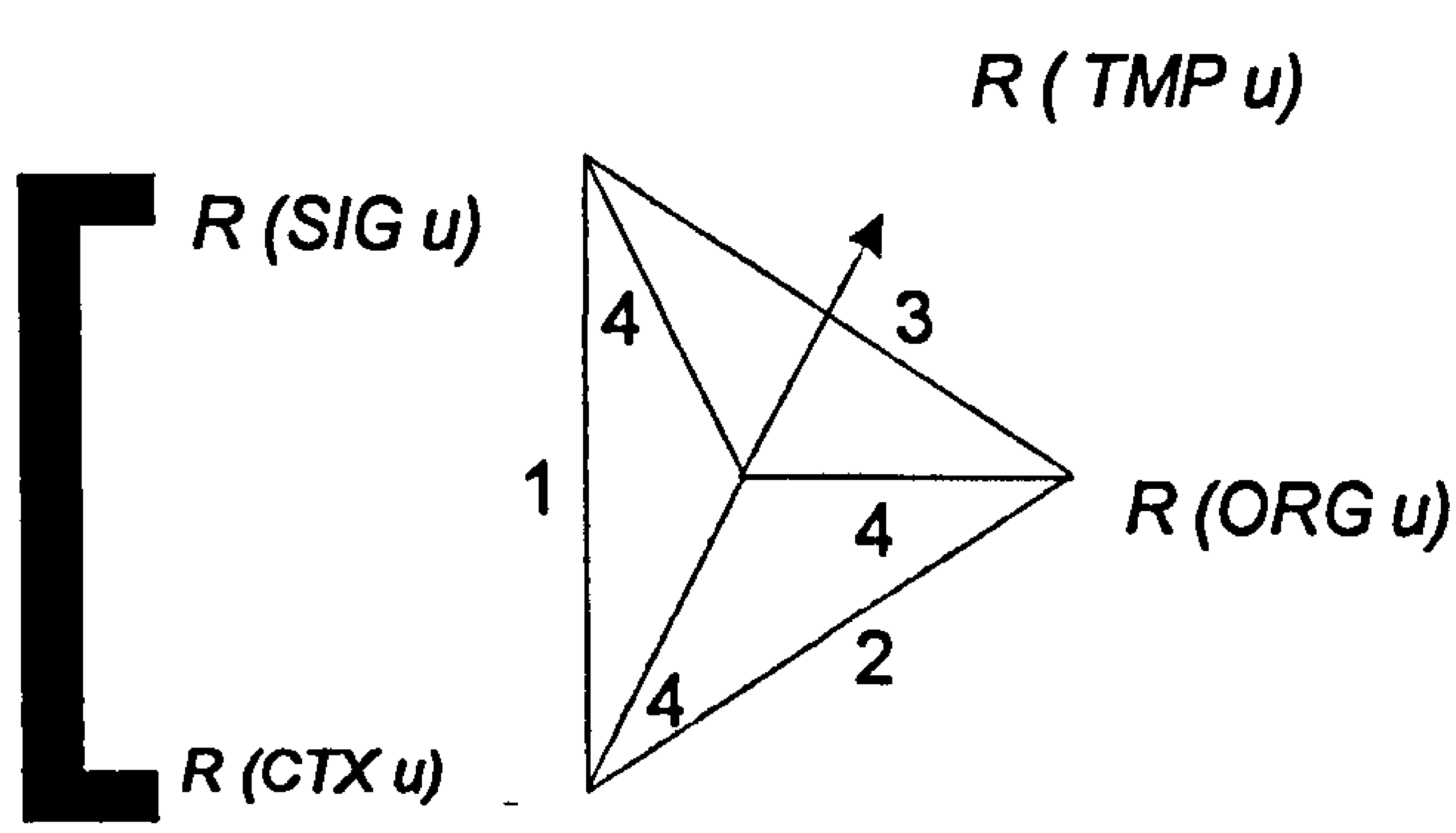
8.4.3.2 Relational system, processed in four movements by affinity to the component unities

R = repertoire

repertoire of

[*(colour / space) time*]

unities



8.4.3.3 Relational system of *repertoire of (colour / space) time unities*

The system can be constituted in two ways:

- series of repertoires, whose communicational specific values are equalised in the environmental / intentional relation;
- series of repertoires, whose specific values are differentiated in the environmental / intentional communication.

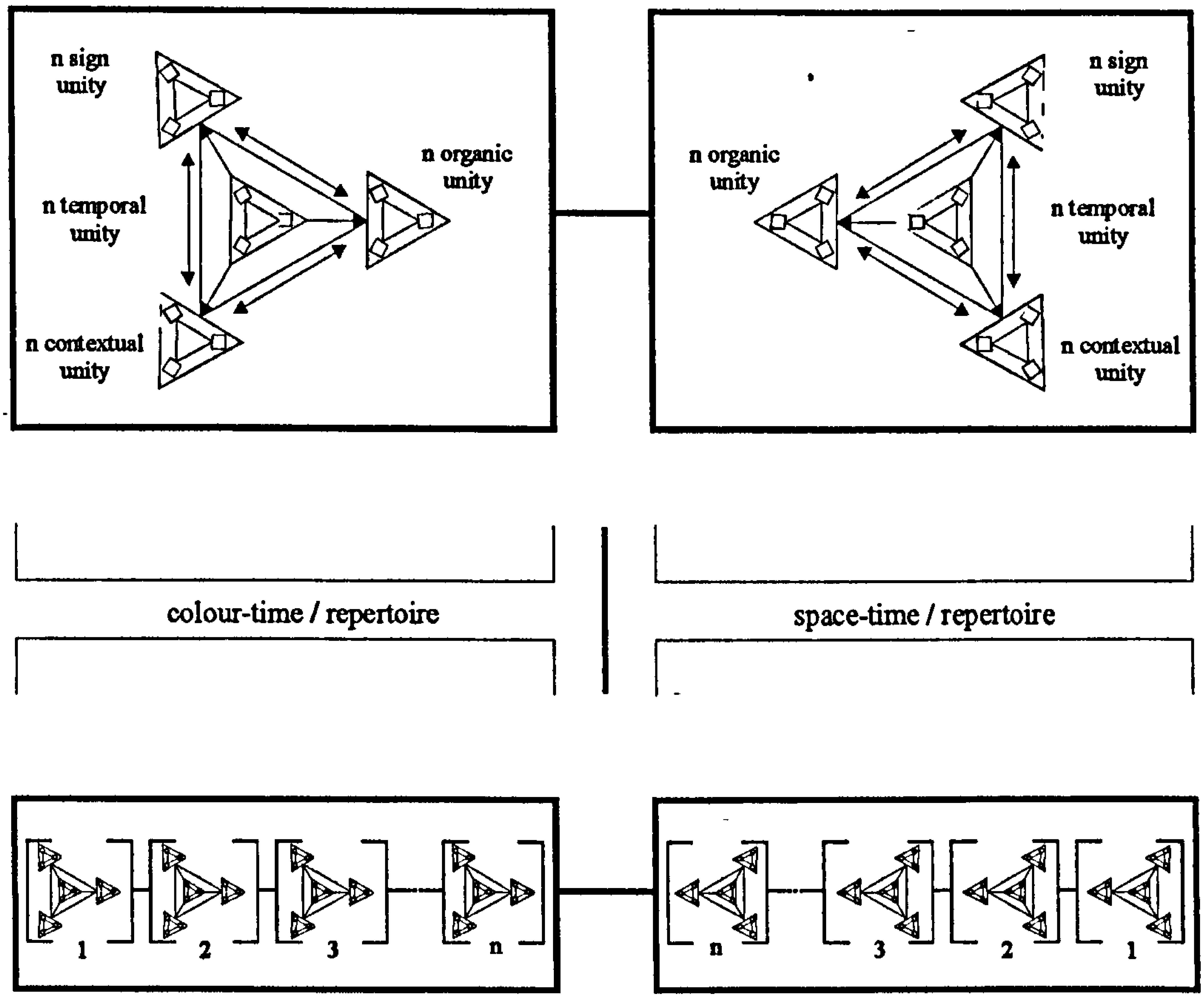


Fig. 8.11 Repertoires system of [(colour/space) time] unities (3)

For the first series of repertoires, they all present participation in languages which, even if differentiated and heterogeneous in context, none of them stands out, therefore, presenting approximate relevance levels. The standing out is in respect to an imposition on others because of stronger communicative interests, and / or, for stronger perceptive stimuli. In this case, they can all stand out in a moderated way, depending on the informative solicitations by the receivers, which vary from moment to moment, according to the communicational necessities and environmental use.

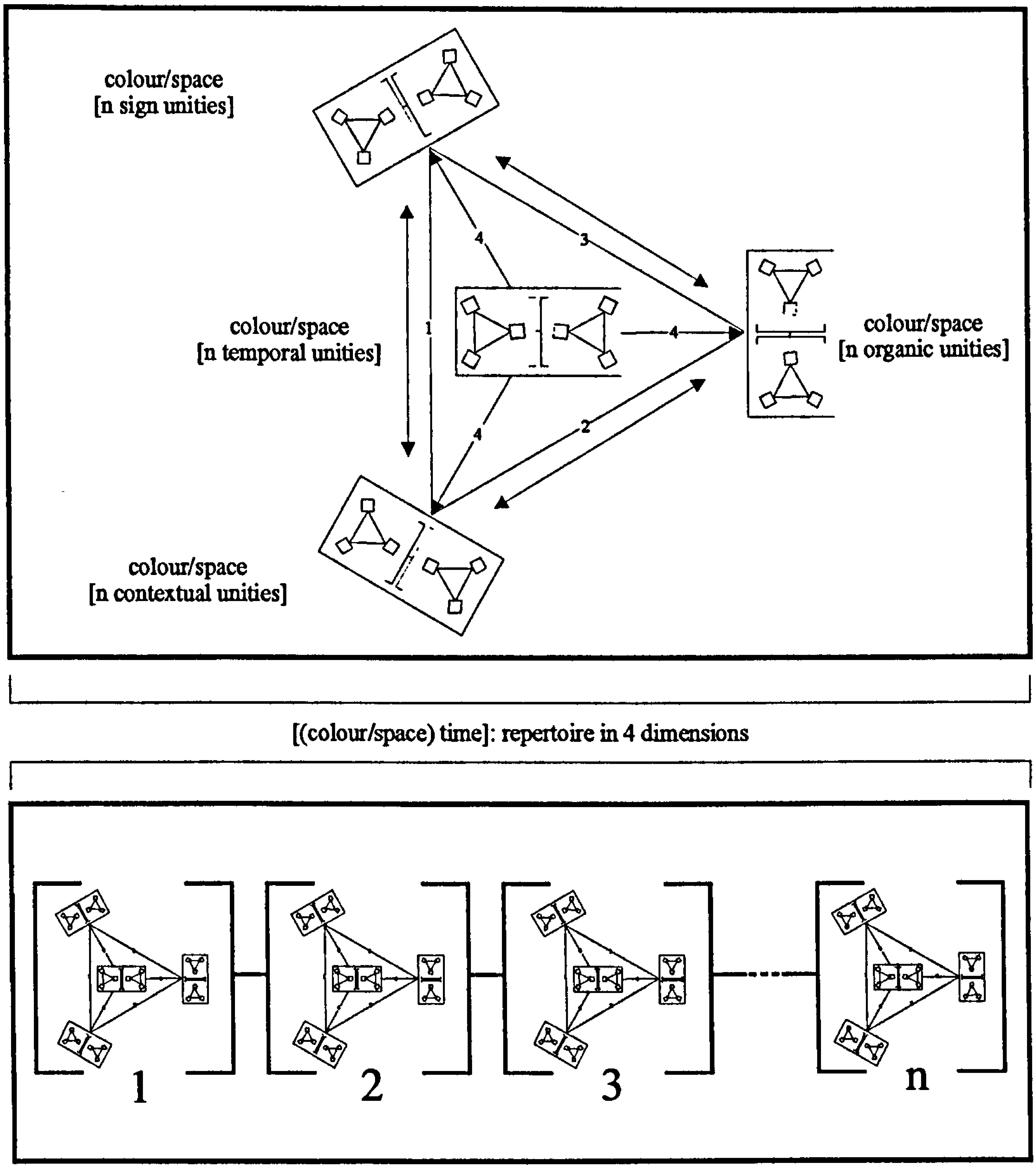


Fig. 8.12 Repertoires system of [(colour/space) time] communicative unities (4)

For the second series of repertoires, there are differences in the relevance levels of the languages to which they belong.

In this case, one or more stands out from the others in an accentuated way, constantly stressing its presence in the environment. The concept of key / repertoire is outlined, which in the same sense of key / colour has a predominance in the whole organisation of the message. Depending on the case, more than one repertoire can be considered as the key one, establishing in that way a hierarchy which reflects itself in the languages scale.

Summarising, the repertoires relate themselves:

First series: $\left[R_1 \circ R_2 \circ \ldots \circ R_n \right]$

$\circ$ n groups of $\left[(\text{colour / space})\ \text{time}\right]$ unities

Second series:

1 -

$$\left[\begin{array}{l} \left[R_1 > R_2 \circ R_3, \ldots \circ R_n \right] \text{, or} \\ \left[R_1 \circ R_2 > R_3 \ldots \circ R_n \right] \text{, or} \\ \left[R_1 > R_2 \circ R_3, \ldots \circ R_n \right] \end{array} \right]$$

always one standing out against the others.

2 -

$$\left[\begin{array}{l} \left[(R_1 > R_2) > R_3, \ldots \circ R_n \right] \text{, or} \\ \left[R_1 < (R_2 > R_3) \ldots > R_n \right] \text{, or} \\ \left[R_1 > (R_2 \circ R_3) \ldots < R_n \right] \end{array} \right]$$

some stand out more, others less.

One can find difficulty in an environmental communicative system where the languages come from repertoires, all of them equivalent in qualitative/ quantitative dimensions of colour / space.

This type of environmental visual expression, with a reduced dynamic, falls nearly totally upon the dialectical pole where the contents of less information are situated (Graves 1951).

An example could be what often happens with repertoires of colour/space used in residential areas. Many times in these environments, nature and the green areas are so reduced that they become unnoticed, for lack of visual stimuli. The built space is made up of differentiated languages, because they have a varied and heterogeneous structure, but they don't reach a sufficient minimum dynamics to correspond to a normal and common environment. They come from repertoires of excessive dimensional qualitative / quantitative visual equivalence.

The others series of repertoires are the ones which one can find in the most different environments and in the most different languages, whose degree of predominance is in the dependency of the scope of the articulation orders, in the present communication; in orders of incidences: sign, contextual, organic.

There is an extreme possibility of exaggerated predominances of many of the repertoires, the environmental expression falling upon the dialectical pole, where the contents of greater information are situated.
As an example that could be mentioned is what happens in a terminus bus station, whose architectural environment was originally well balanced in the informative qualitative / quantitative relationship, but other languages are superimposed, linked to the architectural visual structure itself, disturbing the formation of the spatial / functional unity, which becomes a shredded message and where each part seems to be an informative noise of the other. All possible messages of road signs, all possible and imaginable ads, fixed or movable, are added to it, and with all the vehicles also full of visual dynamics in the languages and paintings. A truly chaotic commotion of visual signs, which instead of communicating serve to confuse more.

As an example of balance in [(colour / space)] time , one can look at the city centre of Guimarães (North of Portugal) or the city centre of York (United Kingdom), whose repertoires were transformed in language / harmony, architecture and city. Messages which belong to a past time / moment, whose sign orders of colour / space persist in its intentions and meanings, in today's context. Existing and living in today's society, because it is organic and gets closer to the human being, reminds one of an intention which, harmonised with the object form and with colour atmosphere, is performed in permanent longing of the urban demanding, which at a certain moment happened like the own intuition of the architecture itself.

8.5 Analysis of the colour/space language kinetic according to the variables and invariables of the system.

According to the levels of organisation of the message the following items are considered variables and invariables in the colour / space systems.

8.5.1 Colour / space invariables

8.5.1.1 In the structure level they are defined according to the perceptive capacity of physical stimuli of colour / space, transformed in signals in the communicative structure.

Therefore, are invariables:

- The $(h \frac{v}{c})$ / S unities, in the relationships between their attributes and in spatial conception;
- The visual field of the $(h \frac{v}{c})$ / S unities;
- The principles of organisation of colour / space image in the relation figure - ground;
- The tonal contrast in harmonic spatial relationships.

8.5.1.2 At the signification level they are defined in accordance with the prevalence of the colour / space signs, which by some reason, such as that of constituting by themselves invariables in the context (the case of the signs proceeding from nature, for example), or by cultural, social traditions, etc., they remain constant in taking part in the significant structure.

8.5.1.3 In the communication level, similar to what happens in the signification, they are also defined by prevalences of colour/space, as to individuals behavioural uses and traditions, or in the society where they belong to and are linked to the significations which became invariables in the system.

8.5.2 Variants of colour / space

8.5.2.1 In the structural level they are defined according to the possibilities of perceptive extensions

· In the $(h \frac{v}{c})$ / S unities as to the degrees of differentiation between their attributes and spatial dimensions, and the constitution of different tonal classes derived for general and specific repertoires of colour / space signals;

· In the variation of image fixation point in the visual field, the principal point of stimulus or of perceptive interest deriving for the variation of the principal point of informative interest;

· The different types of image organisations as figure-ground, as to different forms and colours;

· The variation of the contrast factor in the definition of tonal repertoires.

8.5.2.2 At the signification level, they are defined according to the colour / space signs which are renovated, by exhaustion of functions or by evaluative transformations of their own environmental and life experience meanings (the example of styles and trends in art, architecture, or the technological transformations as well as materials, process of construction, etc.); or they proceed to similar languages, or other ones, which are new in the context.

8.5.2.3 In the communicative level, they are defined in accordance with solicitations of environmental and intentional needs of languages and messages of colour / space, linked to a relative renovation at the signification level. Signs and communicative unities of [(colour / space) time].

8.6 Behaviour of the colour/space signals and signs repertoires, as to the kinetic of the system.

8.6.1 With regard to the invariants of colour / space, the repertoires of signals obey the systems of tonal classes in their limits and differential thresholds.

8.6.2 With regard to the variants of colour / space, they obey to general lines established for variants in the system, already analysed, based in the formation of specific of colour / space signals and signs repertoires.

8.7 Colour/space, as an essential element of the project of architecture.

8.7.1 Architecture and urban planning: interaction of sensorial spaces.

Architecture deals with spaces, which are related to the group of our sensorial capacities. In the analysis done on space, it was defined as an essential element to the visual world, according to the physic-sensorial perceptive possibilities in relation to people's own being. Through the senses (the simple senses and complex senses) which are able to apprehend it and the conditions and sensorial extensions of spatial judgements, one tries to define the notion of environmental perceptive image, that in the whole is proportioned by those sensorial relations.

From the spaces with multiple functions, which architecture deals with, the participative space is defined as visual and in the composed sensorial relations, which concern it.

Like architecture, urban planning is a science of spatial relations in which the semantic-aesthetic values of the arts and communications are integrated. Urban planning co-ordinates multiple spaces of multiple homogeneous and heterogeneous structures, for multiple uses and functions. Spaces in which, like in architecture, there also exists the space of visual nature, in all its compound and complex sensorial relationships.

The environmental image of architecture and city is defined by the whole of the images particular to each sensorial group. Therefore, in order to have a dimensionally perceptive correspondence, the environmental image must belong to a field whose structure is co-ordinated by a sole system of extensions which are reached by perception.

For a relational act between man - environment, the field of perceptive nature has its extensions correlated with other type of fields: that of significative nature and that of communicative nature. Stimuli, significations and communicational organisms are therefore congregated, which in a structural interdependency compete for the formation of the perceptive / significative / communicative field of interaction, which constitutes the basis for the communication field itself.

Furthermore, through the communicational field, the environment has its own projection on people, as existing and living means and, consequently, people have their own projection on the environment as a mean of experience and existence grasp.

8.7.2 [(Colour/Space) time] communicational field

As one of the characteristics of the environmental image of architecture and of the city, that one which comprises the visual communicational manifestation is a structural participant in the communicative field, the visual space is a constituent element of the structural spatial whole of the environment.

One knows that visual space is constituted by a relationship between space / light and colour, and space / geometrical configuration, resulting in the expression and visual content defined as colour / space.

Therefore, colour / space belongs to the environmental image of the communicational field.

The communicational field of colour / space is defined as the one which joins in interaction the respective perceptive, significative and communicative fields of space / light and colour, and of space / geometrical configuration.

In the analysis previously done concerning the fields related to those different natures and levels of apprehension, the temporal dimension was defined, which gives the image the meaning of succession in space-time, in the interdependency with others from which it is derived.

The communicational field, therefore, has its own temporary structure, which follows that of its components in interaction.

In conclusion, the communicational field of the environmental visual image belongs to the [(Colour/Space) time] dimension.

Considering the existence of both temporary conditions of the communicational field, it subdivides itself thus:

· Communicational field of the present moment, which is real and effective, physically emitting signals, signs and communicative unities to the recipient;

· Communicational field perpetuated in space and time, which also belongs to that which is transmitted at the present, but resulting from an assembly, or conjugation, or fusion, or superimposition of other images which had their other moments, with the particularity of extending their existence by a constant definition of strong signs which enforce their continuity.

By this type of field, the present image, transmitted to our eyes, allows these same eyes to see other images of past moments from which some values of signs, contexts, and organic orders, even if very reduced, complete a perceptive, significative and communicative whole. Present images joined together with images of the visual thinking.

Present images are a physical and tangible event, because they are in front of people at the perceptive moment of the field. Continuing images in space and time belong to the visual thinking, because, beside the current event, they have deep communicative values: they put into perspective ways of knowledge, reflect culture, associate individuals, display existential, environmental and lived characters, and from them derive signs for a produced space which continues in insertion and appropriation of the natural space.

8.7.3. In the communicational field: the interpretation of colour/space codes in continuity, in space-time.

Considering the kinetic relationship of space - time $\left(\frac{s}{t}\right)$, and the interpretation of the codes which are constituted by the relationship between points of communicative intention and moments of intentional communication, in the game of constant (variable) and inconstant (invariable) values, the result for the communicational field is a sum and/or conjugation of languages that extend themselves:

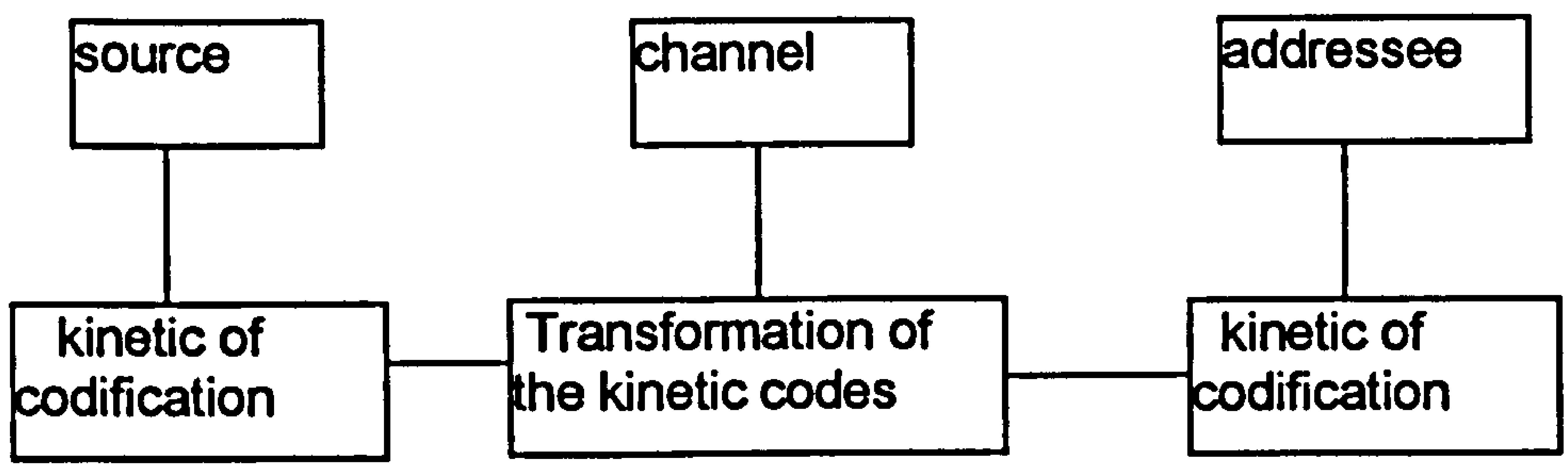
- from the moment of origin
- at the actual moment, and
- at the hypothesis of future possibilities.

On the whole, the colour / space codes, originated from those communicational fields, are established by the continuous and constant relationship between the possibilities of variation in the source - environment, and the demands of variations requested by the addressee - receiver. Belonging to an evolution, which occurs in the relationship space - time $\left(\frac{s}{t}\right)$, between a code and another code there is a connection through a channel $\left(\frac{s}{t}\right)$, which is therefore also of kinetic nature.

The relationships between language codes are established, therefore, through connective channels $\left(\frac{s}{t}\right)$. These channels are of environmental / intentional nature, therefore, joining constants and inconstants of syntactic / semantics / pragmatical nature.

As a result, the colour/space languages have their own definition in codes of space - time, which are ordered according to constant values and changing values, i.e., according to the following relationship:

Constant codes / transforming codes, defining the kinetic of visual communication of colour / space in the communicational field in environmental / intentional continuity, in space and time:



As a conclusion, the group of hypotheses verified and evaluated in the environmental process, aims for the formulation of the concept of colour/ space communicational unity, the environmental/intentional whole in the interdependency of the parts by space and time.

8.8 Colour Planning

"There must be a balance between excitement and repose, between the inevitable and perhaps desirable overloading of our senses on occasion and the familiar and stable, but equally necessary, parts of our surroundings" (Lancaster 1996).

"Architecture is the manifestation of a certain type of hypothetical-deductional thought, which uses ordinations of scientific and artistic type." (Rodrigues 1998)

"By the nature and specificity of the habitat they constitute, cities are a privileged space for the study of environmental questions and for the evaluation of the interaction of the whole of factors, which integrate the ecological urban system.
In this system, the natural factors inter-relate themselves with the human factors, originating a particular echo-system of intense energetic changes where the ecological and anthropologic components, assembled, perform an essential role in the formation and regulation of the habitat.

But in reality, most of the times, this eco-system is profoundly changed and it presents symptoms of a deep and growing unbalance, which reveals its fragility as environmental entity and as life permanent support.
According to this warrant reality it is opportune to verify what cities are nowadays and in what they may become. For the very first time in the history of humanity, more than half of the world population lives in cities, presenting a growing tendency. Cities are already the dominant human habitat, what justifies their relationship with the territory life, the universe of the physical urban planning, limited and limitative, to become a debate subject and a worry of citizens who live, work and amuse themselves in them, giving them life.
The social pressure, as factor of transformation of reality, has been focusing the increasing of better urban environmental conditions as a central objective of the urban life, with reflex action in the establishing of new relationships in its interior and in its understanding, as a built reality, where the natural and social factors interconnect themselves in a strict way and originate an autonomous entity.
Being possible to have a better life in nowadays cities, it is necessary to find the correct proposals, in a way this possibility to become real and visible. This is a responsibility that people have, as technicians and as citizens.
The reality and the history of growing and expansion of cities show quite different situations, where life/social/urban environment quality presents breaks between the wanted (desired) thing and the projected one" (Fadigas 1993).

