MEERWEIN | RODECK | MAHNKE

COLOR COMMUNICATION IN ARCHITECTURAL SPACE

Color – Communication in Architectural Space

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INTRODUCTION

Color: Communication in Architectural Space is the revised edition of the German book *Mensch-Farbe-Raum*, which was first published in 1998.

This revised version places greater emphasis on the communicative value of color in architectural space, with a focus on the physiological, psychological, and neuropsychological aspects, as well as the relationships of visual ergonomics. Fashions and trends in color are excluded, as the publication concentrates on substantive references to color in architecture and interior design. The significance of the materials used in color design is an important new aspect. The book aims to sharpen our awareness of differentiated architectural and interior architectural objectives, and to convey a fundamental knowledge of the presence and effect of color and applied color psychology. The spatial environments that are formative to people's main areas of life are analyzed here. Chapters 1–10 in *Color: Communication in Architectural Space* present today's general knowledge as the basis for all design that uses color, and chapter 11 describes examples in practice.

The book is aimed at architects, interior designers and color designers, as well as students and committed practitioners. There is also valuable information and inspiration for communal planning authorities, decision-makers, teachers, psychologists, and doctors.

We would like to thank all those who supported us in working on this book:

Professor Renate Gebessler, whose essays made a major contribution to our understanding of the topic,
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1
HUMANS – THE FOCUS OF DESIGN

Humans are the center of concern in the design of the architectural environment. In order to design an environment that is tailored to people's needs, human beings must be seen holistically. It is also important to understand the phases of life and development, the different areas of people's lives, and the environmental requirements that these entail. Humanistic psychology's fundamental anthropological positions are concerned with humans as a holistic concept, according to which a person is a physical-psychological-intellectual being, closely connected with the material and immaterial components of his or her world. "World" refers here to the entirety of the human condition. It is synonymous with the human environment, in the sense that it is a holistic habitat containing essential biological, physical, physiological, psychological, social, and aesthetic elements.

Viktor E. Frankl, internationally acclaimed founder of existential analysis and logotherapy, sees a human being as a three-dimensional entity, consisting of body, mind, and spirit – meaning that humans always act and react holistically. All three dimensions, somatic, mental, and spiritual, are active participants in the relationship between people and their environment.

The somatic dimension consists of all

_ Physical processes
_ Organic, cellular processes
_ Biological-physiological bodily functions and the related chemical and physical processes.

This dimension is the active center for physical and material action. It governs our physical and material interaction with the environment.

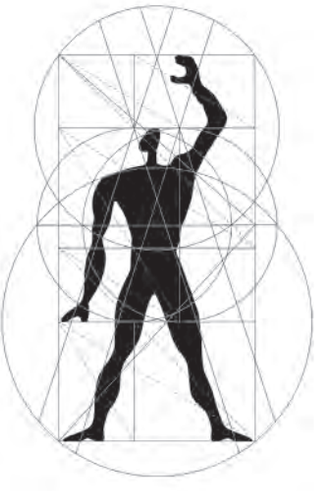
The mental dimension consists of

_ Emotions, feelings, and moods
_ Intellectual talents
_ Instincts, drives, affects, and habits
_ Social characteristics and acquired behavioral patterns.

This dimension is the experiential center of what we experience physically and intellectually. It governs our intellectual and qualitative interaction with the environment.

The spiritual dimension consists of

_ Autonomous decisions and free will
_ Material and artistic interests
_ Creative-visionary ideas directed at human development
_ Human compassion and ethical competence.



Construction of Modulor, Le Corbusier >

This dimension is the focal point for cognition, inner wisdom, humanity, and awareness. It governs our spiritual, sensory, and cognitive interaction with the environment.

Due to this intellectual and uniquely human dimension, it is in our nature to focus on values and meaning. Human beings are reflective, thoughtful and decisive, and are responsible co-designers of their existence and environment. People communicate with their surroundings with body, soul, intellect, and all their senses. They interact actively with the environment, as individuals and as social beings.

Based on a holistic human concept in line with classical humanist ideas, we see human beings as the measure of the space that surrounds them, a space defined as the architectural and interior architectural design of form, material, light, and color.