"Colour can best portray the particular character of a city, what it was, is, or wants to be in the future" (Tosca 1994).

In the urban space, the hidden dimension of colour is determinant, constituting itself as a data of the project.
To forget the spatial of architecture, when using colour, to consider the object as something in itself without the inevitable disruptive presence of light, is a pictorial

attitude separated from the contingency of submission of the points of view and lighting.
Even assuming that a building can be seen as a silhouette on the space, the fact is that to complement itself it needs the light, which gives it shape and its relationship with the environment.
The chromatic effect of a space doesn't come only from the pigments applied on surfaces, which configure or contain itself, but the impression also comes, in similar proportions from the shades and their distribution; because the shade has colour and, therefore the relations between shades and surfaces has to be thought about because they can nullify themselves.
Since one cannot separate shade and shape, and since the more complex the shape, the more complex the shade, the formal development establishes a limit for the necessity to apply colour to a certain point.

When introducing certain materials in the design of space or the same material in different positions in space it is inevitable to deal with and articulate a variety of coloured impressions, which change themselves by the supplementary experience of all the other visual elements (Loução 1993a).

This way, any chromatic experience is the result of its contents, i.e., people see the colour associated with other colours, silhouettes and textures because each material has many variations of shade, saturation and value.
In the project of architecture, the material of construction becomes the material of architecture and, with it, colour which confirms it. People cannot consider static values of colour in which only the walls and coloured glass (reflective or otherwise) count. The combinations of colours are infinite; and if people had the steel, the copper and the marble whose varieties and tonalities are in themselves infinite, one can have an infinite number of tonalities. The colour, being derived from space, establishes relations with the other components, which create a dialogue. It is following the constitution of the visual speech that one gives a meaning to it.

Throughout history, colour has been used as a dramatisation of space like dimensions, silhouettes, volumes and textures.
The motives that originate certain chromatic expressions are various. It has not always been an act expressed intentionally: often the colour occurred casually. There are some factors like taste, negligence or even irony which head some of the choices people make.

The city colour comes from substance as well as it being a cóndition of life, a characteristic of an era's style, giving a certain way to view the world. It is, therefore, an aspect of its history.
The reflected light defined by lighting and by reflector power on illuminated surfaces, originate the luminosity. The relations of luminosity are the ones that constitute the material of the project of architecture, because they relate to four conditioning levels:
- The visual field
- The outline
- The peripheral field
- The environment.

Visual field evolves decisions about the level of luminosity against visual objective, chosen as an ordering element of the space in question, as well as the assumption of contrast of luminosity between object and ground. Normally, complemented by decisions on contrasts of colour, to preserve or to cancel, definers of the type or the outline, which will create the administration between various peripheral fields, constitute a background to the visual action, contributing, in a clear way, for the expression of environment and of space characteristics.
Lighting changes the dimensions of colour and, therefore, the characteristic and potential of the space contained in it. So, the colour doesn't intervene in the space, it only intervenes in itself, by the way it is used, according to its situation. Lighting, being seen as a functional element, assumes itself as spatial substance, because it brings safety and comfort as well as creating images (Loução 1993a).

As the colour of architecture is a colour of synthesis and of relationships, it varies depending on the point of observation and, in each quota it confirms or annihilates the space structural relations.
The reality of a city (the urban reality), particularly at the street level, lives from the continuous changes, the graffiti, the advertisements, and the colour of the cars. The city colour forms itself from factors, which are beyond the architectural space components although they alter their meaning.
The readings of a city, at street level reveal in a clear way the cultural identity, the tastes and the way to satisfy them, conferring on the scenery a kaleidoscopic sense, in which the juxtapositions lead to frequent alterations to the rules of the composed volumes which configure the space, as if it was another visual universe.

In the urban space, the reading of colour is always done in confrontation with the factors which determine it: materials, light and user, organised in variables such as solar orientation, relations of proximity with the observer, the way the pavement or the sky intervene with visual components of space and, consequently as project data of that same space.
As the lighting is the first factor of variation in the chromatic perception, the second one is the spectral properties of the architectural material, which cannot be considered as not being present in the reading of the urban space. The third factor is the colour of the non-architectural configurations; the colour of the sky, the pavement, the ghost colour (not expressed) in the territory.
Finally, the fourth factor is the chromatic sensitivity of the observer. It is a complex process because it is at the same time cultural, therefore collective; psychological therefore private; and also physiological and therefore universal.
Despite the infinite variety present in the chromatic manifestation of the urban space, it is possible to establish a method basis of reading, which involves:
· scales of observation
· speed of observation

• type of vision: lateral, central, below or above
• type of light

This way, an approach of project type will have to have influence on: ways of approaching, conditions of observation, recognising the exogenous factors to the visual impression like the memory and culture, in order to make a diagnosis and subsequent proposal.

The same substance presents various chromatic expressions depending on the variation of its position. A roof-tile, even if made of the same material as a wall, will always seem darker although it receives more light from the sun, because the effect caused by the projected shadow of the elements which comprise it on the surface's colour, creates an effect of macro-texture.
Because the reality is indissociable from the scale, form and proportion, the space through colour assumes the value of significant.

The plastic value of the colour comes from it as a whole, having therefore to establish relations between colours, and such operation is never inconsequential.
The polyphony or contrast of values is specifically presented in the variation of distance of observation, where value acquires a special role against hue or saturation.
Considering now the variable values. They are: the incidence of light on surfaces, water, trees, the shades, the reflexes, firmament, the vehicles, people with their drab coloured clothes...
Within all this diversity there only exists one common denominator: the observer, space user, and only he has the key to decipher it. The user has the keys for decoding the chromatic universe, which come from its physiological constitution, its psychological structure and its cultural pattern, at the same time, adding to the sense of chromatic impressions, from which originates the chromatic characteristics of the city.

The process of colour planning must be at once sufficiently prescriptive to make the objectives achievable and flexible enough to accommodate changes of use, occupation, building structure, fashion and taste.
A colour strategy implies not only a plan but also the establishment of procedures. Above all, it depends upon the prediction and communication of an acceptable vision of the future.

"Changes are occurring among a number of scientific premises, and these changes are not restricted to modern physics. Change is also occurring in human culture through a radical transformation of our values. In this cultural context, colour seems to have acquired a primeval function, either as an indicative sign or as a sign that, when manipulated and structured, serves as an accelerating agent in the development of a new universal vision. Colour is the pretext for a new form of interaction and integration among beings and with the world about them" (Henry 1991).

Most large-scale examples of colour planning have been generated by the perceived need for conservation. The colour plan of Turin was the first successful experience. There has been a proliferation of colour plans for other cities, especially for the historic centres, like Rome, Valencia, Barcelona, York, Guimarães, Bruges or Aschabad, among (several) others.

Fig. 8.13 The historic centre of Turim
(Lancaster 1996 b)

Fig. 8.14 Bruges (Lancaster 1996 b)

Fig. 8.15 Plan of Aschabad, Turkmenia (Lancaster 1996 b)

8.8.1 Traditional Architecture

The buildings of traditional character have a characteristic communicational field, transmitting constant codes in space and time, in a game of environmental / intentional constancies and transformations, through which the channels of communicative connection, an expressive group of communicative intention points of the colour / space languages, maintain themselves unchangeably, in the evolution of intentional communicational moments.

The persistency of a certain number of invariables contributes to keeping a certain equilibrium in the dynamics of changing languages caused by variables, transformations caused by influences received from other communicational sources which transmit other codes and introduce changes in the points of intentional communication at different moments of intentional communication, in traditional architecture.

Each time, an invariable present moment meets with various other moments in time, variables of strange codes, a sort of conflict of languages starts, introducing the kinetic of the adjustment and of the continuous and constant search of local values, and imposing new codes in the regional individualisation of new repertoires.

It is true that the influences were also the result of the development of human life, which even if having not received information from other cultures, transform itself and its own repertoires, creating new codes, although the process is extremely slow.

In the cities, there are other materials, resulting from elaborated techniques. The spaces are previously limited, the objects are shown for acquisition appealing to a new comfort, indicating new ways of life. The colours are superimposed as if trying to overpower an environment already predominated by manufactured chromatic artifices.
The repertoires in the cities are blown up, the choice becomes tiring, the vast amount of displays are a distress and there is a tendency to forget the original values. The technological imposition is a necessity. The extension of comfort is indispensable. The orientation for improvement in quality of life, is an obligation of one who plans and projects.

8.8.2 The Architecture of the city

Contrary to traditional architecture, construction in the urban centres, in developed cities, set up examples of messages, which transform the codes in an unstable balance with the environmental / intentional constant values. Frequently, in these languages the values of origin don't exist anymore, they are part of a story told by abstract codes, which fade from the memory even though they once existed or were known as having existed.

The city has a characteristic communicational field but is constructed on concepts different from that of popular housing. In the city the messages are based on the quick kinetic of variables which keep in continuous unsteadiness the points of communicative intention, which vary inside the same moment of intentional communication in order to reach the scale of individual communicational field in the society of masses which multiplies values, stretches aspirations and stimulates competition. The invariables are, therefore, defined in an absurdity: what doesn't vary are the transformations, therefore, the own variables are invariables.

The landscape of fullness and voids transmits codes which are in constant mutation, and they almost lose themselves in continuity in the space and in time, through connective channels which most of the time are not able to keep tracks of expansion / environmental content / intentional of colour / space signs.

In the confrontation between the example of popular architecture and the architecture of a city, one can conclude that the messages are situated in different poles regarding qualitative / quantitative dimension of colour / space visual information. Therefore, if one wanted to measure the strength of the codes in confrontation, the opposition and contrast, on one hand, define values as: more common, redundant, intelligible, periodic, foreseeable; on the other hand, they define them as: not common and not redundant, unstable between the emission and reception by the irregular and unforeseeable addressees.
An informative dialectic of colour / space, in the own dialectic of city / countryside visual communication.

8.9 Summary

After the investigation of the first part of the hypothesis, to prove the existence of a unity formed by colour and space, which is a unity of visual communication, the research continued in this chapter, exploring the colour/space systems and its visual programming for the built environment.
It also addressed the colour planning issue, in such a way as to prepare for the investigation in the next chapter, where a survey search through questionnaire and interviews was conducted. This survey search will serve to allocate the findings and interpretations of the first part of the hypothesis, investigated through a review of the relevant theory, and to modify the initial theory.

CHAPTER 9

SURVEY

9.1 Introduction

In chapters 6, 7 and 8 the author investigated the first part of the Hypothesis through the continuation of the relevant literature review, plus the author's personal experience as a professional architect and urban designer, as a teacher running courses of architecture over 20 years and as an investigator of the subject since 1984.
In this chapter the investigation will address the experts evaluation on the subject, as well as the opinion of a large group of society members, in a way to not only evaluate the findings of the first part of the research done through literature review, but also to add the investigation more information about the hypothesis.

9.2 Survey methodology

Survey methods themselves are classified according to the means of communication: mail surveys, face-to-face interviews and telephone interviews. Each method has strengths and also weaknesses. Refer to Table 9.1 for some of the strengths and weaknesses (adapted from Ohemeng 1998). The most appropriate method to use depends on the circumstances of the research.

Hence a communication method by way of questionnaire survey was chosen for the collection and analysis of data. The main reasons for this are:

- This was an academic research, which had the objectives of confronting public opinion with the research findings and with colour application and management in the built environment. Time to collect and analyse the data was not considered to be much of a determining factor in this situation because of the relatively long duration of the research programme.

Besides, the results were neither required to solve an immediate management problem nor would they have become outdated in the time it would take to present the findings.

Using the criteria of minimum cost and wider coverage in a situation where speed of data collection was not a major factor, the most appropriate survey method was mail survey (see Table 9.1).

Table 9.1 shows that mail survey has certain weaknesses, which must be minimised to improve the quality of the research. For instance:

- there is no control over who fills out the questionnaire. An ineligible subject could therefore complete the questionnaire.
- since respondents can read the entire questionnaire before deciding to answer, they could decide not to respond at all if they find that the time and effort required of them is too much.
- since there is no interviewer present to probe for more information or clarification, the quality of responses could be poor.
- there is no control over when the questionnaires are completed and returned.
- there is usually no way of knowing if subjects have either changed addresses or moved away. Thus research resources could be wasted on subjects who cannot be contacted.

Notwithstanding these drawbacks, mail survey was chosen. Precautions were, however, taken in the data collection and subsequent analysis to minimise the effects of these drawbacks.

9.3 Sampling

The next step considered after choosing the data collection method was the selection of subjects for the study: the sampling process. The sampling exercise that was carried out considered the issues of:

- defining the population of interest;
- the availability of sources where elements of the population are listed (the sampling frame);

Table 9.1 *Strengths and Weaknesses of the Basic Survey Methods (adapted from Ohemeng 1998)*

Criteria	Mail Survey	Telephone Survey	Face-toface Interview
1. Speed of data collection	No control over return or questionnaire; can be slow	very fast	moderate to fast
2. Cost	lowest	low to moderate	highest
3. Geographical coverage	may be wide	may be wide	limited to moderate
4. Versatility of questioning	highly standardised	moderate	quite versatile
5. Questionnaire Length	short to medium	medium to long	can be long
6. Respondent co-operation	moderate	good	excellent
7. Item non-response	high	medium	low
8. Interviewer bias	none	moderate	high
9. Anonymity of respondent	high	moderate	low
10. Possibility of respond misunderstanding questions	high	average	lowest
11. Use of visuals aids	good	usually not possible	very good
12. Quality of recorded responses	fair to good	very good	very good

- the size of the sampling; and
- the means by which the sample is selected.

From the research objectives, the intended subjects of the study were architects, landscape architects, engineers, designers, colourists, students (undergraduate students of architecture and design courses) and users (people living in different areas of the city), because they are the primary population of interest. The aim of the study was to be able to generalise the findings beyond the sample to the population of interest. Consistent with this, simple probability sampling techniques, where each element had an equal chance of selection, was therefore adopted.

9.4 Questionnaire design

As mentioned earlier, the data required to satisfy the information needs of this research was collected by means of a questionnaire (full test response). A good questionnaire must be able to:

1. validly measure the factors of interest;
2. induce respondents to cooperate with the study; and
3. elicit acceptably accurate information from respondents.

In designing the questionnaire for this study, consideration was given to these criteria. From the literature, there is no one set of formal guidelines to follow in the design of questionnaires. The steps followed, which were not sequential as shown, are presented in the following order for ease of discussion (after Schuman and Presser 1981):

- the question content of the questionnaire;
- question framing;
- the response format;
- the question sequence;
- the questionnaire layout; and
- pretesting and revision.

9.5 Question content

The questions in the questionnaire were intended to satisfy three basic conditions:

1. they were to ensure that the data was collected from the intended subjects.
2. they were to ensure that the information collected was sufficient and did satisfy fully the information needs of each of each main research question.
3. they were to ensure that any possible variation of the measured factors with the population sub-groups were investigated.

9.6 Framing of questions

The determination of the desired question content was followed by the consideration of how to translate them into word expressions to elicit the intended responses. Schuman and Presser (1981) describes the process survey respondents go through to respond to questions as:

- the initial reading of the question;
- the attempt to understand and interpret the question;
- depending on the nature of the question, recalling of past information or the formation of a judgement; and
- finally, the provision of a response consistent with the recollection or the judgement made.

Each questionnaire item was framed to make each stage of the process described above as easy as possible. This was not only to ensure that accurate responses to the questions would be obtained, but more importantly, to induce respondents to complete the questionnaire.

Simple words were used in framing the questions to avoid ambiguity and unclear questions. This was to minimise the risk of misinterpretation of questionnaire items and also to make the task of respondents less difficult. Whilst ensuring that bias was not introduced, careful hints were given on the questionnaire to guide respondents.

In the design of the questionnaires, an attempt was made to construct the questions for each of the seven groups of participants in such a manner so as to facilitate an inter-group comparison.

9.7 Response format

The next issue that was considered, after framing the questions, was the form of the responses to the questions. For each questionnaire item, this depended on the question and the amount of information already available from the literature review search. Careful consideration was given to the fact that the questionnaires were to be self-administered in deciding the response format.

The aim of this data survey was essentially given as confirmation of the findings identified trough the relevant literature review search and the uncovering of additional findings that were not found in the literature review. These circumstances meant a highly structured questionnaire consisting of mostly closed-ended questions. This was however balanced by making provisions for respondents to add more information in an open-ended format (sections 2 & 3).

9.8 Question sequence

The next essential issue considered was the sequence of the questions in the questionnaire. The prime objective of the question sequence was the securing of maximum cooperation from respondents. Another objective was to avoid biasing later responses by questions that had been asked earlier. This required a logical flow to the request for information. The following guidelines were therefore adopted (Davis 1978):

- questions about one topic were completed before moving on to the next;
- questions about job titles, job responsibilities and decision capacities of respondents were asked last.

9.9 Questionnaire layout

The final issue that was addressed was how the questions were to be laid out in the questionnaire. To minimise confusion, each of the different topics in the questionnaire was clearly demarcated into distinct sections. Each section was preceded by a brief commentary on the frame of reference and the general purpose of the questions in that section. Instructions were also given where it was considered necessary.

Attention was given to such physical characteristics of the questionnaire as line and character spacing. Adequate space was provided between lines, multiple-choice tick boxes and the different sections (see questionnaire in Appendix A). Adequate space was also provided for responses to the open-ended questions. Finally, within the limited budget of the research, the questionnaires were laser printed on good quality paper. The cover to the questionnaires stated boldly the title of the study, giving the impression of a professional looking document to increase respondent interest.

9.10 Pretest and Revision

The questionnaire design was carried out on the basis that respondents would understand the questions and know what was required of them. Pretesting of the questionnaire therefore became essential to test the validity of the assumptions made on how respondents would understand and answer the questions. Pretesting was also critical to determining whether the questionnaire would collect all the data required to satisfy the research objectives.

The pretest exercise was carried out in two stages.

The first stage consisted in a feasibility test, using a panel of 25 experts. In this first stage, the research used structured interviews, in a way to reinforce the strengths of the survey method:

- face-to-face interviews;
- to be sure all the questions to be answered;

- to verify the questionnaire layout;
- to validate the approach to the research subject.

The constituents of the panel of experts were as following: 9 architects, 5 colourists, 5 engineers, 3 landscape architects and 3 designers. As the author teachs in schools of architecture and design, it was quite easy to find an select the experts. They are considered experts for the recognised role they have been playing in their professional areas.

After introducing several changes into the questionnaire design, as the main result of this test, a second stage was carried out on a small sample of individuals who were considered to be similar to the target population (21 individuals, being 3 by each group of respondents).

To sum up, the pretesting was carried out to check:

- whether the language of the research area had been captured properly;
- the questionnaire was capable of collecting the required data to satisfy the research objectives;
- there were other responses that had been omitted for the multiple-choice questions in the initial draft.

The pretesting was very useful and it led to some useful changes in the number of questions, the wording of some of the questions and the sequence of the questions. Refer to Appendix A for the final draft of the questionnaire which went out to respondents.

9.11 Fieldwork

The questionnaires were sent by mail, with covering letters, to the sample groups of survey participants with the exception of the users. The author himself administrated the questionnaires to the users, giving them a previous explanation about the subject and the context of the survey. The users are people in general, city inhabitants. all the students are in undergraduated courses where the author teachs. Before the distribution of the questionnaires among the students, the author gave a lecture about the research subject. The remain groups were selected according to the national associations lists and author's personal acquaintance. The survey was undertaken in Lisbon (Portugal), from 22 June 1997 till 19 September 1997, (it being much easier to receive the returned questionnaires as the author is based in the city). 2,802 questionnaires were distributed: architects - 581; landscape architects - 253; engineers - 282; designers - 445; colourists - 104; students - 518; users - 392. The questionnaires were conducted in portuguese and a copy of the portuguese version is included in Appendix A, as well as an english translation. The participants were requested in turn to return the completed questionnaires by post. A proportion of the questionnaires were delivered personally given to the respondents, especially those, which were distributed to the undergraduate students of the universities where the author runs classes and, of course, to the users group.

The cover letter was composed in an effort to maximise cooperation. It stated the institution conducting the survey, the purpose of the survey, and who should complete the questionnaire. Perhaps most importantly, the cover letter also contained an assurance of confidentiality should any of the respondents find some of the information sought to be either sensitive or confidential. As a further bid to maximise return of the questionnaires, a self-addressed envelope was enclosed with each questionnaire.

To be able to monitor the progress of the survey returns, a spreadsheet table was created. The table had columns fields for respondent name, date questionnaire posted, date of questionnaire returned, date of follow-up and the date questionnaire returned after follow-up. It also had a comments column which commented on whether a particular survey was successful, a non-contact, a refusal or a non-response.

A period of eight weeks was allowed for return of the completed questionnaires. By the end of this period, the returns had already tailed off and stopped completely. The total number of questionnaires returned was 2,092. Of these, 107 had been returned by the Post Office as addressee unknown. One thousand nine hundred and eighty five replies were received. This response rate (71,2%) is really significant and sufficient to provide a reliable representation of the whole sample frame. So, a follow up of the unreturned questionnaires was not necessary. One hundred and twenty questionnaires were not correctly filled. So, remained 1865 questionnaires to be analised: architects - 410; landscape architects - 168; engineers - 149; designers - 280; colourists - 93; students - 373; users - 392 (as the questionnaires to users were self administrated, the total number of distributed questionnaires and the number of selected ones is the same).

Only results from the questionnaires were reported.

9.12 Data reduction and analyses

The final stage in the data collection process was to analyse and interpret the data collected. The data analysis involved the reduction and presentation of the collected data into a format that permitted meaningful conclusions to be drawn with respect to the objectives of the research.

The data reduction for this study consisted of the initial salting of the collected data followed by the creation of tables and graphical representations, involving the calculation of sample statistics. The analysis ended with the hypothesis testing.

The steps followed are described under the following headings:

- Validation and editing of questionnaires;
- Coding and data entry;
- Graphical representation of data and descriptive statistics;
- Estimation and hypothesis testing.

9.13 Validation and editing of questionnaires

Each completed questionnaire was validated and edited before the data was entered into the analysis. The validation and editing exercise included the checking of the eligibility of the respondents as well as the completeness of the questionnaires.

The first eligibility check was to determine if the respondent belonged to the population of interest, according to the population definition.

Then, the completeness of each questionnaire was inspected to see if any question items had been left unanswered or had been answered incorrectly. The unanswered questions, as well as the pontually answered incorrectly, were recorded as <u>no opinion</u> or <u>no answer</u>.

9.14 Data coding and entry

The next step was to reduce the sanitised data for analysis. The first step was to code the responses before entering them into coding tables. The coding exercise started by establishing codes for the range of responses for each questionnaire item. For each question, the response categories were represented by alphabetical letters. Alphabetical codes were used to allow data counting by Microsoft Excel version 5.0 spreadsheet package (Appendix C).

The questionnaire was highly structured where most of the response categories had already been established during the questionnaire design stage. The only remaining task was to specify the codes for the response categories.

It can be seen that the questionnaire (Appendix A) did contain some open-ended questions which required respondents to supply responses in their own words.

For these questions, the response categories were established after the return of the completed questionnaires. For each of these questions, the coding categories were only established after the consideration of the range of responses.

The coding exercise was followed by the entry of the codes into basic data arrays for all the questions for all respondents.

9.15 Graphical representation of data and descriptive statistics

In the following discussion of the results, percentages refer to groups responding to specific questions. However, it should be noted that greater reliability attaches to the whole sample than to individual sub-groups.

The survey results are discussed question by question and compare the participating groups' opinions about each issue.

Respondents comprised 410 architects (22%), 168 landscape architects (9%), 149 engineers(8%), 280 designers (15%), 93 colourists (5%), 373 students (20%) and 392 users (21%).

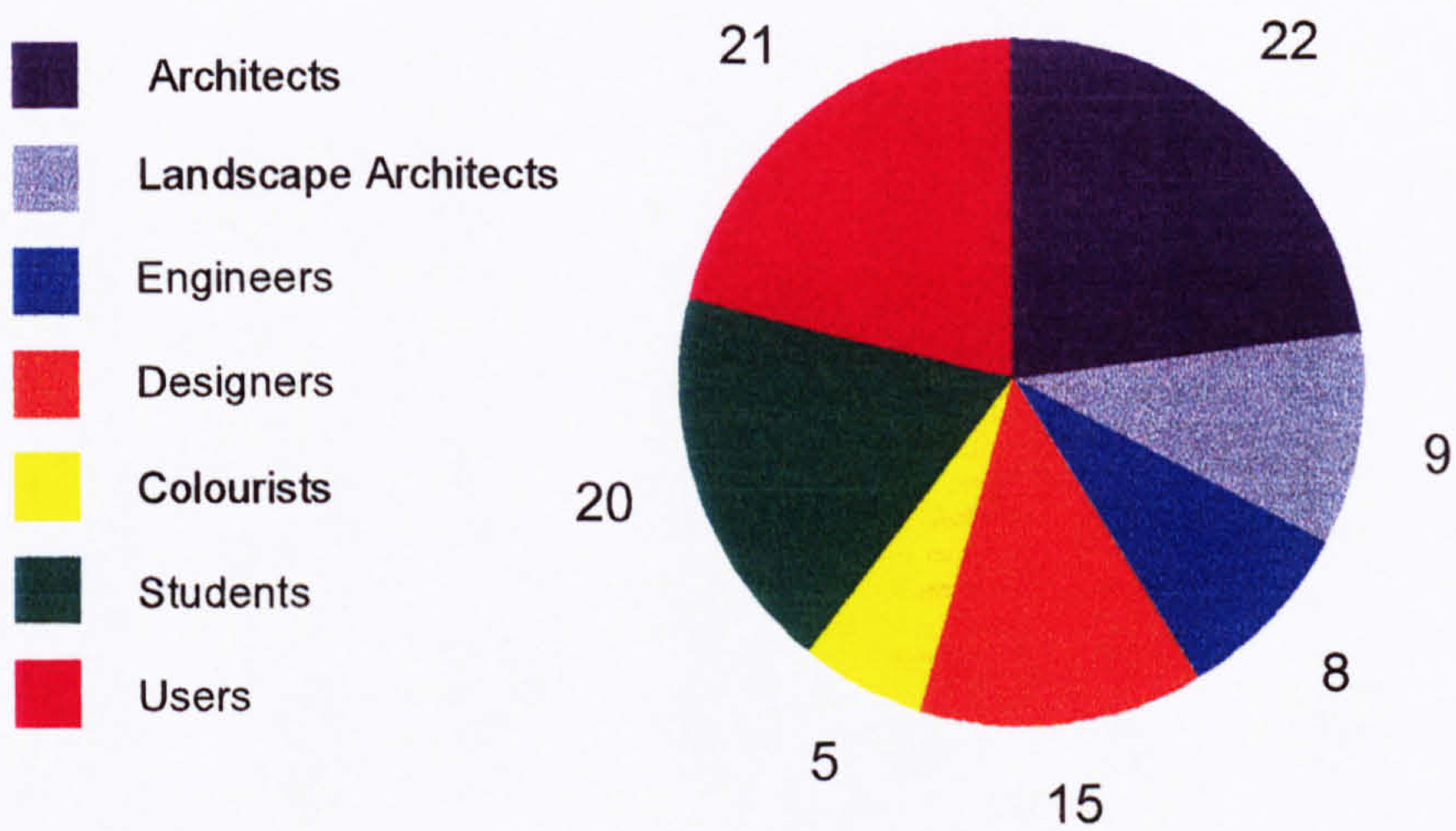


Fig. 9.1 Graphical representation of respondents

The questionnaire was divided in 7 different sections, making it much more simple not only for the person who is completing the questionnaire, but also for the statistical analysis and interpretation of the responses.

Section 1 . Colour and Space: Colour/space unity.

Question 1: When dealing with colour in architecture, do you agree that there is a straight relationship between colour and space (as quantity of colour)?

The purpose of this question is to reinforce the findings obtained in the first part of the investigation, through literature review and the author's personal experience as an architect (induction and deduction). According to survey findings, people in general (61%) are aware of the existence of a strict relationship between colour and space. With the exception of the engineers, all the other respondents answered *yes* over a percentage of 52%. The reason for the engineers' attitude is maybe because they are more conservative in their answers.

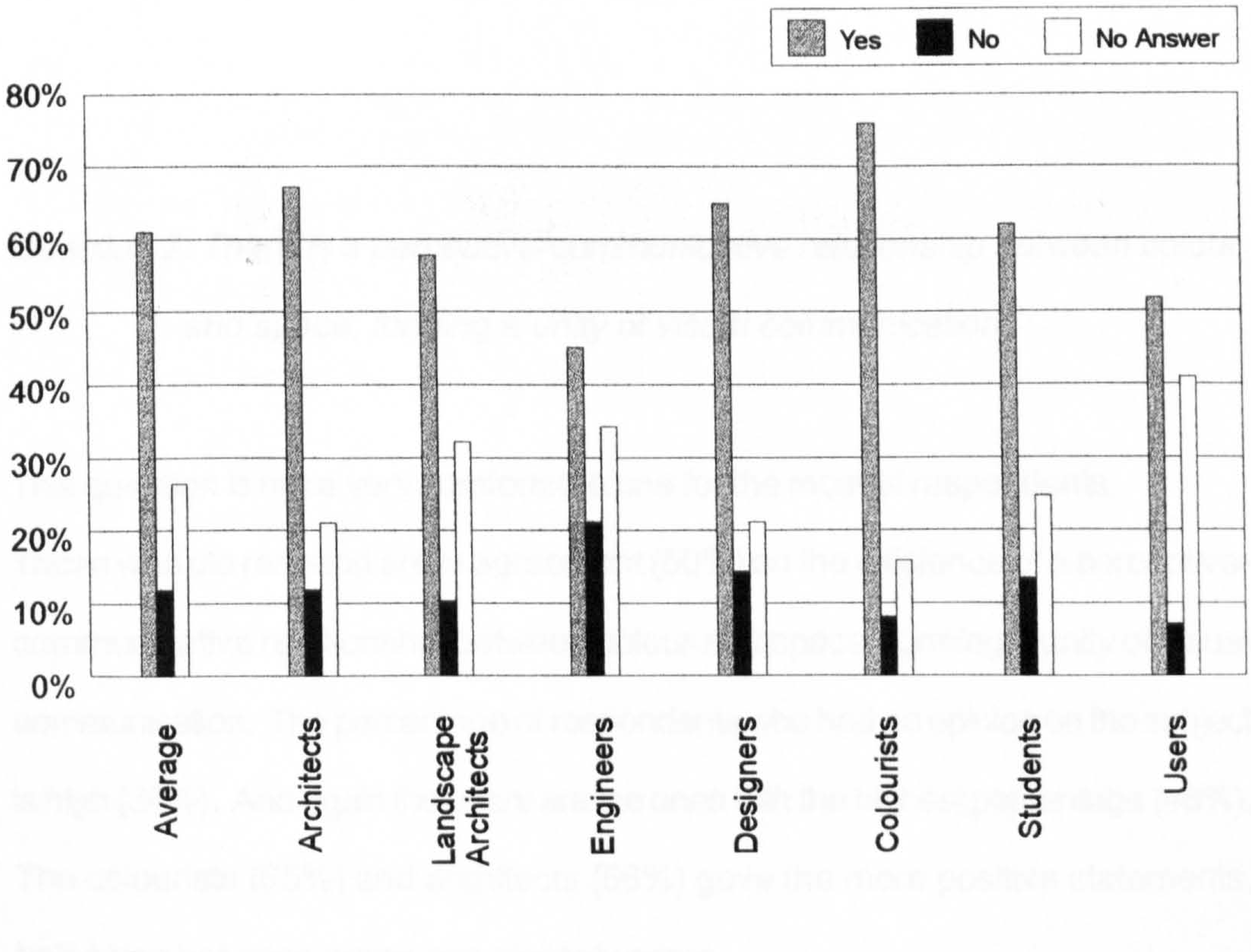


Fig 9.2 The existence of a straight relationship between colour and space.

On average there was a percentage of 27% of respondents that didn't answer. This is mainly influenced by the users, followed by the engineers and the landscape architects. This is a natural response because: most of the users don't have an academic background allowing them to have sufficient knowledge on the subject, besides their personal sensibility, or may not understand the meaning of quantity of colour.

During the analysis of the questionnaire responses it will be evident that the replies illustrate the inadequacies of the education of certain of the groups.

The engineers, in their profession, deal more with the functional problems than with the formal ones.

By academic formation, the landscape architects in general don't deal directly with the architectural form itself, and probably they are not so confident on the subject and they prefer not to answer the question.

Question 2: There is a perceptive-communicative relationship between colour and space, forming a unity of visual communication.

This question is not a very comfortable one for the most of respondents.

Those who did respond are in agreement (50%) on the existence of a perceptive-communicative relationship between colour and space, forming a unity of visual communication. The percentage of respondents who had no opinion on the subject is high (38%). And again the users are the ones with the highest percentage (48%). The colourists (65%) and architects (56%) gave the more positive statements, balancing between *agree* and *strongly agree*.

The engineers (22%) gave the highest percentage of disagreement.

In their formation there is a lack of information about perception and communication of the object of architecture; the ones who gave their agreement (45%), did it more as users, using their own sensibility.

Users (48%), landscape architects (45%) and students (41%) prefer to have no formal opinion on the subject: the users because the subject is a very academic one and they are don't feel very sure on the subject; the students probably because this a new subject for them; and the landscape architects, because once more they don't deal directly with the *object of architecture* – for them it is a pre-existence and a conditioning they have to deal with in their projects.

Table 9.2 The perceptive-communicative relationship between colour and space forming a unity of visual communication

	Assessment of respondents regarding the perceptive - communicative relationship between colour and space forming a unity of visual communication							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	20	25	15	20	18	27	18	12
Agree	30	31	27	25	33	38	25	23
No Opinion	38	32	45	33	37	33	41	48
Disagree	8	10	8	15	5	2	11	17
Strongly Disagree	4	2	5	7	7	0	5	0

Question 3: Colour/space unity characterises an environment, defines it, takes part in its message.

Respondents' opinions are more uniform to this question, in spite of "no opinion" presenting a similar position with question 2. The average response of 51% indicates a small balance of agreement (being 18% of *strongly agree*). Architects present the highest percentage of agreement (65%), closely followed colourists (60%), because they deal with the subject in their projects.

In spite of presenting a highest level of agreement (40%) in comparison with the disagreement (30%), engineers are still the ones who disagree more, probably because they don't deal with aesthetic and perceptive problems when they work in their projects.

Table 9.3 *Colour/space unity characterises an environment, defines it, takes part in its message.*

	Assessment of respondents regarding that colour/space unity characterises an environment, defines it and takes part in its message.							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	18	28	18	7	21	22	15	13
Agree	33	37	32	31	35	38	33	25
No Opinion	34	28	37	33	28	35	33	47
Disagree	12	7	10	21	11	5	12	15
Strongly Disagree	3	0	3	8	5	0	7	0

Question 4: Colour/space unity is an essential element in the architectural project.

Respondents (58%) appear to be in general agreement that colour/space unity is an essential element in architecture. Approximately 74% of colourists and 70% of designers present a clear statement of agreement with the subject. Also architects (64%) and students (65%) are very sure of the importance of colour/space unity when dealing with the project of architecture.

Users are the more unsure of all, presenting a percentage of 50% of no opinion on the subject. As they don't have a formation in this area (this is a very specific question), most of them don't feel comfortable in giving an opinion.

Table 9.4 ***Colour/space unity is an essential element in the project of architecture.***

	Assessment of respondents regarding colour/space unity being an essential element in the project of architecture.							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	**18**	**21**	**18**	**15**	**23**	**23**	**23**	**0**
Agree	**40**	**43**	**35**	**32**	**47**	**51**	**42**	**31**
No Opinion	**29**	**24**	**34**	**37**	**25**	**23**	**10**	**50**
Disagree	**11**	**12**	**13**	**11**	**5**	**3**	**17**	**19**
Strongly Disagree	**4**	**0**	**0**	**5**	**0**	**0**	**8**	**0**

Question 5: Colour/space unity is an essential element in the environment.

It is very interesting to verify that all respondents are much more confident in this area, if one compares with the last question. In all, there wasn't a single response of disagreement, presenting a very high percentage of agreement (84%) – being 70% of *agree* and 14% of *strongly agree*. Colourists (100%) and architects (96%) are the respondents who present the highest level of agreement.

The findings are really positive, showing that people in general are not only very aware of the importance of the colour/space unity, as well as they know that everyone who works with environmental issues must always have it present.

Table 9.5 ***Colour/space unity is an essential element in the environment.***

	Assessment of respondents regarding colour/space unity being an essential element in the environment.							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	**14**	**22**	**18**	**15**	**13**	**19**	**8**	**0**
Agree	**70**	**74**	**71**	**58**	**62**	**81**	**77**	**68**
No Opinion	**16**	**4**	**11**	**27**	**25**	**0**	**15**	**32**
Disagree	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Strongly Disagree	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Section 2 . Colour and the effects of colour

Question 6: Colour and light are major factors in man-made environment and their impact influences man's psychological reactions and physiological well being.

Respondents (75%) are in general agreement that colour and light are major factors in man-made environment and that their impact influences man's psychological reactions and physiological well being. It is also very interesting to analyse that once more all the respondents or agree with the statement (75%), or they have no opinion on the subject (25%). No one disagrees.

Architects (96%) followed by colourists (95%), are the most confident respondents in what concerns the effects of colour (and light, because without light there is no colour) in some of man's reactions. Users are still the less confident respondents to this question, presenting a high percentage of no opinion (53%), because the question deals with specific scientific subjects and most of them are not very familiar with them.

Table 9.6 *Colour and light are major factors in man-made environment and their impact influences man's psychological reactions and physiological well being.*

	Assessment of respondents regarding the idea of colour and light being major factors in man-made environment and their impact having influence in man's psychological reactions and physiological well being.							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	**10**	**21**	**0**	**12**	**8**	**18**	**13**	**0**
Agree	**65**	**75**	**64**	**61**	**65**	**77**	**69**	**47**
No Opinion	**25**	**4**	**36**	**37**	**27**	**5**	**18**	**53**
Disagree	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Strongly Disagree	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Question 7: Texture and light are very important issues when people deal with the quality and quantity of colour in architecture.

This question has a similar outcome when compared with the former one, because there isn't a single respondent who disagrees. The respondents agree that texture and light are very important issues when people deal with the quality and quantity of colour in architecture (77%), or they have no opinion (23%). Colourists (98%) and architects (90%) are the respondents who present the highest percentages of agreement. This is absolutely natural because they are the ones who work preferentially with texture and light in the man-made environment. Users (68%) are also much more aware of the importance of these environmental factors.

Table 9.7 ***Texture and light are very important issues when people deal with the quality and quantity of colour in architecture.***

	Assessment of respondents regarding that texture and light are very important issues when people deal with the quality and quantity of colour in architecture							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	9	18	0	0	10	21	13	0
Agree	68	72	61	66	68	77	64	68
No Opinion	23	10	39	34	22	2	23	32
Disagree	0	0	0	0	0	0	0	0
Strongly Disagree	0	0	0	0	0	0	0	0

Question 8: Colour and the concept of colour can be approached from different perspectives and different disciplines.

Question 9: If your answer was agree or strongly agree, name the different disciplines which you think are the main ones for the colour approach.

These two questions are inter-connected, so the interpretations of the findings must be combined. The average of response of 70% represents a good level of agreement that colour, or the concept of colour, can be approached from different perspectives and different disciplines. There is a generalised judgement about the subject. Colourists (99%), designers (89%), landscape architects (79%) and architects (75%) are the groups of respondents who present a higher level of agreement. This is to be anticipated as they are the groups of respondents who have more contact and information on the subject.

Engineers and users present a more divided position. Users agree (47%) or prefer to give no opinion (53%); most of them don't have much knowledge on the matter, and they answer only by sensibility. Engineers, prefer to give no opinion (49%), or they balance between the agreement (34%) and the disagreement (17%); once more the investigation shows that this group is not very attached at the use of colour in architecture – they use materials, which have colour and texture, and that's it.

Table 9.8 *Colour and the concept of colour can be approached from different perspectives and different disciplines.*

	Assessment of respondents regarding that colour and the concept of colour being able to be approached from different perspectives and different disciplines							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	7	10	8	0	12	17	0	0
Agree	63	65	71	34	77	82	68	47
No Opinion	26	25	21	49	8	1	27	53
Disagree	4	0	0	17	3	0	5	0
Strongly Disagree	0	0	0	0	0	0	0	0

Concerning question 9, 8 different areas were presented as the most important for the approach to colour, in a descending order as follows: art (N=851), colour theory (N=471), psychology (N=172), biology (N=132), philosophy (N=39), natural sciences (N=36), medicine (N=33) and technology (N=30). Other areas with less significance were answered, in a total of 101 replies. All the respondent groups named art as the most important. It is interresting to verify that biology presented a high score for landscpae architetcs (N=43), higher than colour theory (N=12) or psychology (N=21).

Question 10: Colour produces mood associations, subjective and objective impressions.

The findings show clearly that not a single respondent was found, disagreeing with the question statement. The average response presents a generalised high level of agreement (82%). The investigation can distinguish the colourist from the rest of respondents, with a 98% percentage of agreement. This shows clearly that colourists by formation and professional training are the ones who are most aware of the consequences in the use of colour.

Table 9.9 *Colour produces mood associations, subjective and objective impressions.*

	Assessment of respondents regarding the idea that colour produces mood associations, subjective and objective impressions							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	13	11	6	5	18	21	8	21
Agree	69	73	71	62	70	77	81	52
No Opinion	18	16	23	33	12	2	11	27
Disagree	0	0	0	0	0	0	0	0
Strongly Disagree	0	0	0	0	0	0	0	0

Question 11: Colour monotony induces anxiety, tension, fear and distress.

Analysing the findings, one can verify that the average response is more divided over the consequences of the use of colour that the question identifies. This is a very technical question and it was formulated only to investigate if the range of respondents was aware of this issue. According to the majority of respondents (64%), people agree (57%) or strongly agree (7%) with the statement, but they also reveal many doubts about this subject. The respondents, who reveal to be surer about the subject of question, are the colourists who present an 86% percentage of agreement. This is certainly due to their specific interest on colour, and it also reveals, by comparison, that the other groups of respondents don't have adequate knowledge on the subject.

Table 9.10 *Colour monotony induces anxiety, tension, fear and distress.*

	Assessment of respondents regarding that colour monotony induces anxiety, tension, fear and distress							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	7	18	0	12	0	15	7	0
Agree	57	46	57	43	50	71	65	64
No Opinion	19	15	25	13	28	14	4	32
Disagree	13	13	10	22	22	0	21	4
Strongly Disagree	4	8	8	10	0	0	3	0

Question 12: Colour influences our estimation of volume, weight and size.

When comparing with the former question, it is interesting to verify that, besides being another specific matter of colour knowledge, people are aware that colour influences the estimation of volume, weight and size. This is certainly due to the nature of the question, which deals more with the sensibility and common sense of the respondent.

In the findings one can verify that there isn't a single position of disagreement in the entire sample of respondents. Architects are the ones who present the highest level of agreement (99%). This position is related with the fact that the question content deals with space and form issues, which are always directly connected with the project of architecture.

Table 9.11 *Colour influences our estimation of volume, weight and size.*

	Assessment of respondents regarding that colour influences people's estimation of volume, weight and size							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	9	18	0	0	10	21	13	0
Agree	68	72	61	66	68	77	64	68
No Opinion	23	10	39	34	22	2	23	32
Disagree	0	0	0	0	0	0	0	0
Strongly Disagree	0	0	0	0	0	0	0	0

Question 13: Please indicate other areas that you think colour influences.

Respondents gave a wide range of areas, which they think colour influences, which may be summarised as the following: temperature (N=1578), time (N=1391), noise (N=1300) and sound (N=1070). Some of them also presented smell (N=178) and taste (N=118), but with less importance. There were 78 replies about other areas. Architects refered time (N=393) and noise (N=315) as the main areas, followed by temperature (N=217). The same happened with landscape architects and designers. Engineers put in first place temperature (N=142) followed by time (N=127) and noise (N=52). Designers, colourists, students and users, they all refered temperature in first place. Sound presented high scores for colourists and users. Users even placed sound (N=298) after temperature (N=354).

Question 14: Cultural heritage influences the effect of colour.

The findings don't present a single response of strongly disagreement. But, in spite of this, the majority of respondents are unsure about the influence of the cultural heritage on the effect of colour. Especially the users who present a 23% percentage of disagreement. This is certainly due to the lack of knowledge of the subject. In opposition to this, architects (82%), landscape architects (79%) and colourists (89%) present a high level of agreement, perhaps because they feel more comfortable with the statement.

Table 9.12 ***Cultural heritage influences the effect of colour.***

	Assessment of respondents regarding that colour heritage influences the effect of colour							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	7	15	13	0	0	21	0	0
Agree	56	67	66	42	64	68	53	32
No Opinion	28	14	13	45	32	11	35	45
Disagree	9	4	8	13	4	0	12	23
Strongly Disagree	0	0	0	0	0	0	0	0

Section 3 . Colour and the Built Environment.

Question 15: Do people take account of the effects of colour, when it is used externally within the built environment?

This question served to determine the level of attention that people in general have when living in the built environment. Almost all respondents showed a high percentage of concern about the effects of colour, when it is used externally within the built environment. Designers (84%), colourists (81%), followed by users (78%) and architects (67%), are the ones who gave the most positive statement in this evaluation. Engineers, even with an affirmative response (42%) higher than the negative one (37%), are the respondents who presented the most divided position. Certainly a greater emphasis could be placed on the colour knowledge of people in general (at the elementary school), and especially on the engineers graduation courses.

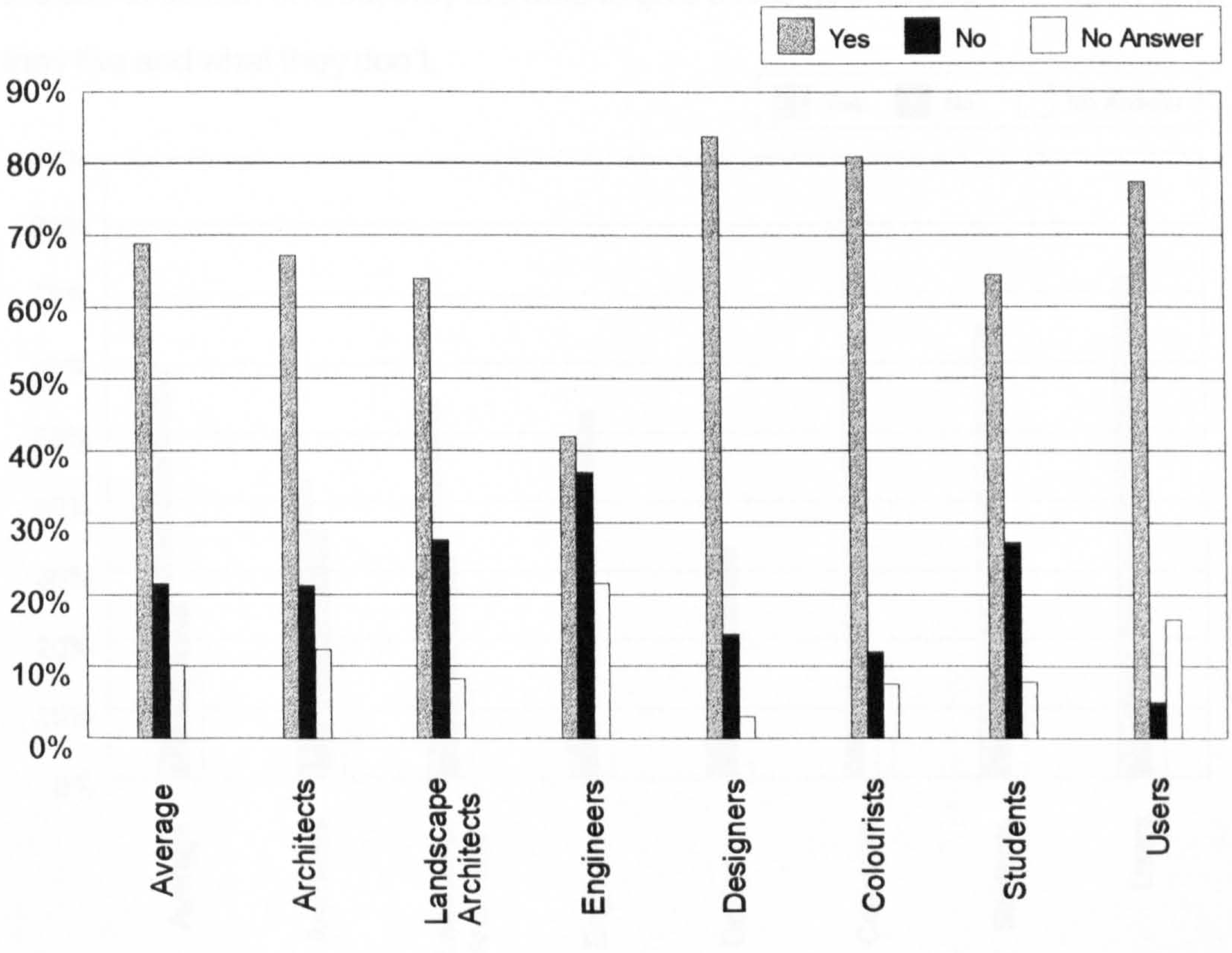


Fig 9.3 *People taking account of the effects of colour, when it is used externally within the built environment.*

Question 16: Are the effects of colour significant enough within an external environment to warrant consideration?

This question divided the general opinion. Most of the respondents gave an affirmative statement; but a great percentage of engineers (54%) think that the effects of colour aren't significant enough within an external environment to warrant consideration. Engineers background is very poor on the evaluation on form and, consequently, on colour. The architects' opinion is also very divided. A percentage of 43% agrees on the versed subject of the question; but 38% of the respondents who are architects don't have the same opinion. The lack of formation on colour in the undergraduate courses of architecture is certainly the main responsible for these findings. Colourists, logically because of their academic formation and professional practice, have the highest level of affirmative statements: 83%. Students and users are also much aware of colour effects within the environment. The first ones, because they deal with the problem of being users and knowing that they don't have specific formation on this area of knowledge; the second ones, in spite of not having a special formation on colour, they are less prejudiced about the use of colour, and so, they are able to give a less guarded opinion upon what they like and what they don't.

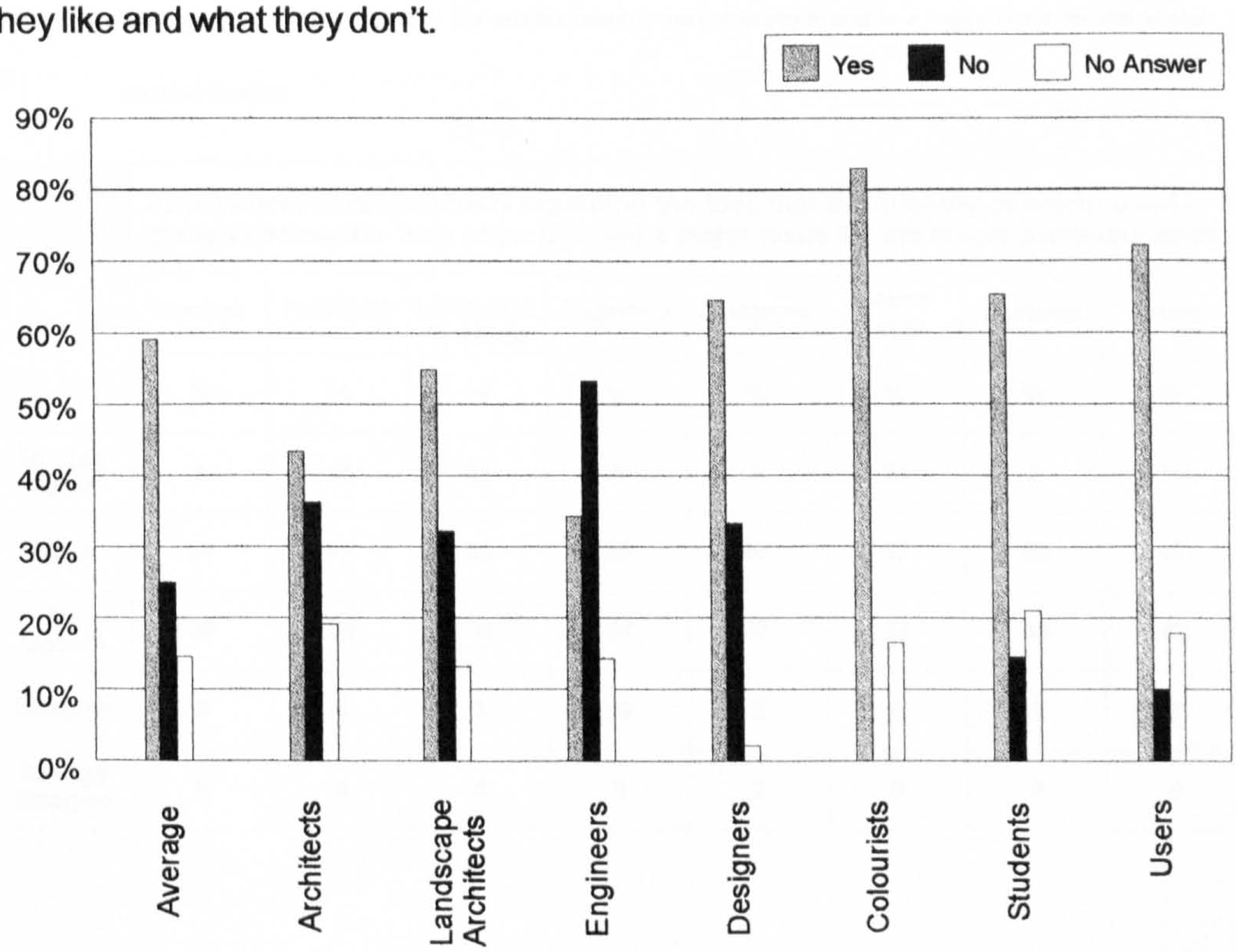


Fig 9.4 *The effects of colour are significant enough within an external environment to warrant consideration.*

Question 17: The quantity of colour used in the environment is very important and is a major issue for the visual communication.