The theories below are related to humane design:

Humane design

_ relates to people as body-mind-soul entities

_ serves humans and their environmental requirements.

Humane design

_ is meaningful and responsible

_ reflects emotional and functional considerations.

Humane design

_ is an interactive process that requires communication, co-operation, and active dialog.

Humane design

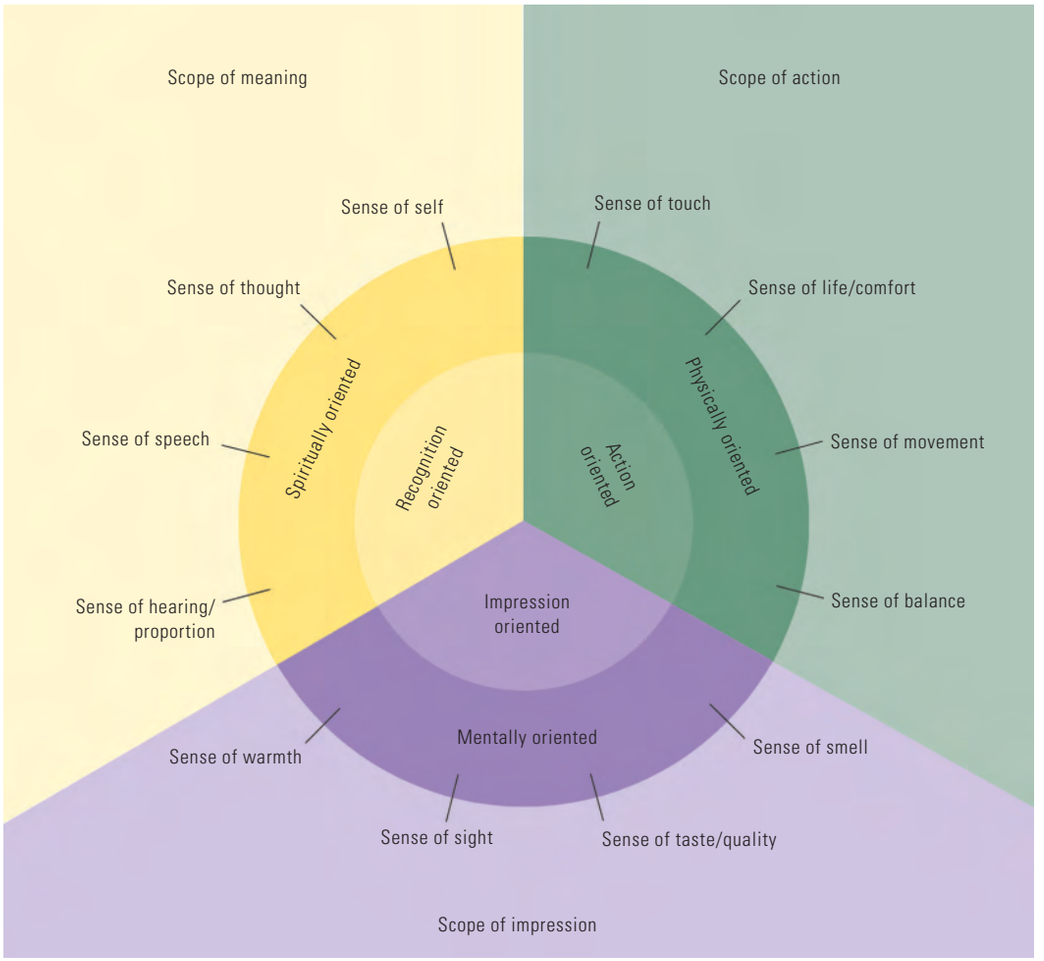
_ is an interdisciplinary process that combines humanities, natural sciences, and design disciplines.

Humane design

_ has social qualities

_ displays empathy and intuition

_ enhances health and well-being.



Spectrum of the senses

2
THE SENSES AS INSTRUMENTS OF COMMUNICATION

Our senses are the instruments of communication that facilitate our relationship with the environment. They convey information and contribute to our appropriation of the environment by means of sensory impressions and experience: we can perceive, experience, recognize, evaluate, and design the environment and ourselves. Each sensory organ has a specific structure that enables it to respond to a specific sensory stimulation. Current sensory physiology and phenomenology describes the human-environment relationship as being based on twelve senses. These refer to three spatial categories: action, impression, and meaning.