Once again, the group of engineers present a different opinion from the whole group of respondents. They prefer to give no opinion (51%), than to respond affirmatively (39%). Engineers also present the highest level of disagreement: 10%. This is due to the lack of information they possess about colour and communication.

Colourists (88%), landscape architects (67%), architects (62%) and students (62%) are the respondents' groups who present the highest levels of agreement with the initial statement. In spite of architects, landscape architects and students not having a solid formation on colour, they have a lot of information on the semiotic and semantic, and so they know the importance of colour as a sign of visual communication.

Table 9.13 *The quantity of colour used in the environment is very important and is a major issue for the visual communication.*

	Assessment of respondents regarding the idea that the quantity of colour used in the environment is very important and a major issue for the visual communication							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	8	13	11	0	0	21	0	11
Agree	53	49	56	39	53	67	62	47
No Opinion	36	38	30	51	47	12	30	42
Disagree	3	0	3	10	0	0	8	0
Strongly Disagree	0	0	0	0	0	0	0	0

Question 18: In the built environment, do you consider the absence of colour positive or negative?

In spite of being well understood by most of respondents, this was an ambiguous question.The colourists are the respondents who present the most extreme position: or they think is negative the absence of colour in the built environment (77%), or they don't answer (23%). There isn't a single response of disagreement. Engineers once again have their opinion divided. Architects are the respondents who present the highest percentage of no answer: 36%. There are still many architects that think the use of colour is a very dangerous matter; so, they prefer to have no opinion on the subject. Architects probably with a more "*Modern Period*" background stated that the absence of colour is positive (13%). Landscape architects (68%) and students (64%) present a very similar position, stating that the absence of colour is negative. They present the same percentage (21%) when tey state positively.

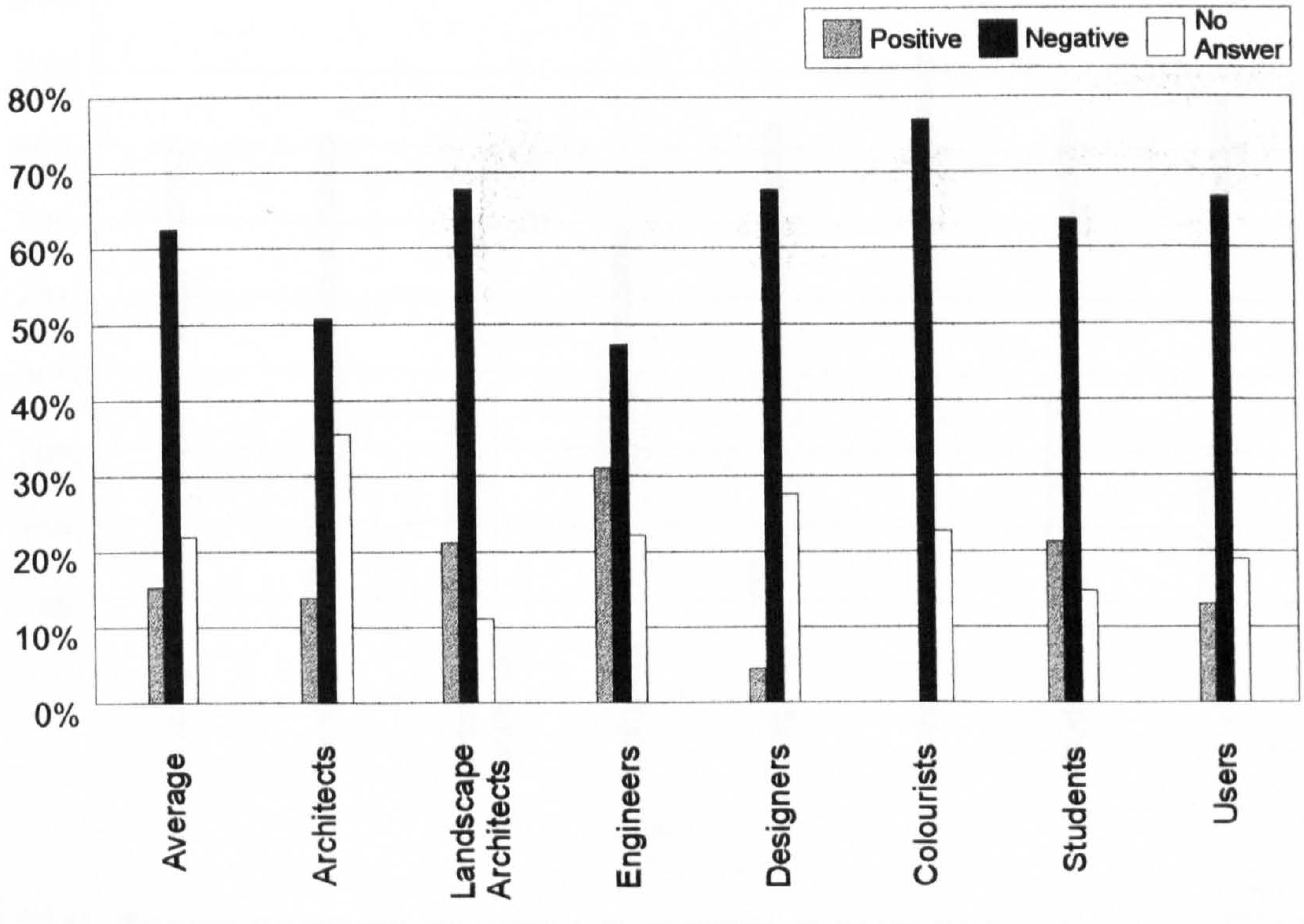


Fig 9.5 *In the built environment, the absence of colour is positive or negative.*

Question 19: Do you prefer a colourless environment or an environment with the use of colour?

This question was designed in a way to verify question 18 outcomes. One can also see that in this question the author was leading a little bit the respondents' opinion.

The findings of this question are very similar to that of the last question. People in general prefer environments within the use of colour. Colourists (77%), users (68%), students (65%) and designers (64%), are the more decisive about this subject. Even for the engineers, there is a bigger group that prefers environments with colour (49%), than colourless ones (33%). Landscape architects are not so sure about use of colour within built environments, probably because they think the other elements besides architecture can assure the desired level of colour.

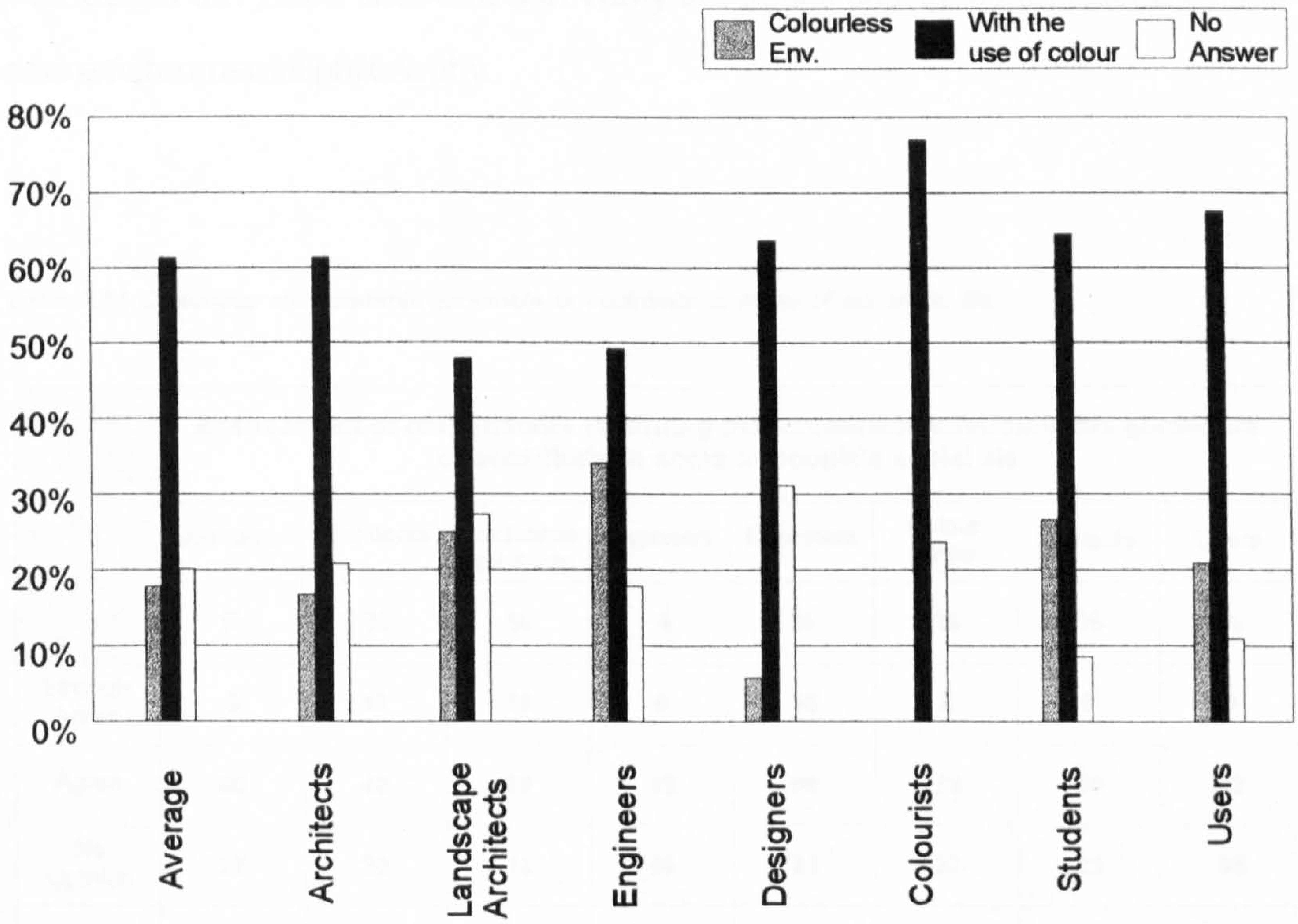


Fig 9.6 *Preference of a colourless environment or an environment with the use of colour.*

Question 20: Colourless environments germinate or contribute to some of our social ills.

Being more or less sure about the subject, a greatest part of respondents (65%) agrees that colourless environments germinate or contribute to some of our social ills. Engineers are the respondents' group who presents the highest percentage of no answer (46%). Probably as they don't know much about the matter, they prefer to give no final statement.

One of the poorest districts in Europe is a Lisbon's district: Casal Ventoso. A survey conducted by specialists verified that the colourless, distructed environment had contributed to the local social degradation.

So, they moved the population to a new city area (nearby), where colour took a major place in the architectural project.

Perhaps in ten years time one can verify the social changes introduced by this new environmental philosophy.

Table 9.14 ***Colourless environments germinate or contribute to some of our social ills.***

	Assessment of respondents regarding that colourless environments germinate or contribute to some of people's social ills							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	5	13	15	0	10	5	0	0
Agree	60	48	69	42	66	72	60	62
No Opinion	27	28	16	46	21	23	21	35
Disagree	7	11	0	12	13	0	17	3
Strongly Disagree	1	0	0	8	0	0	2	0

Question 21: Do you consider coloured areas happier than the others?

It is almost common sense between the respondents that coloured areas are happier than the others (63%). Engineers don't have the same opinion, presenting a negative evaluation on the subject with a percentage of 43%; only 35% of this group of respondents gave an affirmative statement. Besides colourists (82%) who presented the highest adherence to the question, users (73%), students (67%) and architects (65%) are also very positive about coloured areas being happier than the others.

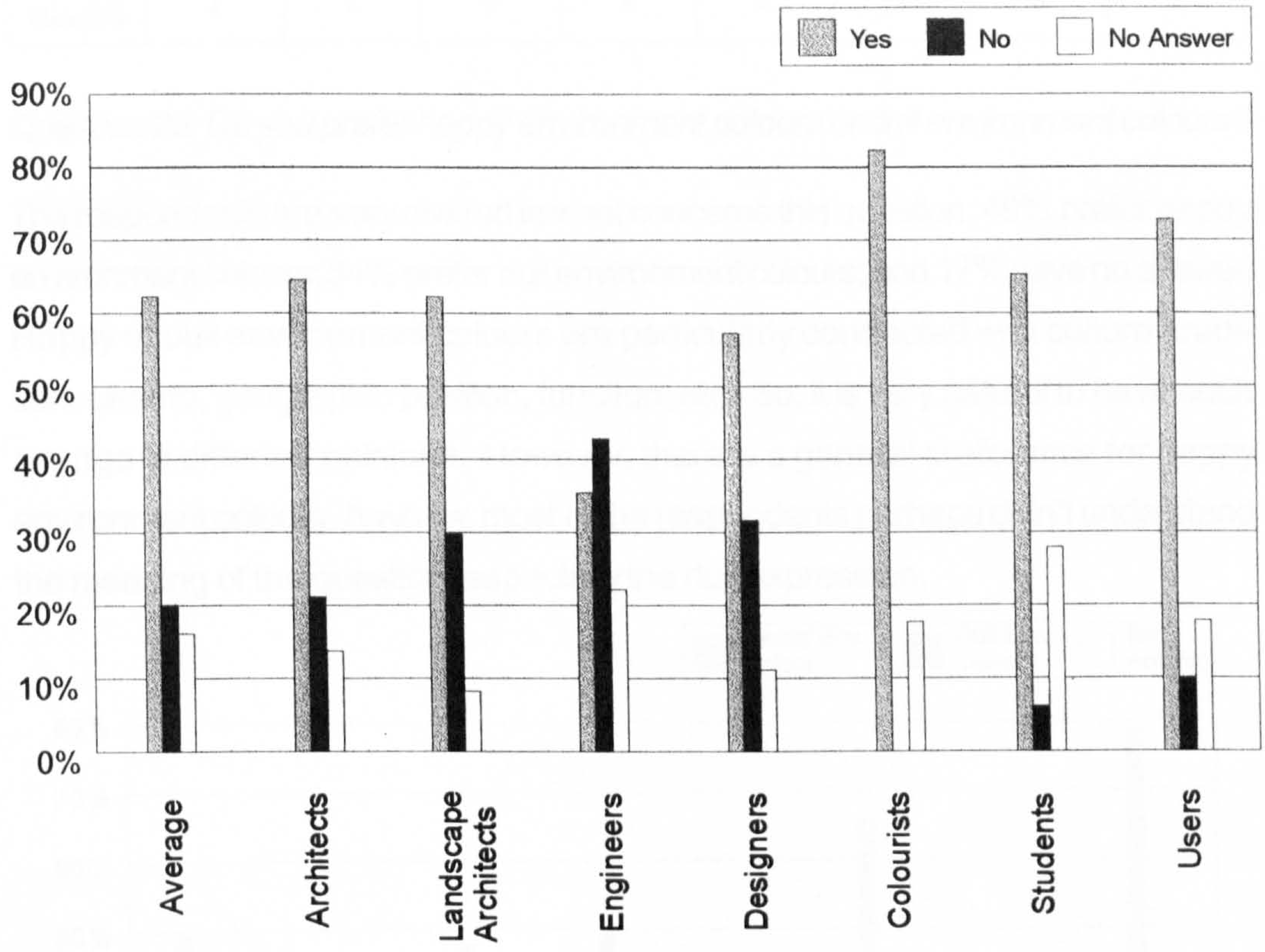


Fig 9.7 *Coloured areas are happier than the others.*

Question 22: Environments that are predominantly neutral in appearance are static, boring and tedious.

The findings show that there is a general positive opinion on the question statement (62%). All the respondents' groups are in tune about the subject.

Table 9.15 *Environments that are predominantly neutral in appearance are static, boring and tedious.*

	Assessment of respondents regarding the idea that environments that are predominantly neutral in appearance are static, boring and tedious							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	**8**	**7**	**9**	**0**	**0**	**21**	**10**	**11**
Agree	**62**	**64**	**64**	**53**	**71**	**66**	**54**	**72**
No Opinion	**20**	**19**	**17**	**29**	**17**	**13**	**28**	**17**
Disagree	**8**	**11**	**10**	**13**	**12**	**0**	**11**	**0**
Strongly Disagree	**2**	**8**	**0**	**5**	**0**	**0**	**3**	**0**

Question 23: Do you prefer happy environment colours or dull environment colours?

The respondents are very divided in what concerns this question: 49% prefer happy environment colours; 34% prefer dull environment colours; and 17% gave no answer. Happy or dull environment colours are particularly connected with culture, tradition, climate, geographic position, function, etc. So, it is very natural to have such a range of different opinions. However, there is a general preference for happy environment colours. Anyhow, most of the respondents perhaps didn't understand the meaning of the question, especially the dull expression.

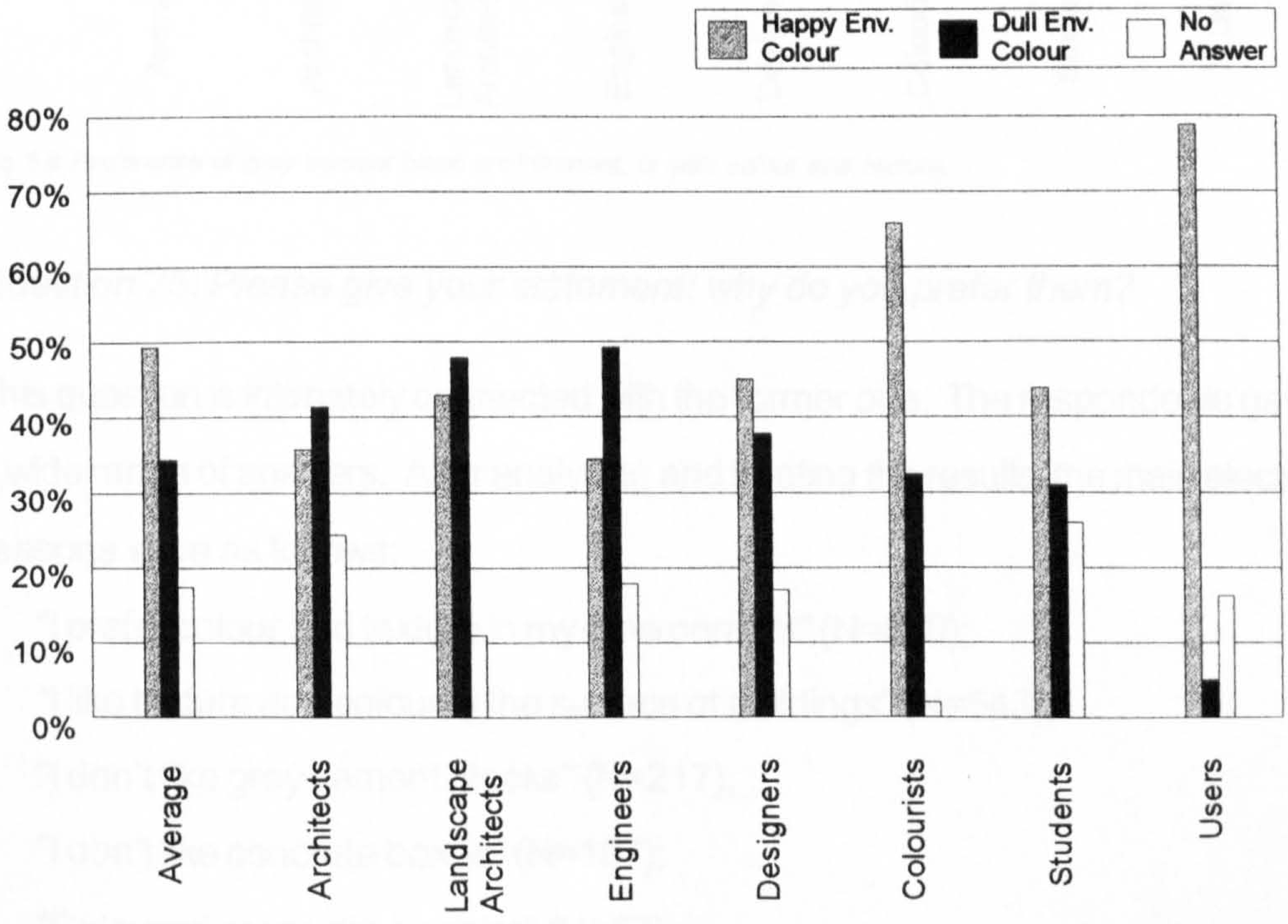


Fig 9.8 *Preference for happy environment colours or dull environment colours.*

Question 24: Looking at the following figures, which of them do you prefer: grey cement block, or with colour and texture?

It is really clear that the vast majority of respondents prefer environments with the predominance of colour and texture (56%), than those with grey cement blocks (15%). The findings prove that people elect for environments with colour and texture, which is, with light and variation.

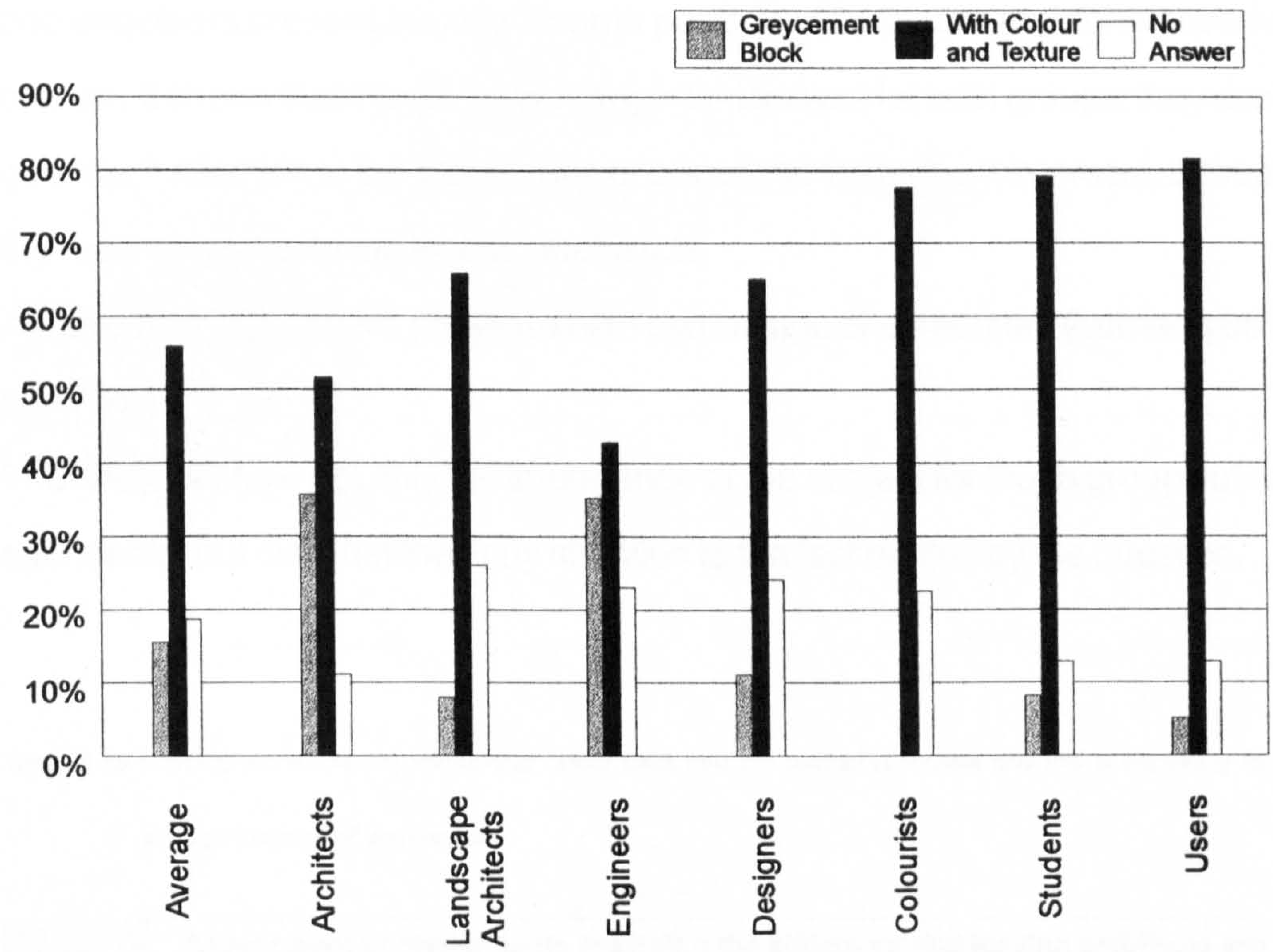


Fig 9.9 ***Preference of grey cement block environment, or with colour and texture.***

Question 25: Please give your statement: why do you prefer them?

This question is intimately connected with the former one. The respondents gave a wide range of answers. After analysing and treating the results, the main elected reasons were as follows:

- "I prefer colour and texture in my environment" (N=820);
- "I like texture and colour in the surface of buildings" (N=548);
- "I don't like grey cement blocks" (N=217);
- "I don't like concrete boxes" (N=107);
- "Coloured areas are happier" (N=67).

Question 26: Some architects are introducing colour back into the built environment and this is beginning to change the face of architecture.

Respondents' opinion about the statement presented in this question is divided in two groups: in one side there is the landscape architects and the engineers; in the other side, there is all the other groups of respondents. Landscape architects and engineers present the exact same position: 47% agree and 53% have no opinion. It shows that this isn't a very important subject for both groups; they don't give much attention to the introduction of colour into the built environment, through the recent projects of the leading architects.

All the other respondents present a high percentage of agreement (between 65% and 73%).

The findings show not only the importance of the subject for these groups of respondents, but also that they pay attention to the fact elicited by the question.

Table 9.16 *Leading architects are introducing colour back into the built environment and this is beginning to change the face of architecture.*

	Assessment of respondents regarding the statement that leading architects are introducing colour back into the built environment and this is beginning to change the face of architecture							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	5	13	0	0	12	0	9	0
Agree	63	69	47	47	65	73	66	71
No Opinion	32	18	53	53	23	27	22	28
Disagree	0	0	0	0	0	0	3	0
Strongly Disagree	0	0	0	0	0	0	0	0

Section 4 . Colour and the use of colour

Question 27: In the use of colour, the public's needs and preferences must be satisfied as well as the architect's aesthetic aspirations.

There is a common opinion about the statement presented in this question: all the respondents (71%) agree that the public's needs and preferences must be satisfied as well as the architect's aesthetic aspirations.

The findings show that nowadays everybody is aware of the respect that technicians must have for the client's positions and ideas.

Table 9.17 *In the use of colour, the public's needs and preferences must be satisfied as well as the architect's aesthetic aspirations.*

	Assessment of respondents regarding the idea that, in the use of colour, the public's needs and preferences must be satisfied as well as the architect's aesthetic aspirations							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	7	11	0	0	5	0	13	18
Agree	64	68	60	55	58	63	69	73
No Opinion	28	21	40	37	37	37	16	9
Disagree	1	0	0	8	0	0	2	0
Strongly Disagree	0	0	0	0	0	0	0	0

Question 28: Which are the main variables for the generic use of colour in the exteriors of architecture?