The Activity and Meaning of the Individual Senses

The four physically oriented senses – the sense of touch, the sense of life/comfort, the sense of movement, and the sense of balance – are characterized by will and action.

The Sense of Touch

Touch is the most elementary of the senses: it is physically the most direct means of contact with the environment, with other living things, and object matter. Touch enables us to experience borders and divisions between our own bodies and the external world. This experience is fundamental to an awareness of and certainty in our existence.

The Sense of Life/Comfort

This sense informs us about our existential orientation and the quality of our lives. It is activated when the organism senses discomfort. An active sense of life allows people to directly perceive what is good and what is not good for their well-being.

The Sense of Movement

The sense of movement allows us to feel our body's motion. It also functions as an organ of control for our movements and motion sequences as well as for every type, form, and process of movement in the environment. It activates the will, which originates from a motivation, to set a goal and to achieve this by using the appropriate motion dynamics. Movement is life, activity, dynamics, and change. Every motion sequence is based on a constant rhythm of design and change, which can be perceived by the sense of movement.

The Sense of Balance

The sense of balance allows humans to stand and move in an erect position. It makes it possible to find an independent, individual position in space. It is fundamental to our spatial orientation and strives for balance and structural order.

The four mentally oriented senses – the sense of smell, the sense of taste, the sense of sight, and the sense of warmth – are empathy- and impression-oriented.

The Sense of Smell

The sense of smell conveys information about substances in the environment and the presence of matter. It informs us about the finest nuances and qualities of ingredients. Smells directly affect the atmosphere. Humans respond to this spontaneously with ease or unease, pleasure or aversion.

The Sense of Taste/Quality

These senses are closely related. The sense of taste informs us about the chemical make-up and composition of flavor nuances as well as about the quality of the food that we eat. It activates our perception for the real and natural or the unreal and artificial. In a broader sense, it activates our perception for aesthetics, quality, and adequacy.

The Sense of Sight

The sense of sight is our most comprehensive perceptive faculty. It supports and complements the other senses. The sense of sight allows us to perceive everything visual, to visually comprehend forms and movements, to visually feel forms and materials, and to visually structure. The sense of sight is our access to the world of light and color's finest nuances, as well as to the diversity of visible environmental qualities. The sense of comfort/life, which is linked to the sense of sight, allows us to perceive visible beauty, pleasantness, harmony, or the ugly, uncomfortable, and discordant.

The Sense of Warmth

This sense allows us to perceive the temperature of our bodies and that of the external world. The sense of warmth is closely associated with physical and mental experiences – pleasure and aversion, ease and unease. Human well-being requires a certain degree of warmth. This refers to temperature, spatial quality, and even social relationships. Warmth is closeness, cold is distance.

The four spiritually oriented senses – the sense of hearing, the sense of speech, the sense of thought, and the sense of self – are recognition-oriented.

The Sense of Hearing/Proportion

The sense of hearing comprises all discernable noises and sounds. It can convey what the eye cannot. Sometimes the tone and sound of the human voice provide better information about one's condition and psychological state than physical appearance. Even the internal qualities of objects and the texture of materials are audibly discernable. According to Hans-

Jürgen Scheurle, sensing sound can be equated with sensing proportion, which is related to sensing harmony.

The Sense of Speech

The sense of hearing perceives the acoustic and musical elements of speech. It conveys the perception of the presence of speech, its form of expression and design, its clarity and conciseness. Every language has its own architecture and tonal color. Sound quality lets our state of mind and mood resonate and comprehend by the sense of language. Even nonverbal forms of expression – gestures and facial expressions – and elements of body language are attributed to the perceptive faculties of the sense of language.

The Sense of Thought

This sense is related to perceiving conceptual language content, to the deeper meaning of the spoken word, even to perceiving secondary or hidden conceptual intentions and messages. Sensing thoughts requires sensitivity and intuition. Thoughts can be heard non-verbally – via body language, gesture, and facial expression. We look to feel out internal truths with the sense of thought.

The Sense of Self

The sense of self allows us to detect the self of others, their individuality, their core-being. Its activity demands an astute distance from oneself, to free oneself from judgment, sympathy, and antipathy. The sense of self is the instrument for interpersonal relations and is extremely important to social dealings. An active sense of self in dialog with others can overcome misunderstandings and alienation and build understanding.

The flourishing and care of the senses is fundamental to:

_ Sensitizing and differentiating perception
_ Discovering the new
_ Stimulating emotional life
_ Deepening the ability to experience
_ Reinforcing the ability to make judgments
_ Reinforcing the power to decide
_ Thinking, feeling, and acting consciously.

The flourishing and care of the senses is also fundamental to:

_ The development of creativity
_ A creative, meaningful design of the living environment
_ The formation of our personality
_ Our interpersonal relations
_ The design of our world.

3
COLOR – AN ENVIRONMENTAL ELEMENT

Colors are fundamental elements of our visual perception and environmental experience; they are the substance of how we experience the environment. We encounter and are surrounded by color whenever we open our eyes. It accompanies us in diverse visual ways and is always connected with and influenced by light in the natural or human-designed environment. In nature, we see color in the light of the sky, when looking at water and landscapes. We see it in trees, stones, plants, fruits, and flowers. We encounter color in diverse combinations in the animal kingdom: on animals' skin, shells, markings, feathers, and fur. People's skin, eyes, hair, and clothing also contain color. The human-designed environment is all in color: streets and shops, buildings and spaces. We see it, in all its variety, in different objects and cultural products. Color is of major significance in every realm of life and fulfills many different functions. Colors serve as information, communication, and design material. They

_ Communicate symbolic messages
_ Signal
_ Camouflage and deter
_ Provide help with orientation
_ Contribute to order and differentiation
_ Indicate special functions
_ Are geographic, ethnic, and cultural attributes
_ Are features of fashion and style
_ Are markers of personal and group identity
_ Express image and are a status symbol
_ Are marketing factors
_ Express style and design trends
_ Are indicators and expressions of the zeitgeist, which is subject to change
_ Crucially influence the statement, effect, and acceptance of objects and space.

Color is much more than an aesthetic statement: it is part of a life-giving and life-preserving process. It is part of the terms and conditions under which humans live and experience. Besides other sensory perceptions, humans orient themselves according to optic signals, and learn through visual messages. This makes color vitally important to the meaning of the environment as well as to human interaction with it. Our emotions are always touched by what color reveals to us about our environment, what it communicates. We are all influenced by colors and have a lively relationship with them. Colors affect

us and our emotional world, even when we do not consciously perceive them.

COLOR – COMMUNICATION IN ARCHITECTURAL SPACE

Communication takes place on a personal level in the exchange of information between people, as well as on an impersonal level through symbols in the environment. Color is an important medium of visual communication in the human-environment relationship: it conveys symbolic messages and aesthetic-atmospheric information. Important aspects of color in architecture relate to the communication between humans and the spatial environment, and to the interactions that take place there. Space is the framework for social relationships and human activities. A fundamental aspect of the function of color as a communication factor is thus linked to its interactive characteristics. "Color exists in itself, it connects things with each other and connects things with people." (Pieter Uyttenhoven)

4

HUMANS AND COLOR

To illustrate the complex relationship between humans and color, the three parameters of seeing, perceiving, and experiencing color are discussed below.

WHAT IS COLOR?

All manifestations of color are created when electromagnetic radiation at wavelengths in the visible spectrum interact with physical matter. One widely accepted definition of color is: a specific visual sensation produced by visible radiation, or "color stimulus." Color stimulus occurs when light from a natural or artificial source is interrupted by an object or a dust particle. The incident light rays are absorbed or reflected in different ways depending on the physical matter's composition. That is, some wavelengths are filtered out from the light's color spectrum, while the remaining wavelengths reach our eye as color stimulus. If intact light, for instance, meets a blue surface, all components of the light spectrum except blue will be absorbed, and the blue will be reflected. The colorful appearance of objects, however, depends on the type of light, whether daylight or various types of artificial light. Colors change according to the different qualities of light.