The analysis of the responses allowed the investigation to synthesise the five main variables, which all respondents (72%) stated as the most important for the generic use of colour in the exteriors of architecture: Light (N=1647), surface (N=1449), distance (N=1157), environmental impact (N=1226) and visual objectives (N=1169). The respondents gave other variables (N=152) with no statistic meaning. All the groups, with the exception of users, had a very balanced statement in what concerns the different main variables. Users didn't point very much visual objectives (N=23) as a main variable for the generic use of colour in the exteriors of architecture, if one compares with light (N=358) or surface (N=327). This is probably due to users background in the use of colour.

Question 29: Colour should serve to increase the overall effect of the architectural value of each building, of an entire street or square, or of a built environment.

The author thinks that this is a too long question an it should be splited in three different questions; it would be much easier for respondants to undestand and answer the question.

The average response (69%) presents an affirmative opinion about the statement. All the groups, with the exception of the users, have similar findings. Users, perhaps because they don't have the professional point of view, balance between agreement (56%) and no opinion (43%).

Table 9.18 *Colour should serve to increase the overall effect of the architectural value of each building, of an entire street or square, or of a built environment.*

	Assessment of respondents regarding the idea that colour should serve to increase the overall effect of the architecture value of each building, of an entire street or square, or of a built environment							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	2	5	10	0	0	0	3	1
Agree	67	68	73	64	65	73	70	56
No Opinion	27	27	17	25	25	27	22	43
Disagree	4	0	0	11	10	0	5	0
Strongly Disagree	0	0	0	0	0	0	0	0

Question 30: Colour can contribute to the unity of the street or square, or it may destroy that unity.

This question is connected with question 29, and so the findings are almost identical. All respondents (70%) agree that colour can be an element of union in the street, as well as an element which can destroy it.

Table 9.19 *Colour can contribute to the unity of the street or square, or it may destroy that unity.*

	Assessment of respondents regarding that colour can contribute to the unity of the street or square, or it may destroy that unity							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	3	5	12	0	0	2	4	0
Agree	67	68	75	64	66	71	69	57
No Opinion	26	27	13	25	24	27	22	43
Disagree	4	0	0	11	10	0	0	0
Strongly Disagree	0	0	0	0	0	0	0	0

Question 31: Whichever colour scheme is followed the street should be viewed strategically as an element in the city.

Question 32: When developing a colour scheme for a building it must first be seen in its strategic relationship with its immediate surroundings.

These two questions are very similar in a way to check the validity of the sample. They are so related that their findings must be analysed together. The percentage of no opinion is almost identical for both questions (26% and 24%). Colourists (83% and 85%) and architects (92% and 84%) are the groups of respondents who present the highest level of agreement. Students are also very aware of the problem and present for both questions a high percentage of agreement (67% and 68%). These results are strongly connected with the professional experience of these groups.

In spite of having no direct professional experience with the subject, users present a positive evaluation of the problem (53% and 65%).

So, the findings show clearly that people agree on whichever colour scheme is developed for a building or a street, it must be viewed, respectively, in its strategic relationship with its immediate surroundings or as an element of the city.

Table 9.20 *Whichever colour scheme is followed the street should be viewed strategically as an element in the city.*

	Assessment of respondents regarding the idea that whichever colour scheme is followed, the street should be viewed strategically as an element in the city							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	**4**	**13**	**4**	**6**	**0**	**5**	**2**	**0**
Agree	**67**	**79**	**64**	**68**	**65**	**78**	**65**	**53**
No Opinion	**26**	**8**	**32**	**21**	**35**	**17**	**36**	**35**
Disagree	**3**	**0**	**0**	**5**	**0**	**0**	**7**	**12**
Strongly Disagree	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Table 9.21 *When developing a colour scheme for a building it must first be seen in its strategic relationship with its immediate surroundings.*

	Assessment of respondents regarding the idea that, when developing a colour scheme for a building, it must first be seen in its strategic relationship with its immediate surroundings							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	**8**	**15**	**0**	**0**	**8**	**13**	**5**	**12**
Agree	**60**	**69**	**47**	**55**	**64**	**72**	**63**	**53**
No Opinion	**24**	**16**	**42**	**32**	**20**	**15**	**19**	**22**
Disagree	**7**	**0**	**11**	**10**	**8**	**0**	**11**	**13**
Strongly Disagree	**1**	**0**	**0**	**3**	**0**	**0**	**2**	**0**

Question 33: Do you think it is important to establish the building's visual function within the city or district, when developing its colour scheme?

This question provoked different findings for the different groups of respondents, even because it is a very complicated question for most of respondents (especially users). Users are the group who present no formal opinion on the subject, perhaps eliciting the technicians as the ones who should decide if it is or not important to establish the building's visual function within the city or district, when developing its colour scheme. They prefer to give no answer (68%), in spite of the positive evaluation (19%) being higher than the negative one (13%).

Engineers are very divided, presenting almost the same values for the positive (38%) and the negative (35%) answer. As they aren't very related with the colour problem, this isn't a very important issue for them. Students also present a divided opinion on the subject: 49% yes, against 37% no. As they are in a period of formation, some of them are still more concerned with the formal problems, and others with the functional ones; at this stage it is still very difficult to reach the exact balance between both.

All the other groups, those who really have to work with colour issue, have a similar and positive position (between 65% and 70%).

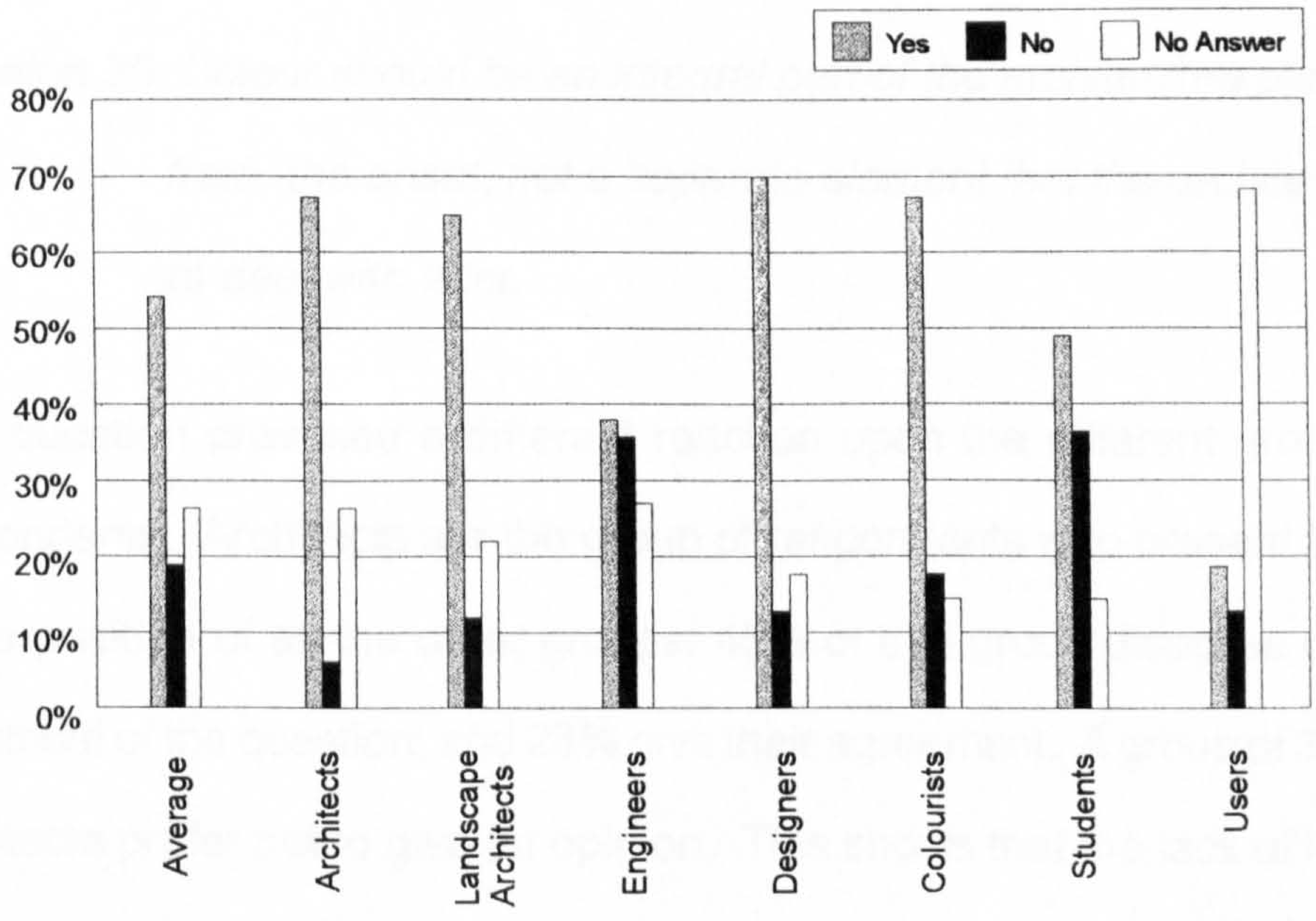


Fig 9.10 *The importance of establishing the building's visual function within the city or district, when developing its colour scheme.*

Question 34: Please give your statement about which factors you think are the most important for the use of colour.

The findings presented a wide range of opinions about the factors people think are the most important for the use of colour. After analysing and treating the results, the investigation summarised the main factors, in order of importance, as following: culture (N=1650); pattern traditions (N=1448); economy (N=1314); geography (N=1054); religion (N=812); climate (N=646); fluctuation of taste (N=625); and educational level (N=570).
The respondents named other factors (N=230) with no statistic meaning. Culture presented the highest score for all respondents, with the exception of enginners and colourists. Engineers stated in first place economy (N=145) and colourists geography (N=92).

Section 5 . Colour Planning

Question 35: Colour should be an integral part of the architecture planning from the onset, not a separate element that the architect has to deal with later.

This question provoked a different reaction upon the different groups of respondents. Architects are the group of respondents who present the inverse position of all the other groups: 45% of this group disagree on the statement of the question; and 23% give their agreement. A group of 32% of architects prefer not to give an opinion. This shows that the lack of importance that most architects give to colour in the process of the architectural project and, therefore in its planning.

Landscape architects (51%) and users (53%) present a high level of no opinion on the subject.

The first ones don't want to involve themselves in the area of the architect's work; the second ones, don't have a formal opinion – perhaps because the question is directly linked with the architect's professional ground.

The remainder of respondents all has a similar position, generally in agreement on the question.

Table 9.22 ***Colour should be an integral part of the architecture planning from the onset, not a separate element that the architect has to deal with later.***

	Assessment of respondents regarding the statement that colour should be an integral part of the architecture planning from the onset., and not a separate element that the architect has to deal with later							
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students	Users
	%	%	%	%	%	%	%	%
Strongly Agree	3	0	0	0	0	12	8	0
Agree	44	23	38	43	53	64	61	28
No Opinion	33	32	51	30	37	10	19	53
Disagree	20	45	11	27	10	12	10	19
Strongly Disagree	0	0	0	0	0	0	2	0

Question 36: Do you think it is necessary to have strict rules for the application of colour within architecture?

On average respondents gave an affirmative response (57%) higher than the negative one (29%). Nevertheless, architects (21%) and engineers (35%) presented a very strong position in not considering important the existence of strict rules for the application of colour. This statement reveals the insurance that these professionals have in what concerns the application of colour in architecture, thinking that these rules could challenge their design freedom and perhaps condition their projects of architecture. Colourists, students and users are the respondents who are surer about the importance of having strict rules for the use of colour in our built environment.

No improvement will take place, unless principles are defined and adhered to all professionals who deal with colour.

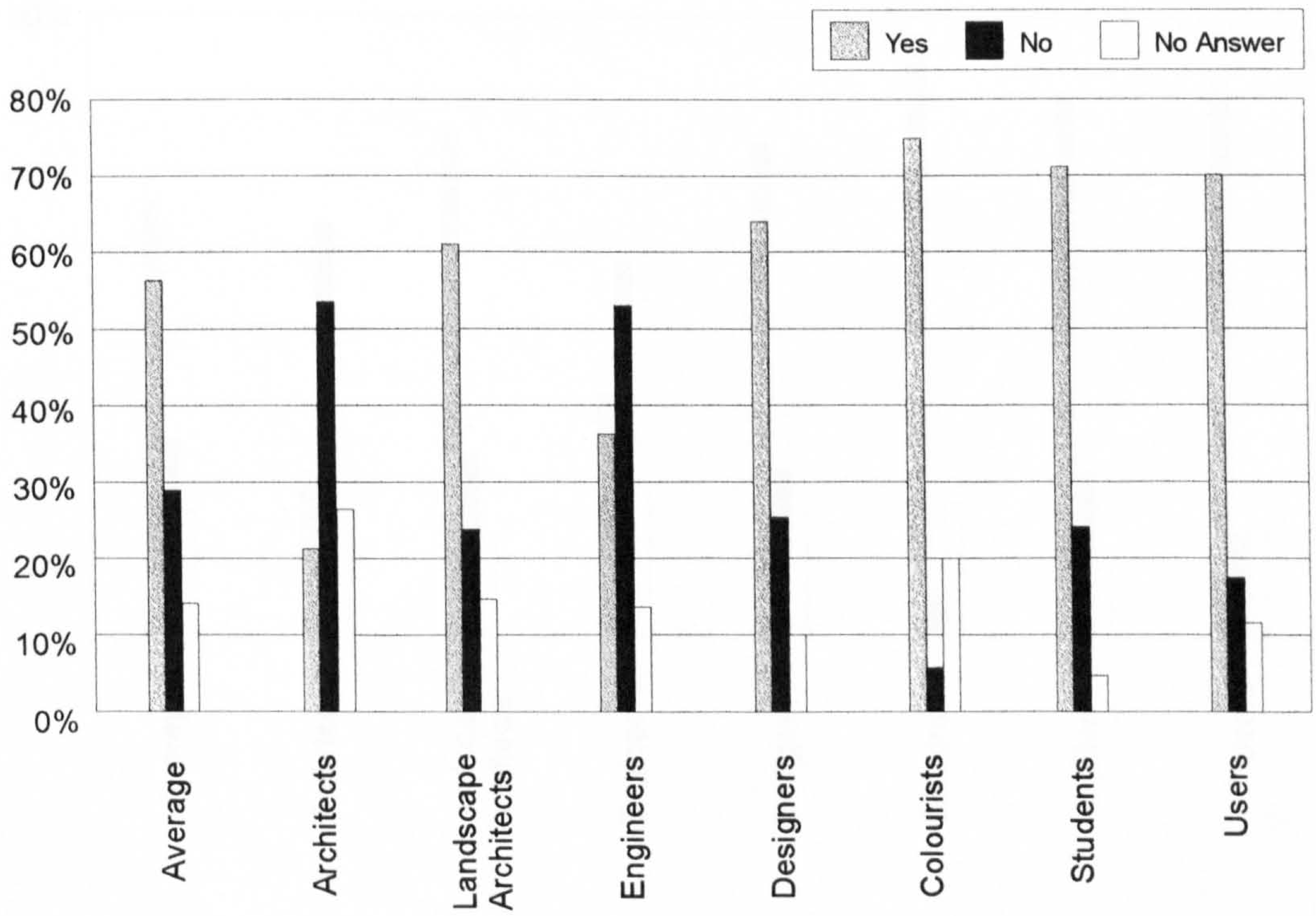


Fig 9.11 *The necessity of having strict rules for the application of colour within architecture.*

Question 37: In the city planning, do you think there must be guidelines for the use of colour?

Architects are the ones who present the most drastic position, followed by engineers. Architects are against rules, guidelines for the use of colour (53%), mainly because they think that this will be a conditioning for their project of architecture, taking away from them the freedom of choosing which colour(s) they want to introduce.

For engineers the situation is possibles slightly different, because, as they don't have a formation on colour, they prefer not to have it as a determinant of the project. All the other groups of respondents present a total different opinion, preferring the existence of guidelines for the use of colour.

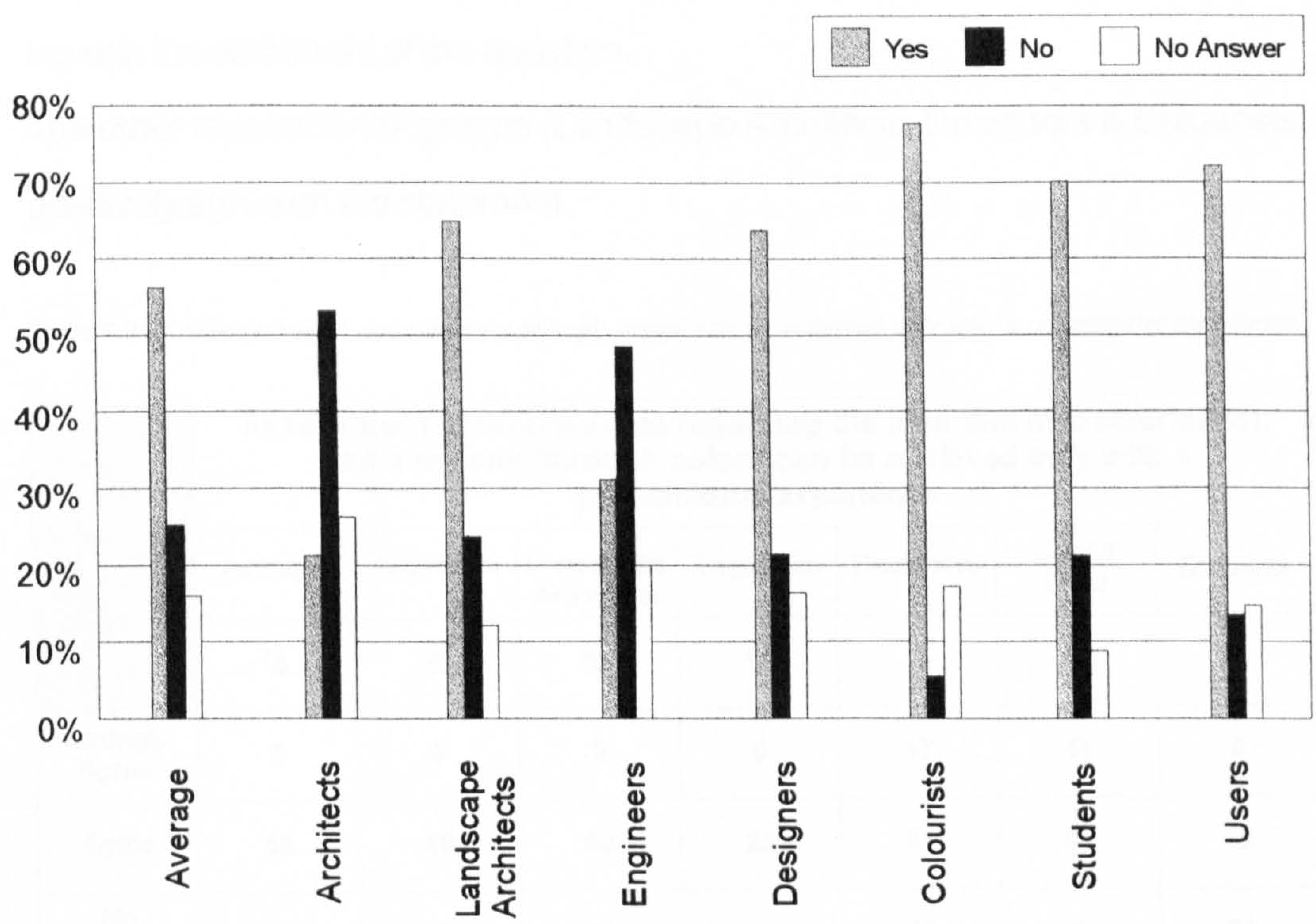


Fig 9.12 *Guidelines for the use of colour In the city planning.*

Section 6 . Design Process

Only the professionals whose work is in the area of the architectural project or design, and the students (undergraduate students of architecture and design courses) were asked to fill these last two sections: Architects, landscape architects, engineers, designers, colourists and students.

Question 38: Characterisation and harmony through colour can be achieved only with a professional experience.

Architects and students present a different position from the other groups. These two divide their opinion between agreement and disagreement with the formal statement. They both think that there are other ways of achieving characterisation and harmony, besides professional experience.

Engineers reinforce more this position, presenting a big majority (52%) disagreeing with the statement of the question.

The other respondents' groups (Landscape Architects, Designers & Colourists) positively agree on the statement.

Table 9.23 *Characterisation and harmony through colour can be achieved only with a professional experience.*

	Assessment of respondents regarding the idea that characterisation and harmony through colour can be achieved only with a professional experience						
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students
	%	%	%	%	%	%	%
Strongly Agree	5	0	0	0	17	11	0
Agree	46	40	53	23	51	68	42
No Opinion	13	7	16	8	19	8	20
Disagree	31	42	31	52	13	13	38
Strongly Disagree	5	11	0	17	0	0	0

Question 39: Do you think colour is considered an important facet of the design process?

The analysis suggests that there is a general agreement (60%) about the statement that colour is *not yet* considered an important facet of the design process. This means that the professionals who work with colour application are not the only ones aware of the problem; even students have the same view (62% stated that they considered that colour is not yet considered, by the professionals who work with it, an important facet of the design process).

However, architects are the respondents who present a more divided position, because some of them are already dealing with the question itself in their daily projects of architecture, and therefore do consider colour as an important facet of the design process.

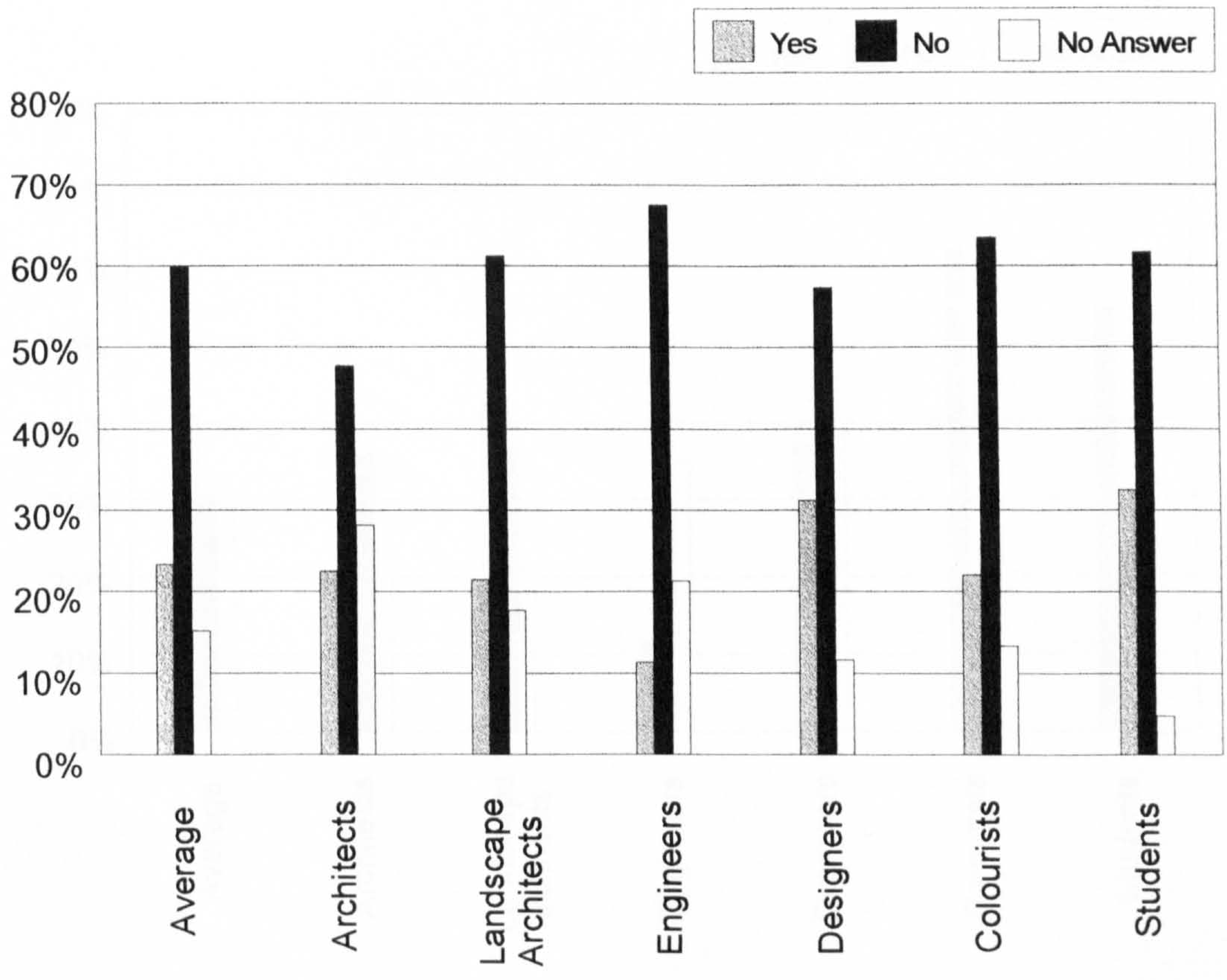


Fig 9.13 *Colour being considered an important facet of the design process.*

Question 40: Do you agree that colour theory must be used in architectural design studio as a conceptual design tool to expand the means for clarifying the figural and hierarchical nature of building form?

Respondents are very divided in this question. The search found colourists, students and designers, clearly agree with the statement of the question. Architects (42%) and landscape architects (43%) stated favourably in a very tentative way. Engineers present a quite different position: a great average stated that colour theory *must not be used* in architectural design studio as a design tool (53%). This last group works directly with the project of architecture and, as the findings have already proved, there is an immense lack of formation on colour; so, it's natural their formal position about the question.

The average of respondents is, therefore, very divided: 41% are in favour; 30% are against and 29% prefer to give no opinion.

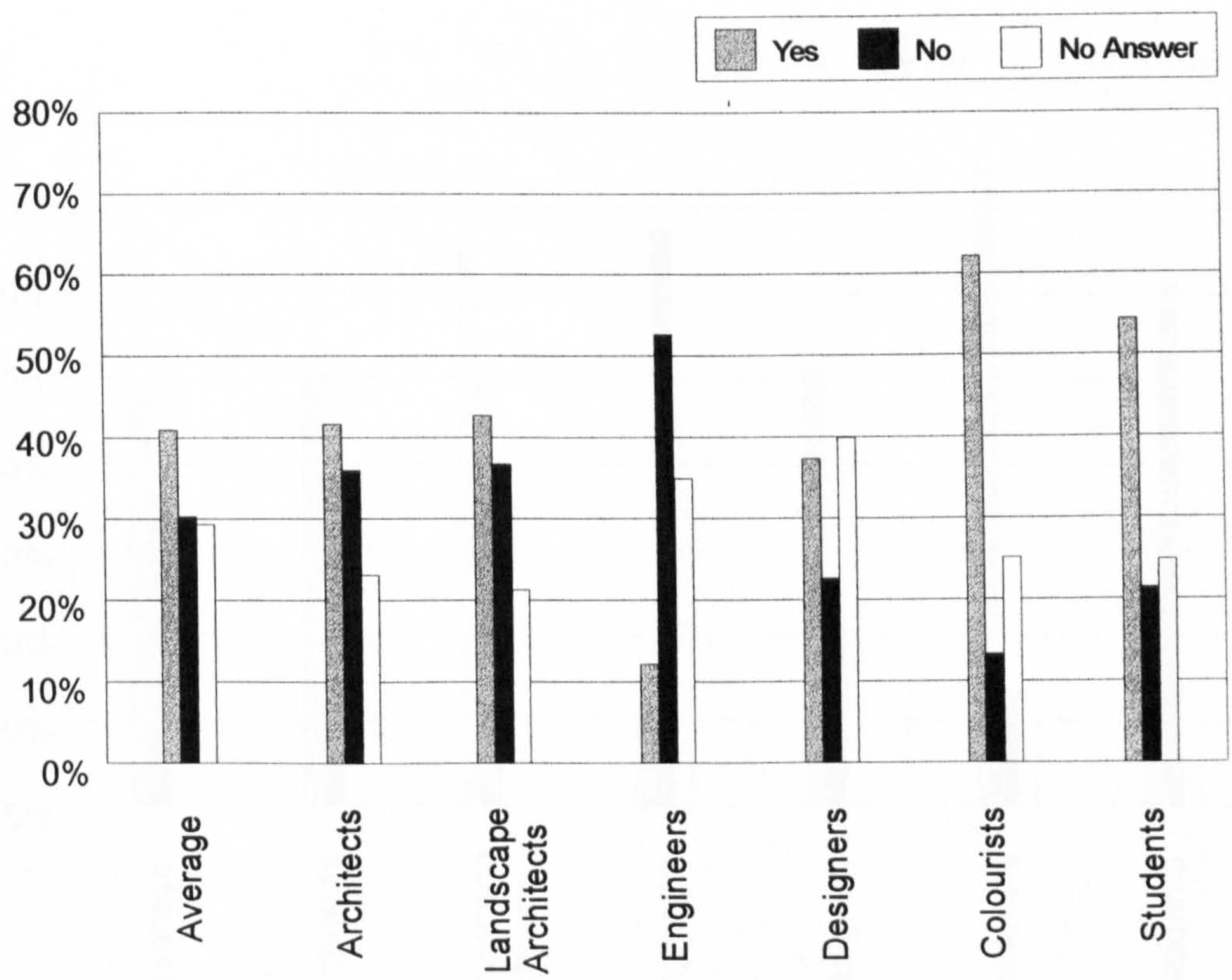


Fig 9.14 *Colour theory must be used in architectural design studio as a conceptual design tool to expand the means for clarifying the figural and hierarchical nature of building form.*

Question 41: Are colour issues discussed when you are working in a project of architecture or design ?

The findings here show a very interesting position. Students (65%) and engineers (67%) present a clear statement: most of them don't discuss colour issues when they are working in a project of architecture or design. On the other hand, the investigation clearly proved that colourists (75%) and landscape architects (71%) have a very positive statement in this question. This is certainly due to their formation: colourists and landscape architects deal always with colour issues in their undergraduate and professional projects.

In what concerns architects and designers, they present a very similar position, showing that colour issue is already returning to the process of project, but yet in a very tentative way.

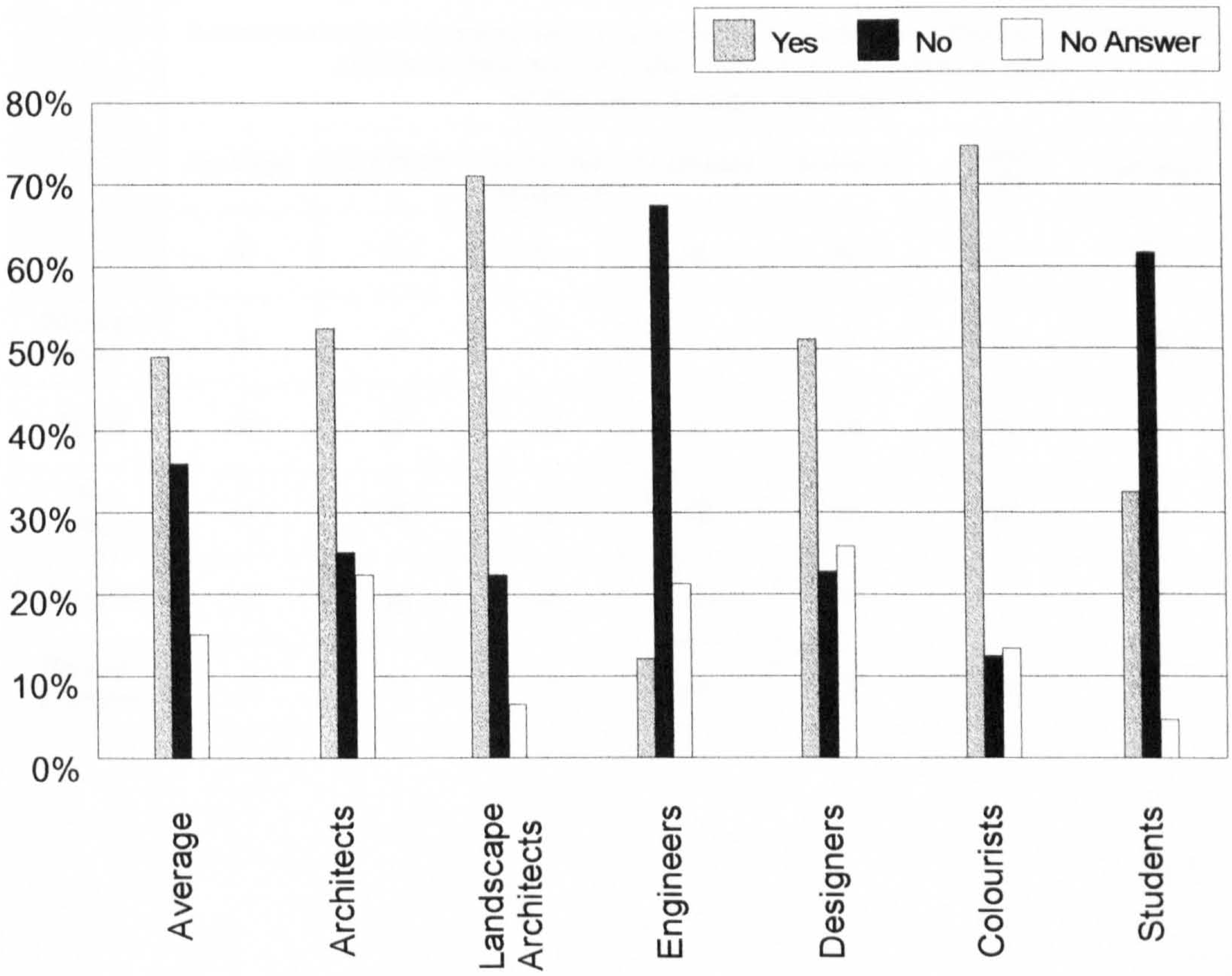


Fig 9.15 *Colour issues are discussed when people are working in a project of architecture or design.*

Question 42: Architects are still reluctant to consider colour as an integral part of the total design process.

The findings clearly demonstrate that architects are aware of their reluctance to consider colour as an integral part of the total design process (52% against 32%). Colourists (61%) are the other group who work directly with architecture and colour and they are also aware of the situation. Designers (55%), engineers (46%), landscape architects (48%) and students (48%), in spite of presenting a positive assessment higher than the negative one, prefer to give no opinion, avoiding the question.

Table 9.24 *Architects are still reluctant to consider colour as an integral part of the total design process.*

	Assessment of respondents regarding the statement that architects are still reluctant to consider colour as an integral part of the total design process						
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students
	%	%	%	%	%	%	%
Strongly Agree	3	5	0	0	0	3	10
Agree	40	47	32	41	29	58	35
No Opinion	42	16	48	46	55	37	48
Disagree	13	32	20	10	11	2	5
Strongly Disagree	2	11	0	3	5	0	2

Question 43: Many architects don't use colour in their projects because they have a lack of knowledge about colour.

There is a general consensus (with the exception of landscape architects) about the statement of the question: architects don't use colour in their projects because they have a lack of knowledge about colour, and not for a question of option. As already referred, only landscape architects are not so sure of that: most of them preferred not to give an opinion (53%), but the others probably think that when architects don't use colour in their projects it is only because they elected that option. Students present a very clear assessment: or they don't want to answer (because they haven't finished their studies and they still are not aware of all the process of project making; or they are not students of architecture); or they already know the reality and they agree (62%) on the statement of the question.

Table 9.25 *Many architects don't use colour in their projects because they have a lack of knowledge about colour.*

	Assessment of respondents regarding the statement that many architects don't use colour in their projects because they have a lack of knowledge about colour						
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students
	%	%	%	%	%	%	%
Strongly Agree	4	8	0	0	5	0	13
Agree	39	42	15	40	27	62	49
No Opinion	42	12	53	48	55	33	48
Disagree	15	38	22	10	13	5	0
Strongly Disagree	0	0	0	2	0	0	0

Question 44: Many architects still use colour as the make-up of the building (cosmetic role).

Architects are the only respondents' group who don't agree (35%) with the statement of the question, in spite of presenting a high level of no opinion (42%). The findings show clearly that all the other respondents know that in most of the cases, architects don't do a serious, responsible and scientific work when using colour in their projects; colour is only the make-up of the building.

Table 9.26 *Many architects still use colour as the make-up of the building (cosmetic role).*

	Assessment of respondents regarding the idea that many architects still use colour as the make-up of the building						
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students
	%	%	%	%	%	%	%
Strongly Agree	2	0	0	0	2	10	0
Agree	58	23	58	69	64	73	62
No Opinion	24	42	7	18	28	17	31
Disagree	16	32	35	13	6	0	7
Strongly Disagree	0	3	0	0	0	0	0

Question 45: With the exception of the historic centres of the cities, most of our cities' experiences with the use of colour are still inconsistent: there is no scientific process for the colour proposal.

Respondents show a very similar position in relation with question 44. Both questions are very related. Once again, architects are the only group of respondents who disagree (48%) with the statement of the question; anyhow, in this question there is a high percentage of respondents who give their agreement (40%), showing clearly that the subject is controversial.

The average of respondents present an agreement on the subject: 56% agree and 7% strongly agree.

Table 9.27 *With the exception of the historic centres of the cities, most of our cities' experiences with the use of colour are still inconsistent: there is no scientific process for the colour proposal.*

	Assessment of respondents regarding the statement that, with the exception of to the historic centres of the cities, most of our cities' experiences with the use of colour are still inconsistent, because there is no scientific process for the colour proposal						
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students
	%	%	%	%	%	%	%
Strongly Agree	7	5	8	13	4	12	0
Agree	56	35	62	65	68	71	43
No Opinion	13	12	13	5	8	15	25
Disagree	23	48	23	17	17	2	32
Strongly Disagree	1	0	4	0	3	0	0

Section 7 . Colour Teaching

Question 46: The lack of guidance in architectural schools about the application of colour within architecture had led to this existent gap in the use of colour.

Architects (77%), students (82%) and designers (75%) are the respondents who present the highest level of agreement, certainly because they are the ones who are more related with the question itself. Landscape architects followed by engineers are not so sure about the question, preferring not to give their opinion on the subject.

The average response shows that certainly a greater emphasis could be placed on teaching the qualities of colour, especially within the design and architectural courses.

Table 9.28 *The lack of guidance in architectural schools about the application of colour within architecture had led to this existent gap in the use of colour.*

	Assessment of respondents regarding the statement that the lack of guidance in architectural schools about the application of colour within architecture had led to the existent gap in the use of colour						
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students
	%	%	%	%	%	%	%
Strongly Agree	5	5	0	0	7	10	11
Agree	61	72	38	51	68	65	71
No Opinion	20	2	42	38	18	14	3
Disagree	11	21	20	0	2	11	15
Strongly Disagree	3	0	0	11	5	0	0

Question 47: For all the professions, which deal with environment planning, it is very important to have a course on colour at the undergraduate level.

There is a general consensus upon this statement: all groups of respondents are unanimous in the importance of having a course on colour at the undergraduate level. So far, the decision-makers of schools where courses prepare students who are going to work with colour in their professional projects, have to re-evaluate the programs of the courses, introducing the study of colour.

Table 9.29 *For all the professions, which deal with environment planning, it is very important to have a course on colour at the undergraduate level.*

	Assessment of respondents regarding the idea that for all professions, which deal with environment planning, it is very important to have a course on colour at the undergraduate level						
	Average	Architects	Landscape Architects	Engineers	Designers	Colour Units	Students
	%	%	%	%	%	%	%
Strongly Agree	8	11	3	2	10	10	12
Agree	60	65	61	43	47	75	71
No Opinion	21	15	25	36	32	10	6
Disagree	8	9	8	12	11	5	3
Strongly Disagree	3	0	3	7	0	0	8

Question 48: Are professionals currently being educated in the effects of colour?

Besides colourists, all the other groups of respondents present a clear statement that professional, in general, are not being educated in the effects of colour. Of course, colourists (70%) present a high level of respondents answering positively, because they have one of the few courses where colour is a main issue. The ones who responded negatively (25%) referred their position to the courses in general.

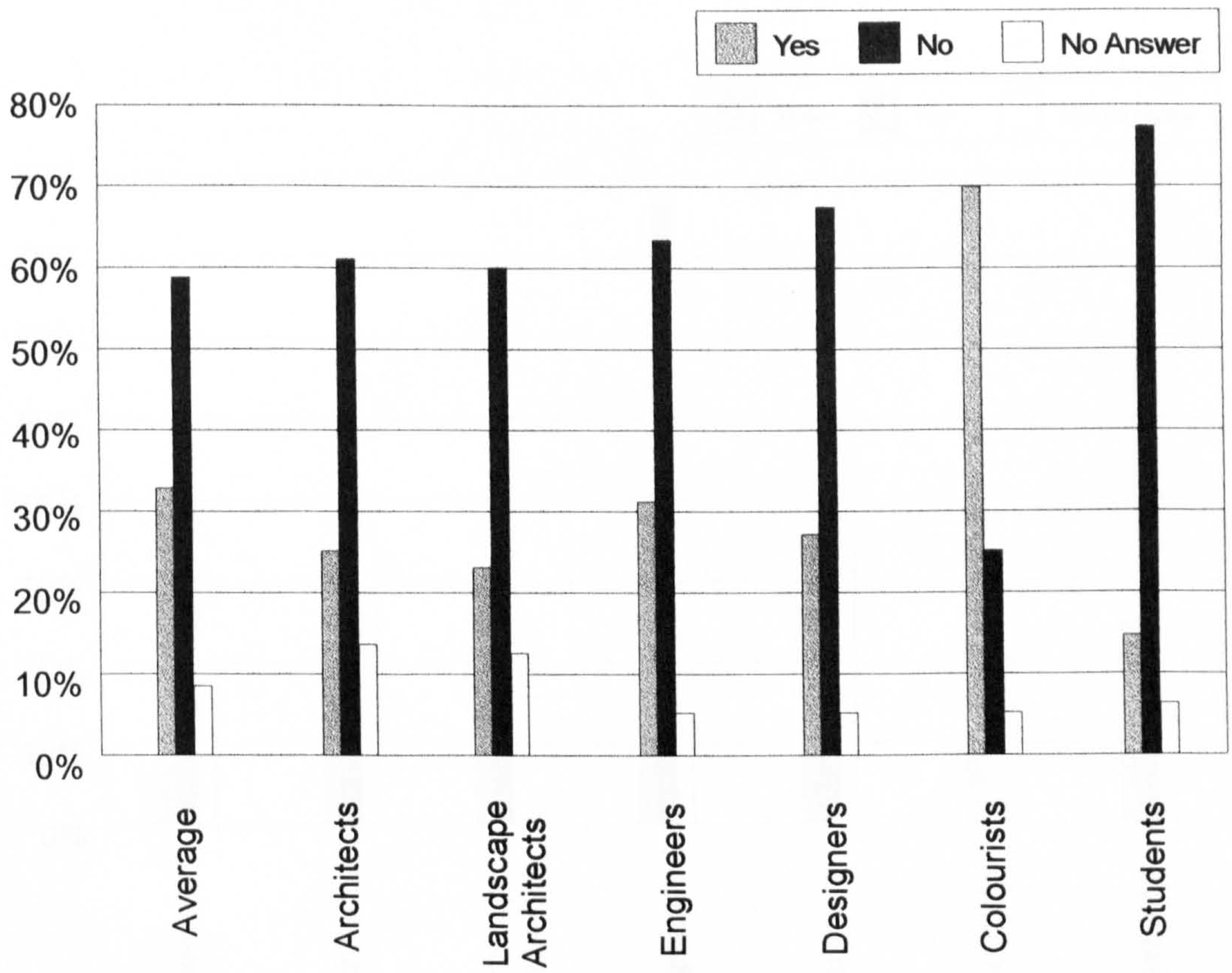


Fig 9.16 *Professionals are currently being educated in the effects of colour.*

Question 49: Do you have any knowledge about colour theory?

These findings reveal the level of knowledge that the different groups of respondents have about colour theory. Colourists are the only group who possesses a real formation on colour. About 1/3 of the landscape architects presents to have some information on colour issue. All the other respondents have a huge lack of formation in this area of knowledge.

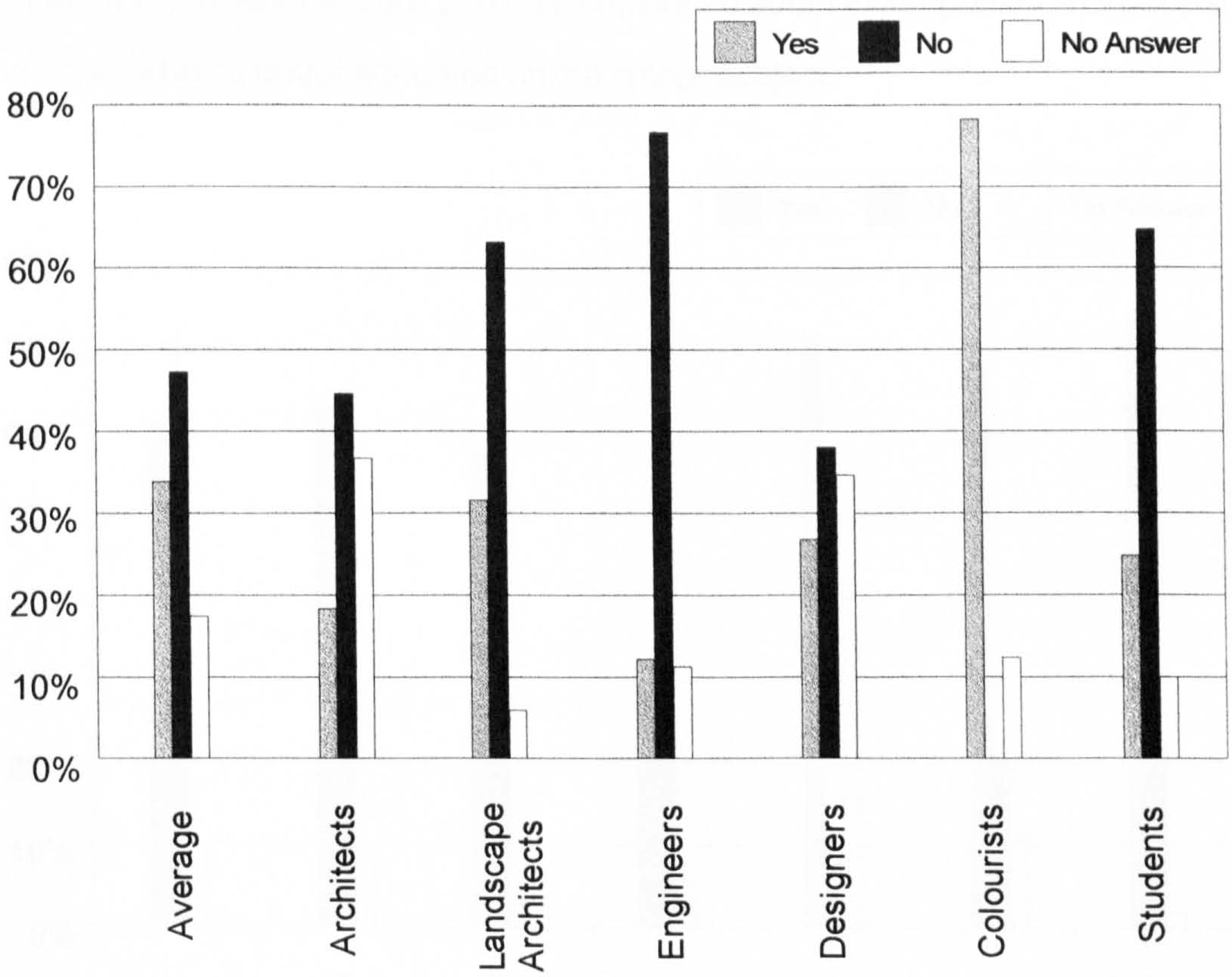


Fig 9.17 *Having any knowledge about colour theory.*

Question 50: Do you think the public in general should have more information on colour use, especially in architecture?

The universe of respondents present a 61% percentage of affirmative statement, thinking that people in general should have more information on colour use, especially in architecture. In Sweden people in general have more information about NCS Colour System. Engineers (63%) present the highest level of negative statement on the subject, being the only ones who have the opposite position in parallel with the other groups of respondents. This attitude is justified by the position that great part of engineers has about the use of colour in architecture: they don't think it is an important issue.

Students and designers are the more convinced about the importance of people in general being better educated on the colour subject.

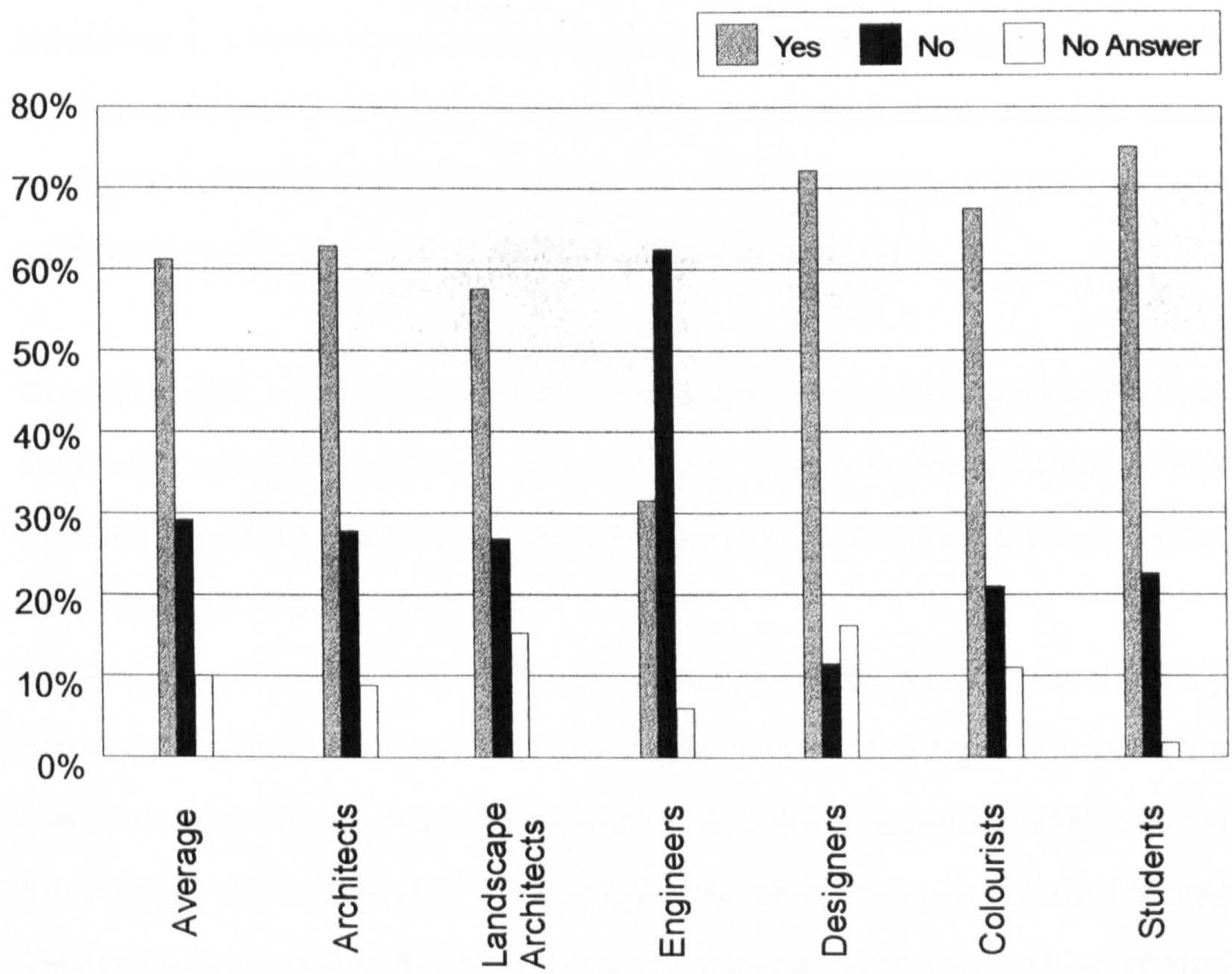


Fig 9.18 *Public in general should have more information on colour use, especially in architecture.*

9.16 Interpretation of the Survey Findings and Second Round of Interviews

As it was demonstrated, the response rate was sufficient enough to provide a reliable sample of the population as a whole.

After the analysis, the questionnaire findings were used to modify the theory through further comments from the initial expert panel.

A second round of interviews was undertaken with the expert panel, in order to add new comments to the findings. Each interview took about one hour. During this period of time, the experts were confronted with the outcomes of the survey and they made important comments which gave a big support to the conclusions of this research.

The experts were not surprised with the outcomes from the survey by questionnaire. Confronted with the lack of information about colour that the professionals who work in the area of architecture generally have, the panel of experts was unanimous in considering that is perhaps the main gap for a restructure in the use of colour in the built environment. It is impossible to manage within quality the built environment if people in general simply don't even have a basic understanding of, nor consider effectively the colour issue.

The experts also agreed that colour must be taught in every undergraduate course connected with the area of built environment. They were really surprised with users and students' positions, showing that they are much aware of the problems with the use of colour and its origin.

Another outcome from this new round of interviews with experts was that they recognise the lack of information about colour use leads designers to avoid the use of colour and to the defensive position that colour is not an important issue in the process of the project of architecture. So, when they use colour, it is only discussed at the end of the project and in a very simplistic way, with no special knowledge of its effects or the impact of the colour/space communicational unity.

The panel of experts continue to have some reluctance in accepting colour planning and the use of guidelines for the use of colour; anyhow, during the interviews they recognised (mainly architects and engineers) that they are afraid of loosing freedom of choice in selecting colour for their projects. Anyhow the experts presented a general agreement about colour aesthetics.

The problem of the visual pollution in the built environment was also addressed. The panel of experts agreed on the position that correct colour management is fundamental to achieve colour quality in the built environment.

9.17 Summary

This chapter has described the last part of the investigation of the hypothesis, done by survey methodology. The survey comprised a full response questionnaire and interviews with a panel of experts. The first round of interviews served as a feasibility test of the questionnaire itself. The second round of interviews was done after the questionnaire findings and it was used to modify the initial theory through further comments from the expert panel.

The experts commented that the main findings of the research would be very significant and useful, especially to architects, designers and decision-makers in the management of the built environment – the cities.

Next chapter will summarise the main conclusions of the study and the recommendations for areas of further research in the application of the colour/space unity within the built environment.

CHAPTER 10

CONCLUSIONS AND RECOMMENDATIONS

10.1 Introduction

The study was undertaken in order to establish the existence of a straight relationship between *colour* and *space*, defining a *unity*, which is a *unity of visual communication* with an impact of major importance in the built environment.

The main aim of this study was to identify that colour should always take part in the process of the project of architecture from the very beginning and, therefore, should always be a concern of our built environment management, in terms of improving the life quality in our cities. The main objectives of the study are restated below. Finally, recommendations are made for areas of further research efforts for the integration of colour in every aspect related with architectural design.

10.2 Summary

The study commenced with a review literature which identified that bridging the gap between colour and the project of architecture is essential for improving life quality within the built environment.

The literature review of *colour* and *space*, lead to the research question and the hypothesis:

10.2.1 Research question:

" Is it possible to define Colour / Space as a visual communicational unity, which influences directly the architectural project and, therefore, the city itself? "

From this research question the following hypothesis has been developed.

10.2.2 Hypothesis

Colour / Space is a visual communicational unity which is directly connected with architecture and the environment.

To explore this an *integrated research methodology* was used to fulfil the aims and specific objectives of this research, developing a *model* for the investigation which comprises two research techniques:

- Literature review, investigating the existence of strict relationship between colour and space forming the colour/space unity; and that unity is a visual communicational one.
- an evaluation of the literature review findings through *survey methodology*.

The investigation through literature review with the contribution of the researcher's personal experience, showed:

- the existence of the colour/space unity;
- the unity is a unity of visual communication, which takes part in the visual programming languages and, therefore, in the environmental colour planning.

The survey was made through a full test response questionnaire, sent to 7 different survey group of respondents: architects, landscape architects, engineers, designers, colourists, undergraduate students of architecture and design courses, and users.
As a feasibility test of the questionnaire, the investigation used a series of semi-structured interviews to a panel of 25 experts, comprising: architects, landscape architects, designers, engineers and colourists.

Finally, after the analysis and interpretation of the questionnaire findings, the investigation returned to the expert panel to modify the theory through further comments. The interviews with the panel of experts took about one month.

The research has then arrived to the main conclusions and recommendations of the present study.

10.3 Comments on the Quality of the research

A thorough literature review of current knowledge and theory has been undertaken. The limitations of this method of research is that the information gathered is second hand, and so the exact conditions used within the experiments described in the text are not known. The nature and difficulty of work carried out by subjects within the experiments is also unknown, as in many cases, the size and diversity of the sample of subjects used.

Concerning the second method of research, in chapter 9 the strengths and weaknesses of the various survey methods were highlighted. The judgement was made that the strengths of postal survey - wide geographical coverage and larger sample size due to its relatively low cost - outweighed its weaknesses. Postal survey was therefore adopted. The nature of the investigations required some communication with the survey subjects. This inevitably introduces the risk of bias. Because the questionnaire was to be self-administered, it had to be highly structured. This has the potential of biasing the responses. This risk was balanced by the provision of spaces for additional comments to be supplied.

One other disadvantage of the postal survey, as far as the findings were concerned, was the inability to probe respondents as to the reasons behind some of their responses. In this situation, face to face interviews would have been superior. That is why interview the panel of experts was selected as the pretest for the questionnaire, and as the means to allocate more comments to the questionnaire survey findings.

10.4 Main Conclusions

The main conclusions from this study are:

1. This study had as a first target the investigation of the perceptive-communicative relationship between *colour* and *space*, which form a *visual communicational unity*.

To show the existence of the strict relationship between colour and space, the investigation had as main support:

- the relevant literature review
- the personal experience of the author, acquired during his professional experience as teacher, as researcher and as architect, for more than 20 years.

The investigation has proved the existence of the relationship between *colour* and *space*, forming the *colour/space unity*, through identification of the following:

1.1 The research of the colour/space unity.

Colour defined as a component element of the *visual space*, and having defined the essential qualities of the complex *colour/space* in the environmental language, the reasoning drives the research to have a judgement on all the interpretations done about the process of *colour / space systems.*

The study started with the concept research about the structural affinities in visual space, determining the forming of visual unity by the dual

colour–space.

And, analysing each one of these two aspects, isolated and in structural confrontations, the investigation can conclude, by its definition as *essential elements to the visual world.*

1.1.1 So, the investigation concluded that *colour* and *space* form a *unity* : the *colour/space unity*, with the expression $(h\ \frac{v}{c})\ /\ S$, relating the three attributes of colour (hue, value and chroma), with space.

1.1.2 During the second step the research concluded that *colour/space unity* is a *unity of visual communication*, being *communication* the third essential element of the visual world, forming a *triad*: *colour – space – communication.*

1.1.3 Introducing *colour/space* concept as an essential element to the project, exploring perceptive-communicative existing properties, the investigation concluded that one can build up the systems of tonal classes, basis for the constitution of repertoires of signals and signs applicable to visual languages and messages.

1.1.4 The research concluded about the systems: one can define its participation in the image codification and decodification and analyse its communicational characteristics, in the forming of environmental visual field and, its role in the identification of environmental image.

1.1.5 In the interpretation of process of image identification by *the colour/space language,* the study has searched for the interpretation of *system behaviour* according to flexibility degrees of opening and closing in the formation of signals and visual communicative unities, trying to dimension a *kinetic* of *space-time development.*

1.1.6 The investigation has reached the comprehension of codes, which activate the communicative dynamic by constant search of *intentional/environmental equilibrium,* in the game of variables and invariables, in the natural continuity in space and time.

1.1.7 From all this concept and this analytical research, what prevails in this study as a code, which gives information of *colour/space* directly to the perception of reality and, indirectly to the perception of memory, it is the *chromatic spatial value* itself, i.e., the *shade* with its *own spatial dimensions* defined by its *characteristics (or attributes).*

If people identify an image by *colour/space,* prevails one of all the included values, which are appropriate to its communicational field: the *shade* and its *visual spatial definition.*

1.1.8 Therefore, going back to the concept about methodological integration of the project, the quest related to the visual reading and the orientation dedicated to visual planning, the essential considerations fall on the tonal languages which were basis for all discussion, the definition, the dimensioning and the extension of the messages and its codes in the communicational kinetic of the environmental field.

1.1.9 The investigation can conclude, therefore, about the importance of research guided in the direction of the *perceptive tonal spatial unity*, defined as

$$(h \frac{v}{c}) / S,$$

original and procreative element of *space/light and colour and, space/ configuration and colour, in fullness and voids, visual rhythms in vibration of hue of brightness (value) and of saturation (chroma),* points of perceptive interest, points of communicative intention, in moments of perception and of communication which perpetuate themselves in visual time.

1.2 The application of the colour/space unity in the project of architecture

The visual communicative structure is implied in the conceptions and coordinations of spaces particular to buildings and cities, included in the subsidiary functions internal and external to them and, as the architecture and urban planning projects are intended to environmental organisations and reorganisations, they imply in the consideration of visual communicational field and of repertoires and codes which comprise them and communicate their languages and messages.

1.2.1 The investigation concluded that *colour/space systems* belonging to the *visual communicational field*, they have a relationship to the *architecture project*, which is structurally set.

In its relationship to the project, colour/space languages following the order of visual communicational field, they have, therefore, double objectives:

1 - a methodology of visual environmental reading;

2 - a methodology of visual environmental planning.

The *visual environmental reading* means:

- to read the message at the present space-time, searching for links of language to the past space time;
- to define the present spatial message in communicational field, in the search for comprehension of repertoires and codes according to its future projection extension.

The *visual environmental planning* means:

- to plan the message for present space-time, with a search on future hypothesis of projects which might insert themselves in the communicational field of the architecture and the city;
- to computerise the message planned in the dimensions of repertoires and codes, analysed in its extensions, according to communicative environmental / intentional connective channels, in the relationship of past / present / future;
- to define the coordination of spaces according to languages, which included within the significative, of context, organic and temporary limits, in the communicational field, represent a tendency for stability in expression / content, between constant codes and changing codes, in the $\frac{s}{t}$ space / time relationship.

1.2.2 The research concluded that *Colour / space unity* characterises an environment, defines it, takes part in its message, it is a language which identifies it, pointing out a region, a locality, inferring its nature, its appropriation by human beings, with its intervention and production and implantation by the architecture and urban planning by the city.

The *consideration of the visual communicational field* of *colour/space unity*, as an essential element in the environmental, existing and experience order, it must, therefore, be part of the *methodology* and of the *process* of the *architectural project*.

2. After providing evidence of the existence and importance of the colour/space unity as an unity of visual communication, and therefore taking part in:

   . the visual programming of the environment

   . the methodology and global process of the project of architecture,

   the investigation wanted to verify the acknowledgement of the research findings within the experts, and the technicians who work with colour and the users in general. So, through a survey study, which comprised a full test questionnaire survey and rounds of interviews with a panel of experts, the investigation concluded:

2.1 People are aware of the existence of a perceptive-communicative relationship between colour and space, forming a unity of visual communication, which characterises the environment, defines it and takes part in its message (questions 1,2 and 3).

2.2 The study has showed that people in general agree that the colour/space unity is an essential element in the environment, and also that it is an essential element in the project of architecture, which is shown by questions 4 and 5.

2.3 In what concerns colour and its effects, the investigation concluded that people are aware that light and colour are major factors in the man-made environment, as well as texture, and their impact influences man's psychological reactions and physiological well being.

2.4 Colour, or the concept of colour, can be approached from different perspectives and different disciplines, being the main ones: colour theory, psychology, philosophy, natural sciences, biology, medicine art and technology. Art is the main discipline for architects and designers.

2.5 People are aware that colour produces mood associations, subjective and objective impressions, and that colour monotony induces anxiety, tension, fear and distress.

2.6 Colour influences people's estimation of volume, weight, size, time, temperature, noise, sound, and also smell and taste, but with lesser degree.

2.7 Professionals, as well as users agree that cultural heritage influences the effect and perception of colour.

2.8 The investigation also evidence that people are aware of the effects of colour when it is used externally within the built environment, and that these effects are significant enough to warrant consideration, because the used quantity of colour is very important and a major issue for the visual communication.

2.9 The research identified that people in general consider positive the use of colour in the built environment, and they really prefer environments within the use of colour: they consider coloured areas happier than the others; environments that are predominantly neutral in appearance are considered to be static, boring and tedious. They also agree that colourless environments germinate or contribute to some of our social ills. Professionals who work with colour, especially architects, engineers and designers, are less in agreement with these statements, mainly due to the lack of formation they have in colour: so, they prefer not to use colour in their projects, or very neutral shades.

2.10 When confronted with different environments, with or without the use of colour, people prefer environments with colour and texture, because they like texture and colour in the surface of buildings, and they don't like cement blocks (*concrete boxes*, as they call them). Architects and engineers don't all agree with this position. The influence of the modern movement in architecture in the formation of architects and engineers is still important, as well as the lack of information about colour theory or the use of colour.

2.11 Concerning colour and the use of colour, people stated that public's needs and preferences must be satisfied as well as architect's aesthetic aspirations, and that colour should serve to increase the overall effect of the architectural value of each building, of an entire street or square, or of a built environment.

They are aware that colour can contribute to the unity of a street or square, or it may destroy that unity. So, whichever colour scheme is followed the street should be viewed strategically as an element in the city, as well as when developing a colour scheme for a building it must first be seen in its strategic relationship with its immediate surroundings and its visual function within the city or district.

2.12 Confronted with the question about the most important factors for the use of colour, people enounced culture, pattern traditions, economy, geography, religion, climate, fluctuation of taste and educational level.

2.13 Colour should be an integral part of the architecture planning from the onset and not a separate element that the architect has to deal with later. Architects are the only respondents who don't agree with the former statement; this shows clearly the minor importance that architects give to the use of colour in the process of the project of architecture, and therefore, in its planning.

2.14 The investigation concluded that everybody agreed on the necessity of having strict rules for the application of colour within architecture, and therefore, guidelines for the use of colour must be emphasized in the city planning.

2.15 It was also proved that colour is not yet considered an important facet of the design process, especially for architects who present a divided position, but the characterisation and harmony through colour can only be achieved with a professional experience.

2.16 When confronted with the use of colour, the technicians who work with colour in their projects and the undergraduate students of architecture and design courses, stated that colour issues are not discussed when they are working in a project, as well that architects are still reluctant to consider colour as an integral part of the total design process. It was also showed that many architects don't use colour in their projects because they have a lack of knowledge about colour, and sometimes they use it in a cosmetic role.

Not referring to the historic areas in the cities, most of our cities' experiences with the use of colour are still perverse, with no scientific process for the colour proposal.

2.17 The research also concluded that the lack of guidance in portuguese architectural schools about the application of colour within architecture had led to this existent gap in the use of colour (and the author suspects that probably the same happens in other countries –'like U.K., as the literature review showed).

2.18 Professionals who work with colour are not currently being educated in the effects of colour and most of them don't have any knowledge about colour theory. This investigation concluded that professionals who deal with the environment planning should have a colour formation, and public in general should have more information on colour use.

Colour can modulate a building and bring it into harmony with its surroundings. It can differentiate elements; it can contain, unite, equalise, accentuate, underline or draw attention to proportions.

10.5 Issues that should be addressed

The following are considered to be the issues that should be addressed in further research work for the integration of the *colour/space unity* in the process of the project of architecture, with the aim of improving the built environment management and, therefore, the life quality in our cities:

1- The implementation of the colour study in architecture, urban planning, landscape architecture, engineering and design courses.

Except for the teaching of the early Bauhaus and the brief emergence of colour in some art movements (like Impressionism, Constructivism and

Expressionism), colour theory and teaching has been considered supplemental to the mainstream of architectural education. Architecture students rarely are offered a course in which colour in design and the relationship of form and colour to architecture is the focus of the instruction.

Occasionally students from fine arts who matriculate for a professional degree in architecture have some knowledge of colour theory, but for most part colour remains a matter of individual taste. Colour issues are rarely discussed in a design studio review, and then almost never on an objective basis.

The challenge is to bring colour theory into a conceptual framework where its relevance is part of the design process. This challenge has become the point of departure for this investigation. Colour theory must be used in:

- architectural design studio classes as a conceptual design tool to expand the means for clarifying the figural or hierarchical nature of building form;
- the analytical or interpretative phase of the process as a critical tool in examining the integral relationships between the parts and the whole.

2- To develop colour schemes for cities, comprehensive and capable of implementation. In spite of every city being a different issue, there are some general steps that these plans have to follow, which result of my own experience:

- Survey of the site and surroundings;
- An analysis of the data;
- The colour strategy plan;
- Presentation and adjustments;
- Implementation procedures (guidelines);
- Management of the colour plan.

10.6 Recommendations for further Research

The following are considered by the author to be the areas for further research work, which the author had no chances to develop:

1- To investigate if any established colour scheme should follow the laws of harmonic colour composition.

2- To use colourmetry to populate the expression

$$C/S = (h \frac{v}{c}) / S$$

3 - To verify colour can contribute to modify some city areas where social hills exist.

4 - To verify the colour/space unity impact and the four different scales on which colour in the city can be seen: the scale of the city or of the district; the scale of the street or square; the scale of the individual buildings; and the scale of the details – windows, shutters, ironwork, street furnishings.

5- To populate the colour/space unity and its formula: the four different ways it can be seen - from the side; from the front; from above; and from below.

6- To investigate the colour/space unity and the light conditions: a building can be seen in deep shadow; in conditions of blazing sunshine; or harshly against a bright sky.

7- To develop a study about *colour/space unity* and the different ways it can be used in the same façade: even if one maintains the same colour and the same quantity of colour (space), depending on how one uses it, different visual communicational impacts can be achieved.

8- To verify the impact of the colour/space unity in the paint manufacturing industry.

9 - To develop a deeper statistic analysis on the survey results.

10 - To populate the expressions with readings and calculations, in a different context.

The largely unselfconscious uses of colour that have sustained the colour traditions for so long, can no longer be relied upon, even where they are appropriate. As people are slowly discovering, and as the present study illustrates, it is only by the self-conscious processes of design that these can effectively be supplanted.

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APPENDIX A

QUESTIONNAIRE MODEL

COLOUR / SPACE : ITS QUALITY MANAGEMENT IN ARCHITECTURE

THE COLOUR/SPACE UNITY AS AN UNITY OF COMMUNICATION

QUESTIONNAIRE

FERNANDO MOREIRA DA SILVA
POSTGRADUATE PROGRAMME OF RESEARCH

TIME / Research Centre for the Built and Human Environment

University of Salford 1997

INTRODUCTION

I am a researcher at BUHU - Research Centre for the Built and Human Environment - on a fulltime postgraduate programme. I'm preparing my thesis for the PhD degree.

My area of research is the relationship between Colour and Space, as area of colour, and its importance and management in the built environment.

After a literature review on Colour and Space, I arrived to the conclusion that Colour and Space form a unity: the Colour / Space unity, which is a unity of visual communication.

To test my outcomes, I made a feasibility test: structured interviews with experts (architects, colourists, designers, landscape architects and engineers).

After this I produced this questionnaire, which I'm going to send to architects, landscape architects, engineers, designers, colourists, users and students (undergraduate students in architecture and design).

Your participation in this process is very important, because the findings of this survey will contribute to test and modify the conclusions of my study.

I would be very grateful if you complete this short questionnaire and return it to me. The questionnaire should only take about 30-40 minutes to fill in and complete confidentiality is guaranteed.

You will see that later in the questionnaire there is an opportunity for you to request early feedback on the results of the research.

Thank you for your help. Please return the questionnaire in the stamped addressed envelope provided.

PART I

Section 1

This Section concerns the relationship between *colour* and *space,* which forms the *colour/space unity.*

Please tick the appropriate box. If you have no formal opinion on the subject, please pass to the next question.

Question 1 - When dealing with colour in architecture, do you agree that there is a straight relationship between colour and space(as quantity of colour)?

Yes ☐ No ☐

Please indicate by ticking the appropriate box, the extend to which you agree.

N.°	QUESTION	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
2	There is a perceptive-communicative relationship between colour and space, forming a unity of visual communication					
3	Colour/space unity characterises an environment, defines it, takes part in its message					
4	Colour/space unity is an essential element in the architectural project					
5	Colour/space unity is an essential element in the environment					

Section 2

This Section concerns Colour and its effects.

Please indicate by ticking the appropriate box, the extend to which you agree.

N.°	QUESTION	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
6	Colour and light are major factors in man-made environment and their impact influences man's psychological reactions and physiological well being					
7	Texture and light are very important issues when people deal with the quality and quantity of colour in architecture					
8	Colour and the concept of colour can be approached from different perspectives and different disciplines					

Question 9 - If your answer was agree ot strongly agree, name the different disciplines which you think are the main ones for the colour approach

____

____

____

____

Please indicate by ticking the appropriate box, the extend to which you agree.

N.°	QUESTION	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
10	Colour produces mood associations, subjective and objective impressions					
11	Colour monotony induces anxiety, tension, fear and distress					
12	Colour influences our estimation of volume, weight and size					

Question 13 - Please indicate other areas that you think colour influences.

____

____

____

Please indicate by ticking the appropriate box, the extend to which you agree.

N.°	QUESTION	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
14	Cultural heritage influences the effect of colour					

Section 3

This section concerns the relationship between Colour and the Built Environment

Please tick the appropriate box. If you have no formal opinion on the subject, please pass to the next question.

Question 15 - Do people take account of the effects of colour, when it is used externally within the built environment?

Yes ☐ No ☐

Question 16 - Are the effects of colour significant enough within an external environment to warrant consideration?

Yes ☐ No ☐

Please indicate by ticking the appropriate box, the extend to which you agree

N.°	QUESTION	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
17	The quantity of colour used in the environment is very important and is a major issue for the visual communication					

Please tick the appropriate box. If you have no formal opinion on the subject, please pass to the next question.

Question 18 - In the built environment, do you consider the absence of colour positive or negative?

Yes ☐ No ☐

Question 19 - Do you prefer a colourless environment or an environment with the use of colour?

Colourless Env. ☐ With use of colour ☐

Please indicate by ticking the appropriate box, the extend to which you agree.

N.°	QUESTION	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
20	Colourless environments germinate or contribute to some of our social ills					

Please tick the appropriate box. If you have no formal opinion on the subject, please pass to the next question.

Question 21 - Do you consider coloured areas happier than the others?

Yes ☐ No ☐

Please indicate by ticking the appropriate box, the extend to which you agree.

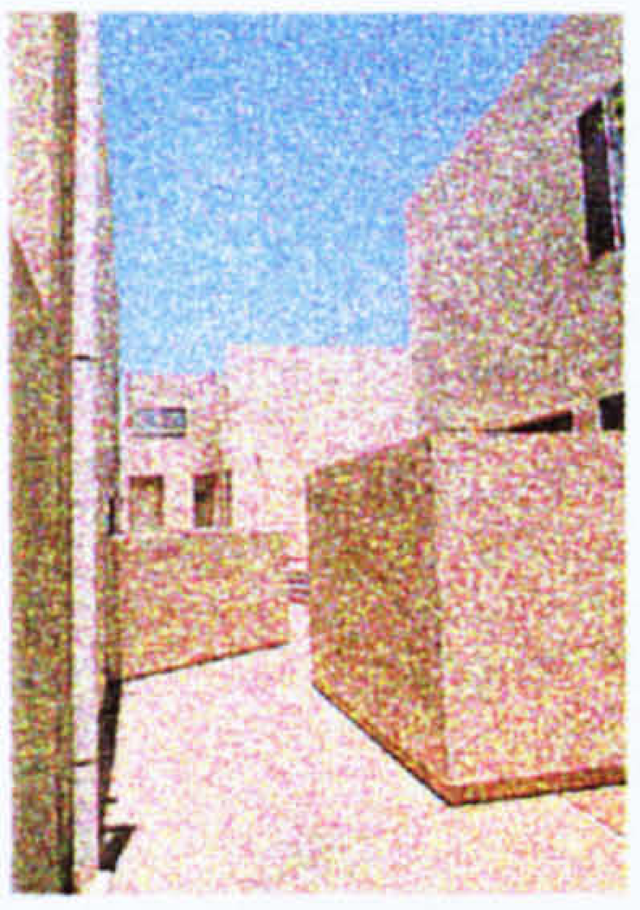
N.°	QUESTION	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
22	Environments that are predominantly neutral in appearance are static, boring and tedious					

Please tick the appropriate box. If you have no formal opinion on the subject, please pass to the next question.

Question 23 - Do you prefer happy environments colours or dull environment colours?

Yes ☐ No ☐

Question 24 - Looking at the following figures, which of them do you prefer: Grey cement block, or with colour and texture?



Grey cement block ☐

With colour and texture ☐

Question 25 - Please give your statement: why do you prefer it ?

Please indicate by ticking the appropriate box, the extend to which you agree

N.°	QUESTION	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
26	Some architects are introducing colour back into the built environment and this is beginning to change the face of architecture					

Section 4

This Section concerns Colour and its use.
Please indicate by ticking the appropriate box, the extend to which you agree.

N.°	QUESTION	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
27	In the use of colour, the public's needs and preferences must be satisfied as well as the architect's aesthetic aspirations					

Please give your opinion on the subject.

Question 28 -Which are the main variables for the generic use of colour in the exteriors of architecture?

Please indicate by ticking the appropriate box, the extend to which you agree.

N.°	QUESTION	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
29	Colour should serve to increase the overall effect of the architectural value of each building, of an entire street or square, or of a built environment					
30	Colour can contribute to the unity of the street or square, or it may distroy that unity					
31	Whichever colour scheme is followed the street should be viewed strategically as an element in the city					
32	When developing a colour scheme for a building it must first be seen in its strategic relationship with its immediate surroundings					

Please tick the appropriate box. If you have no formal opinion on the subject, please pass to the next question.

Question 33 - Do you think it is important to establish the building's visual function within the city or district, when developing its colour scheme?

Yes ☐ No ☐

Please give your opinion on the subject.

Question 34 - Please give your statement about which factors you think are the most important for the use of colour.

Section 5

This Section concerns the Colour Planning.
Please indicate by ticking the appropriate box, the extend to which you agree.

N.º	QUESTION	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
35	Colour should be an integral part of the architecture planning from the onset, not a separate element that the architect has to deal with later					

Please tick the appropriate box. If you have no formal opinion on the subject, please pass to the next question.

Question 36 - Do you think it is necessary to have strict rules for the application of colour within architecture?

Yes ☐ No ☐

Question 37 - In the city planning, do you think there must be guidelines for the use of colour?

Yes ☐ No ☐

Note: *The two last sections of this questionnaire must only be fulfield by professionals working in the area of the project of architecture or design, or by the undergraduate student studying in the same areas of knowledge.*

Section 6

This Section concerns the Design Process

Please indicate by ticking the appropriate box, the extend to which you agree.

N.°	QUESTION	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
38	Characterisation and harmony through colour can be achieved only with a professional experience					

Please tick the appropriate box. If you have no formal opinion on the subject, please pass to the next question.

Question 39 - Do you think colour is considered an important facet of the design process?

Yes ☐ No ☐

Question 40 - Do you agree that colour theory must be used in architectural design study as a conceptual design tool to expand the means for clarifying the figural and hierarchical nature of building form?

Yes ☐ No ☐

Question 41 - Are colour issues discussed when you are working in an architectural project or design project?

Yes ☐ No ☐

Please indicate by ticking the appropriate box, the extend to which you agree.

N.°	QUESTION	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
42	Architects are still reluctant to consider colour as an integral part of the total design process					
43	Many architects don't use colour in their projects because they have a lack of knowledge about colour					
44	Many architects still use colour as the make-up of the building (cosmetic role)					
45	With the exception of the historic centres of the cities, most of our cities experiences with the use of colour are still inconsistent: there is no scientific process for the colour					

Section 7

This Section concerns the Colour Teaching.

Please indicate by ticking the appropriate box, the extend to which you agree.

N.º	QUESTION	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
46	The lack of guidance in architectural schools about the application of colour within architecture had led to this existent gap in the use of colour					
47	For all the professions, which deal with environment planning, it is very important to have a course on colour at the undergraduate level					

Please tick the appropriate box. If you have no formal opinion on the subject, please pass to the next question.

Question 48 - Are professionals currently being educated in the effects of colour?

Yes ☐ No ☐

Question 49 - Do you have any knowledge about colour theory?

Yes ☐ No ☐

Question 50 - Do you think the public in general should have more information on colour use, especially in architecture?

Yes ☐ No ☐

PART II

It would be very helpful if you could answer a few brief questions about yourself.
Please state:

Name ....

Qualifications ....

Occupancy ....

Age ....

Please tick the appropriate box, indicating to which group you belong:

Architect .... ☐

Designer .... ☐

Colourist .... ☐

Engineer .... ☐

Landscape Architect .... ☐

Student .... ☐

Other .... ☐

Would you like to receive early feedback on the results of the research?

YES ☐

NO ☐

Your contact:

____

____

Thank you very much for completing this questionnaire. Please return it in the S.A.E. provided.

COR/ESPAÇO: A SUA GESTÃO DE QUALIDADE, EM ARQUITECTURA

A UNIDADE DE COR/ESPAÇO
COMO UMA UNIDADE DE COMUNICAÇÃO

QUESTIONÁRIO

FERNANDO MOREIRA DA SILVA
Investigador na Universidade de Salford
Reino Unido
Departamento de Surveying
Time – BUHU
1997

INTRODUÇÃO

Sou investigador do BUHU – Research Centre for the Built and Human Environment -, integrado num programa de pós-graduação.

Estou a preparar a minha tese de investigação, para a obtenção do grau de Doutor.

A minha área de investigação é a relação entre a Cor eo Espaço, entendido este como área de Cor, e a sua importância e gestão no ambiente construído.

Após uma investigação literária sobre a Cor e o Espaço, cheguei à conclusão que a Cor e o Espaço formam uma unidade: a unidade de Cor/Espaço, que se trata de uma unidade de Comunicação Visual.

De modo a testar as minhas conclusões, executei um teste de viabilidade: entrevistas estruturadas com um painel de peritos (arquitectos, consultores de cor, designers, arquitectos paisagistas e engenheiros).

Após este teste, elaborei este questionário, o qual irei enviar a arquitectos, arquitectos paisagistas, engenheiros, designers, consultores de cor, utentes e estudantes (estudantes de cursos de arquitectura e design).

A sua participação neste processo é muito importante porque os resultados deste inquérito irão contribuir para testar e modificar as conclusões do meu estudo.

Agradecia que completasse este breve questionário e me-lo enviasse à posteriori. O preenchimento deste questionário deverá tomar cerca de 30-40 minutos e fica garantida total confidencialidade.

Verá que no fim deste questionário haverá uma oportunidade para poder expressar se deseja receber informação sobre os resultados da investigação.

Agradeço desde já a sua colaboração. Por favor, devolva o questionário dentro do envelope selado que se junta.

PARTE I

Secção 1

Esta secção diz respeito à relação entre Cor e Espaço, a qual forma a unidade de Cor/Espaço.

Por favor, assinale com uma cruz na respectiva caixa. Caso não tenha nenhuma opinião formal sobre o assunto, por favor passe à pergunta seguinte.

Pergunta 1 Quando estamos perante a cor em arquitectura, concorda que existe uma estreita relação entre a cor e o espaço de cor?

Sim ☐ Não ☐

Por favor, assinale o seu nível de concordância, assinalando com uma cruz no local respectivo.

Pergunta 2 Existe uma relação perceptivo-comunicativa entre cor e espaço, formando uma unidade de comunicação visual.

Concordo Muito	Concordo	Sem Opinião	Discordo	Discordo Muito

Pergunta 3 A unidade de cor/espaço caracteriza o ambiente, define-o e toma parte na sua mensagem.

Pergunta 4 A unidade de cor/espaço é um elemento essencial no projecto de arquitectura.

Pergunta 5 A unidade de cor/espaço é um elemento essencial no ambiente.

Secção 2

Esta secção diz respeito à Cor e aos efeitos de Cor.

Pergunta 6 Cor e luz são factores importantes no ambiente construído e o seu impacto influencia as reacções psicológicas e fisiológicas humanas.

Pergunta 7 Textura e luz são aspectos muito importantes quando as pessoas lidam com a qualidade e quantidade de cor na arquitectura.

Pergunta 8 A cor e o conceito de cor podem ser abordados por diferentes perspectivas e diferentes disciplinas.

Pergunta 9 Caso a sua resposta tenha sido concordo ou concordo muito, indique as diferentes disciplinas que pensa ser as principais para a abordagem à cor.

Pergunta 10 A Cor produz associações temperamentais, impressões subjectivas e objectivas.

Pergunta 11 A monotonia cromática induz ansiedade, tensão, medo e tristeza.

Pergunta 12 A cor influencia a nossa apreciação de volume, peso e tamanho.

Pergunta 13 Indique por favor outras áreas que considera que a Cor influencia.

Pergunta 14 A herança cultural influencia o efeito da Cor.

Secção 3

Esta secção diz respeito à relação entre a Cor e o Ambiente construído.

Pergunta 15 As pessoas têm consciência dos efeitos da Cor, quando esta é usada exteriormente no Ambiente construído ?

Pergunta 16 São os efeitos da Cor suficientemente significantes no ambiente de modo a serem considerados ?

Pergunta 17 A quantidade de Cor usada no ambiente é muito importante e assume um aspecto relevante na comunicação visual.

Pergunta 18 No ambiente construído, considera que a ausência de Cor é positiva ou negativa ?

Pergunta 19 Prefere um Ambiente em que não haja o uso da Cor ou um Ambiente em que esta tenha sido usada ?

Pergunta 20 Ambientes sem Cor germinam ou contribuem para algumas das nossas doenças sociais.

Pergunta 21 Considera as áreas coloridas mais alegres do que as outras ?

Pergunta 22 Ambientes que são predominantemente neutros em aparência, são estáticos, aborrecidos e causam tédio.

Pergunta 23 Prefere ambientes com cores alegres ou ambientes com cores tristes ?

Pergunta 24 Olhando para as seguintes figuras, qual delas prefere: a do Ambiente de blocos de cimento cinzentos, ou a do Ambiente com cor e textura ?

Pergunta 25 Por favor, justifique a sua preferência.

Pergunta 26 Alguns arquitectos estão a introduzir a Cor de novo no Ambiente construído e este facto está a começar a mudar a face da arquitectura.

Secção 4

Esta secção diz respeito à Cor e ao seu uso.

Pergunta 27 Quanto ao uso da Cor, as necessidades e preferências das pessoas devem ser satisfeitas tal como as aspirações estéticas do arquitecto.

Pergunta 28 Quais considera serem as principais variáveis para o uso genérico da Cor da arquitectura no exterior ?

Pergunta 29 A Cor deveria servir para aumentar o efeito geral do valor arquitectónico de cada edifício, de uma rua inteira ou praça, ou de um Ambiente construído.

Pergunta 30 A Cor pode contribuir para a unidade de uma rua ou praça, ou pode destruir essa unidade.

Pergunta 31 Qualquer que seja o esquema de Cor seguido, a rua deveria ser vista estrategicamente como um elemento na cidade.

Pergunta 32 Quando se desenvolve um esquema cromático para um edifício, este deve ser visto em primeiro lugar quanto à sua relação estratégica com a sua envolvência.

Pergunta 33 Pensa que é importante estabelecer a função visual de um edifício na cidade ou no bairro, quando se desenvolve o seu esquema cromático ?

Pergunta 34 Por favor dê a sua opinião sobre quais os factores que pensa serem os mais importantes para o uso da Cor.

Secção 5

Esta secção diz respeito ao Planeamento da Cor.

Pergunta 35 A Cor deveria ser uma parte integrante do projecto de arquitectura desde o seu início, não um elemento com que o arquitecto tenha de lidar mais tarde.

Pergunta 36 Pensa que é necessário existirem regras para a aplicação da Cor na arquitectura ?

Pergunta 37 No Planeamento da cidade, pensa que devem existir linhas gerais de orientação para o uso da Cor ?

Nota: As duas últimas secções deste questionário destinam-se a ser preenchidas apenas por profissionais que trabalham na área do projecto de arquitectura ou do design, ou pelos estudantes cujos estudos se circunscrevem às mesmas áreas do conhecimento.

Secção 6

Esta secção diz respeito ao Processo de Design.

Pergunta 38 A caracterização e harmonia através da Cor só podem ser alcançadas pela experiência profissional.

Pergunta 39 Pensa que a Cor é considerada como um aspecto importante no Processo de Design ?

Pergunta 40 Concorda que a Teoria da Cor deve ser usada no projecto arquitectónico como uma ferramenta para expandir os meios de clarificação da natureza figurativa e hierárquica da forma de um edifício ?

Pergunta 41 As questões da Cor são discutidas quando está a trabalhar num projecto de arquitectura ou de design ?

Pergunta 42 Os arquitectos ainda estão relutantes em considerar a Cor como uma parte integrante do processo total de projectar.

Pergunta 43 Muitos arquitectos não usam a Cor nos seus projectos porque possuem uma falha de conhecimento sobre a Cor.

Pergunta 44 Muitos arquitectos ainda usam a Cor como a maquilhagem de um edifício (o papel cosmético).

Pergunta 45 À excepção dos centros históricos das cidades, a maior parte das experiências com o uso da Cor nas nossas cidades são ainda uma "total perversão": não existe um processo científico na base da proposta cromática.

Secção 7

Esta secção diz respeito ao Ensino da Cor.

Pergunta 46 A falta de orientação nas escolas de arquitectura sobre da aplicação da Cor na arquitectura, conduziu à existência da falha no uso da Cor.

Pergunta 47 Por parte dos profissionais que lidam com o planeamento ambiental, é muito importante existir uma formação sobre a Cor ao nível da licenciatura.

Pergunta 48 Os profissionais são geralmente educados sobre os efeitos da Cor ?

Pergunta 49 Possui algum conhecimento sobre Teoria da Cor ?

Pergunta 50 Pensa que as pessoas em geral deveriam possuir mais informação sobre o uso da Cor, especialmente em arquitectura ?

PARTE II

Seria de grande utilidade se pudésse responder a algumas breves questões sobre si próprio(a).

Por favor, diga:

Nome ....

Habilitações ....

Ocupação ....

Idade ....

Por favor, coloque uma cruz na caixa apropriada, indicando em que grupo se inclui:

Arquitecto .... ☐

Designer .... ☐

Consultor de Cor .... ☐

Engenheiro .... ☐

Arquitecto Paisagista .... ☐

Estudante .... ☐

Outro .... ☐

Gostaria de receber informação sobre os resultados da investigação ?

SIM ☐

NÃO ☐

O seu contacto ....

....

Muito obrigado por ter completado este questionário. Por favor, devolva-o no envelope selado fornecido.

APPENDIX B

Glossary of terms

GLOSSARY OF TERMS

Achromatic colours – colours without hue: black, white and neutral grey.

Adaptation – the adjustment of the eye to different light conditions; adaptation is an essential factor in making colour judgements under different lighting conditions.

Additive Colour - when all the wavelengths of the visible sun light join at the same time, they originate a *non-chromatic light* or *white light*, in which the colours are not visible while separate entities; red (orange-red), green and blue (blue-violet) lights of equal intensities added together produce white light.

After-image – is the image seen when the eyes are closed or turned away after the cones of the retina have become adapted to an image of a particular colour; the after-image will be in the complementary colour of the original.

Brightness – is the intensity of a light source. Brightness is sometimes confused with the term *lightness*, which refers to the reflectivity or value of surface colours.

Character - is the qualitative term of colour, of colour's value, and it implicates intensity.

Chroma – is one of the attributes of colour, which implies the existence of *hue* and, it is the distinction between one colour and another more or less saturated.

Code - is a system of principles which grants a certain value to certain signals.

Colour - is the sensation caused by certain qualities of light that the eye recognises and the human brain interprets; is a property and the language of form.

Colour Constancy – is the process by which in our perceptions the colours of the objects remain constant under widely varying conditions.

Colour Solid – is a three-dimensional model expressing the three main attributes of colour: hue, value and saturation; the vertical axis invariably represents the scale of value (or greyness, or lightness) from black at the bottom to white at the top, the hues being placed in spectral order around the sides in layers according to their lightness (or value) and saturation (or chroma).

Colour System – is an arrangement of colours according to their attributes, which makes colour sampling possible.

Complementary Colours – are the pairs of colours which when mixed as light beams produce white light.

Elementary Colours – is the term used in the Natural Colour System to refer to red, yellow, blue, green, black and white.

Giantography - is the applied graphic technique to street advertising or *outdoors*.

Ground – is the term used after Faber Birren to describe the background, in the relation figure-background.

Hue – is a variable, which informs about to what particular class one colour belongs to.

Information theory – is a method of computing the transmissible and transmitted signals, not interfering in the field of significance.

Intensity – is the brightness of a light source; colour saturation.

Language – is the *group of signs* articulated among themselves creating a means for the message to be invoked.

Lightness – is the greyness of a colour compared with black and white; the degree to which a surface reflects light, described as *value* in the Munsell System.

Mass - is the amplitude of the chromatic surface: it is quantitative, mechanical.

Metameric colour - is any of two colours which, although having various spectral compositions, seem indistinct because they correspond to identical tri-chromatic values.

Metamerism – is the phenomenon of different spectral compositions being able to stir up the same sensations.

Non-chromatic Colours – is another term for *achromatic colours;* black, white and grey are called non-chromatic colours because their appearance don't result from wavelengths of reflected light, but from the quantity of light reflected.

Optical mixing – is the process by which juxtaposed colours are mixed and thus perceived to combine as a different colour.

Pigments – are small solid particles, not solvent in liquids, having the function of agglutination, and being especially efficient in selectively absorbing certain light wavelengths and reflecting others.

Primary Colours – are a set of three colours from which all the other colours can be derived, but no two of which will produce the third.

Proxemics - is the study of man's utilisation of the space, as a specialised elaboration of the culture, i.e. in which way and how man enjoys and uses, appropriates and interacts with the space.

Reflection – is the process by which light bounces off a surface, enabling it to be seen.

Refraction – is the bending of light rays as they pass from one translucent medium to another, as for instance from air to water or glass.

Saturation – is the intensity or purity of a colour; the term was originally used by dyers to describe the vividness of a hue.

Secondary Colours – are the colours obtained by mixing two or more primary colours.

Shade – is a colour obtained by mixing a hue with black; also called tone.

Sign - is the result between a significant, a physical instrument which carries a meaning, and the meaning itself which gives it a communicative sense.

Signal - is the physical concretness of a message.

Semiotics – is the science which studies the *meanings* (the significant units).

Simultaneous contrast – is the effect on contrast of colours that are simultaneously present in the visual field.

Spectral Colours – are the constituent colours of sunlight and white light.

Subtractive Colour - is a sensation provoked by the light, which results of the absorptions and subtractions occurred on the surfaces, also denominated as *colour of the objects.*

Subtractive Process – is the mixture of *pigments*, being the colour the remaining.

Subtractive Synthesis – is the process by which light, natural or artificial, is filtered and diffused by the atmosphere.

Tertiary Colours – are the colours produced by mixing two secondary colours (in painting).

Tone – is the term used to describe colour modifications; used specifically by Faber Birren to refer to the gradation from a hue towards neutral grey.

Unity - is a whole in which each part is identificable and mantain its initial characteristics

Value -is the distinction between any colour and a lighter or a darker one.

Visual-field – is the contained area defined by a perimeter which is the limitation of people's visual perception, structured in a way to determine until where the extensions and dimensions of the physical field (which acts as sensorial stimulus) can be visualised.

Visual Methodological Programming - is the programming of the visual messages for the environment, in a sequential approach and referenced with all the main variables which exist in a certain built environment.

Visual Space – is the space created by a certain relationship between man and environment, particularising its characteristics of visual perception.

Wavelength – is the distance between the peaks of adjacent waves.

Weight - is the middle term between mass and character; it is the weight that gives shade to colour.

APPENDIX C

Survey Data

		Architects	Landscape Architects	Engineers	Designers	Colourists	Students	Users	Total
	No. Sent	581	253	282	445	104	518	392	Total: 2575
	No. Rec.	410	168	149	280	93	373	392	Total: 1865
Question 1	Y	275	97	67	182	71	232	204	1128
	N	49	17	31	39	7	48	27	218
	NA	86	54	51	59	15	93	161	519
Question 2	SA	103	25	30	50	25	67	47	347
	A	127	45	37	92	35	93	90	519
	NO	131	76	49	104	31	153	188	732
	D	41	13	22	14	2	41	67	200
	SD	8	9	10	20	0	19	0	66
Question 3	SA	115	30	10	59	20	56	51	341
	A	152	54	46	98	35	123	98	606
	NO	115	62	49	78	33	123	184	644
	D	28	17	31	31	5	45	59	216
	SD	0	5	12	14	0	26	0	57
Question 4	SA	86	30	22	64	21	86	0	309
	A	176	59	48	132	48	157	122	742
	NO	98	57	55	70	21	37	196	534
	D	49	22	16	14	3	63	74	241
	SD	0	0	7	0	0	30	0	37
Question 5	SA	90	30	22	36	18	30	0	226
	A	304	120	86	174	75	287	267	1313
	NO	16	18	40	70	0	56	125	325
	D	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0	0
Question 6	SA	86	0	18	22	17	48	0	191
	A	308	108	91	182	71	257	184	1201
	NO	16	60	55	76	5	67	208	487
	D	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0	0
Question 7	SA	74	0	0	28	20	48	0	170
	A	295	102	98	190	71	239	267	1262
	NO	41	66	51	62	2	86	125	433
	D	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0	0

Question 8	SA	41	13	0	34	16	0	0	104
	A	26	120	51	216	76	254	184	927
	NO	103	35	73	22	1	101	208	543
	D	0	0	25	8	0	19	0	52
	SD	0	0	0	0	0	0	0	0
Question 9	Art	215	53	47	106	28	182	220	851
	Colour Theory	142	12	15	79	25	103	95	471
	Psychology	11	21	2	42	20	47	29	172
	Biology	10	43	12	23	5	12	27	132
	Philosophy	7	4	15	---	3	7	3	39
	Natural Sciences	5	12	13	1	---	5	---	36
	Medicine	4	4	17	---	2	4	2	33
	Techology	2	4	5	11	---	5	3	30
	Others	14	15	23	18	10	8	13	101
Question 10	SA	45	10	7	50	20	30	82	244
	A	299	120	92	196	71	302	204	1284
	NO	66	38	49	34	2	41	106	336
	D	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0	0
Question 11	SA	74	0	18	0	14	26	0	132
	A	188	96	64	140	66	242	251	1047
	NO	62	42	19	78	13	15	125	354
	D	53	17	33	62	0	78	16	259
	SD	33	13	15	0	0	11	0	72
Question 12	SA	70	20	0	34	12	0	0	136
	A	336	118	97	204	74	254	137	1220
	NO	4	30	52	42	7	119	255	509
	D	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0	0
Question 13	Time	393	157	127	252	85	265	102	1381
	Temperature	217	143	142	267	93	362	354	1578
	Noise	315	162	52	253	91	317	110	1300
	Sound	112	105	43	211	91	210	298	1070
	Smell	42	15	2	45	48	11	15	178
	Taste	15	8	---	57	18	12	8	118
	Others	5	12	13	11	8	19	10	78
Question 14	SA	62	22	0	0	20	0	0	104
	A	275	111	63	179	63	198	125	1014
	NO	57	22	67	90	10	131	176	553
	D	16	13	19	11	0	45	90	194
	SD	0	0	0	0	0	0	0	0

Question 15	Y	275	108	63	235	75	242	305	1303
	N	86	47	55	36	11	104	20	359
	NA	49	13	31	9	7	26	67	202
Question 16	Y	176	92	48	182	77	310	282	1167
	N	156	54	80	92	0	0	39	421
	NA	78	22	21	6	16	63	71	277
Question 17	SA	53	18	0	0	20	0	43	134
	A	201	95	58	148	62	232	184	980
	NO	156	50	76	132	11	112	47	584
	D	0	5	15	0	0	30	0	50
	SD	0	0	0	0	0	0	0	0
Question 18	Y	53	35	46	14	0	78	51	277
	N	209	115	70	190	72	239	267	1162
	NA	148	18	32	76	21	56	74	425
Question 19	Y	70	42	49	14	0	101	82	358
	N	254	81	73	179	72	242	267	1168
	NA	86	45	27	87	21	30	43	339
Question 20	SA	53	25	0	0	5	0	0	83
	A	197	116	51	185	67	224	243	1083
	NO	115	27	68	59	21	78	137	505
	D	45	0	18	36	0	63	12	174
	SD	0	0	12	0	0	7	0	19
Question 21	Y	267	105	52	162	76	250	286	1198
	N	86	50	64	87	0	19	39	345
	NA	57	13	33	31	17	104	67	322
Question 22	SA	29	15	0	0	20	37	43	144
	A	226	107	79	199	61	201	282	1155
	NO	77	29	44	47	12	104	67	380
	D	45	17	19	34	0	41	0	156
	SD	33	0	7	0	0	11	0	51
Question 23	Y	144	71	52	126	61	31	310	795
	N	168	79	70	84	30	116	20	567
	NA	98	18	27	48	2	97	63	353
Question 24	Y	152	13	52	31	0	30	20	298
	N	213	111	63	182	73	295	321	1258
	NA	45	44	34	67	20	48	51	309

Question 25	I prefer colour and texture in my environment	150	121	---	127	27	202	193	820
	I like texture in the surface of buildines	110	26	25	10	---	93	52	316
	I like colour in buildings	83	2	25	5	62	12	43	232
	I don't like grey cement blocks	23	3	33	111	3	20	24	217
	I don't like concrete boxes	23	11	5	10	---	10	48	107
	Coloured areas are happier	12	---	---	5	---	23	27	67
	Others	9	5	61	12	1	13	5	106
Question 26	SA	53	0	0	34	0	34	0	121
	A	283	79	70	182	68	246	282	1210
	NO	74	89	79	64	25	82	110	523
	D	0	0	0	0	0	11	0	11
	SD	0	0	0	0	0	0	0	0
Question 27	SA	45	0	0	14	0	48	71	178
	A	779	101	82	162	59	257	286	1726
	NO	86	67	55	104	34	60	35	441
	D	0	0	12	0	0	7	0	19
	SD	0	0	0	0	0	0	0	0
Question 28	Light	392	162	94	252	92	297	358	1647
	Surface	375	105	127	207	93	215	327	1449
	Distance	312	108	23	112	67	323	212	1157
	Environmental impact	405	165	115	95	82	315	49	1226
	Visual Objectives	403	67	123	198	47	308	23	1169
	Others	15	23	12	42	12	211	27	342
Question 29	SA	21	17	0	0	0	11	4	53
	A	279	123	96	182	68	261	220	1229
	NO	110	28	37	70	25	82	168	520
	D	0	0	16	28	0	19	0	63
	SD	0	0	0	0	0	0	0	0
Question 30	SA	21	20	0	0	2	15	0	58
	A	279	126	96	185	66	257	223	1232
	NO	110	22	37	67	25	82	168	511
	D	0	0	16	28	0	19	0	63
	SD	0	0	0	0	0	0	0	0
Question 31	SA	53	7	9	0	5	7	0	81
	A	224	107	102	182	72	242	208	1137
	NO	33	54	31	98	16	134	137	503
	D	0	0	7	0	0	26	47	80
	SD	0	0	0	0	0	0	0	0

Question 32	SA	62	0	0	22	12	19	47	162
	A	283	79	82	180	67	235	208	1134
	NO	65	71	48	56	14	71	86	411
	D	0	18	15	22	0	41	51	147
	SD	0	0	4	0	0	7	0	11
Question 33	Y	278	109	57	196	63	183	74	960
	N	21	22	52	36	17	138	51	337
	NA	111	37	40	48	13	52	267	568
Question 34	Culture	408	162	123	223	85	298	351	1650
	Pattern Traditions	327	153	98	212	84	275	299	1448
	Economy	315	123	145	198	57	198	278	1314
	Geography	212	115	112	157	92	112	254	1054
	Religion	195	92	21	123	75	95	211	812
	Climate	212	67	17	115	64	73	98	646
	Fluctuation of taste	298	34	23	95	58	72	45	625
	Educational level	275	62	25	58	49	62	39	570
	Others	85	25	43	27	13	18	19	230
Question 35	SA	0	0	0	0	11	30	0	41
	A	94	64	64	148	61	235	110	776
	NO	131	86	45	104	10	71	208	655
	D	185	18	40	28	11	37	74	393
	SD	0	0	0	0	0	7	0	7
Question 36	Y	82	103	52	179	70	280	274	1040
	N	217	40	78	73	5	19	71	503
	NA	111	25	19	28	18	75	47	323
Question 37	Y	82	109	46	176	72	261	282	1028
	N	217	39	73	59	5	78	51	522
	NA	111	20	30	45	16	34	59	315
Question 38	SA	0	0	0	48	11	0		59
	A	164	89	35	143	63	157		651
	NO	29	27	12	53	7	75	---	203
	D	172	52	77	36	12	142		491
	SD	45	0	25	0	0	0		70
Question 39	Y	94	35	16	87	20	123		375
	N	197	103	102	162	60	232	---	856
	NA	119	30	31	31	13	19		243
Question 40	Y	172	72	18	106	58	201		627
	N	144	61	79	62	12	78	---	436
	NA	94	35	52	112	23	93		409

Question 41	Y	217	120	18	143	70	119	---	687
	N	103	37	100	64	11	242		557
	NA	90	11	31	73	12	11		228
Question 42	SA	20	0	0	0	3	37	---	60
	A	193	54	60	81	54	131		573
	NO	66	81	69	154	36	179		585
	D	131	33	15	31	2	19		231
	SD	0	0	4	14	0	7		25
Question 43	SA	33	0	0	14	0	48	---	95
	A	172	42	59	76	57	183		589
	NO	49	89	72	154	31	179		574
	D	156	37	15	36	5	0		249
	SD	0	0	3	0	0	0		3
Question 44	SA	0	0	0	6	10	0	---	16
	A	94	97	103	179	67	232		772
	NO	173	12	27	78	16	116		422
	D	131	59	19	17	0	26		252
	SD	12	0	0	0	0	0		12
Question 45	SA	20	13	19	12	11	0	---	75
	A	144	104	97	190	66	31		632
	NO	49	22	7	22	14	93		207
	D	197	22	26	48	2	119		414
	SD	0	7	0	8	0	0		15
Question 46	SA	21	0	0	20	10	41	---	92
	A	295	64	76	190	60	265		950
	NO	8	71	57	50	13	11		210
	D	86	33	0	6	10	56		191
	SD	0	0	16	14	0	0		30
Question 47	SA	45	5	3	28	10	45	---	136
	A	266	102	64	131	68	265		896
	NO	62	43	54	90	10	22		281
	D	37	13	18	31	5	11		115
	SD	0	5	10	0	0	30		45
Question 48	Y	131	39	46	76	65	56	---	413
	N	242	101	96	190	23	291		943
	NA	57	28	7	14	5	26		137
Question 49	Y	78	52	18	76	82	93	---	399
	N	185	106	115	106	0	242		754
	NA	147	10	16	98	11	37		319

Question 50	Y N NA	258 115 37	97 46 25	46 94 9	201 31 48	63 20 10	280 86 7	---	945 392 136

Key to abbreviations

Y = Yes
N = No
NA = No answer

SA = Strongly agree
A = Agree
N O = No opinion
D = Disagree
S D = Strongly disagree