SEEING COLOR

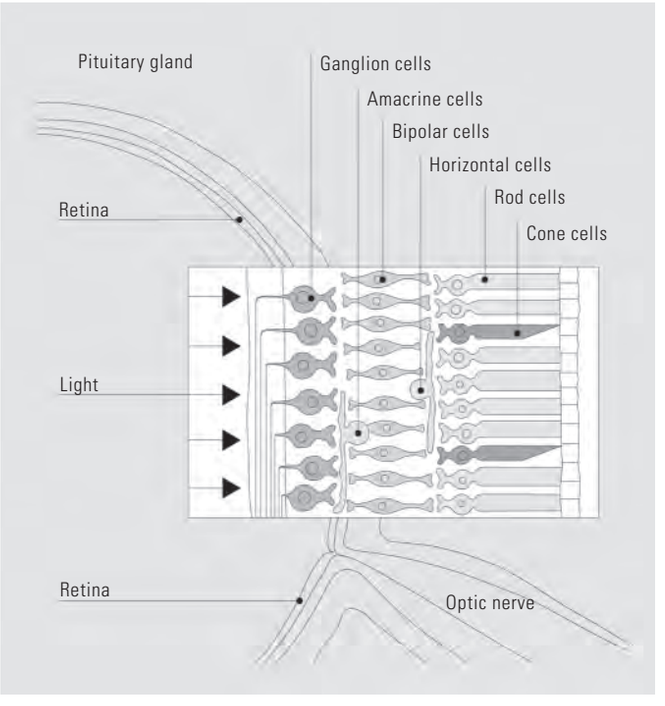
Seeing color is a sensory experience that depends on the following conditions:

_ The existence of light

_ The ability of the eye to record and relay color stimulus

_ The ability to perceive and process relayed color stimulus as a visual sensory sensation.

The eye is an optical system that directs visible, luminous radiation to the retina. This contains the individual receptors, the rod and cone cells, which decode the physical stimulus and translate it into a physiological one. The rods differentiate between light and dark, only registering light's intensity, while the cones differentiate between colors. They react to the different portions of the light spectrum. The Young-Helmholtz theory assumes there are three different types of color-sensitive cones, for short, medium, and long wavelength light rays, which are correspondingly sensitive to blue, green, and red respectively. Science also includes advocates of the Hering theory, which assumes there are four receptor types: two antagonistic systems, yellow-blue and red-green. The retina's receptors – the rods und cones – relay the stimulus through



Sectional view of the retina >

nerve fibers into the optic nerve and thus into the brain, where the stimulus is converted into conscious vision. By a complex process of physiological-psychological data processing, the recorded color stimulus is transformed into seeing and perceiving color.

PERCEPTION OF COLOR

Seeing color is an act of sensory perception. We perceive color mainly as a characteristic of the objects that surround us. In addition to form, surface quality, smell, and taste, color is one of the characteristics that enable us to determine, judge, and evaluate an object. People looking at a color already possess a certain amount of experience and preconceptions in their memory, which influence their color perception. For example, color perception is linked to associations and previous experiences where color played a role. At the moment color is recorded, it also involves the human psycho-physical structure. Color perception is even accompanied by cultural and social factors such as education and the environment. A certain color impression not only evokes a momentary visual sensation, but also involves our entire experience, memory, and thought processes.

EXPERIENCING COLOR

Perceiving colors means experiencing them and becoming more aware of them, and is always accompanied by associated meanings. Diverse conscious and subconscious factors play a role. Every objective color stimulus that we record from the outer world corresponds with a subjective reaction from our inner world. The human experience and response to color are as diverse as people themselves. For this reason, it is not possible to generalize color experience, color effect, or the human response to color.

We must first assume that we experience color subjectively and thus react individually. It should be noted here that our personal color experience, our responses to, and evaluation of, color always contain an element of the "collective," which is stored in our "genetic memory." The effect of color on people is explained by the interplay of physiological and psychological events, by the physical process of seeing color, and the data processing in our brain. It has been scientifically proved that color influences cortical activation (brainwaves), functions of the autonomic nervous system, and hormonal activity. We also know that color evokes certain emotional and aesthetic associations.

Field of vision of the left eye

The energetic effect of color affects our entire organism. It influences physical procedures. It also affects our psyche, our feelings, thought processes, and emotions. Through holistic associations and parallel sensations within our sensory organization, colors stimulate not only the sense of sight, but also other sensory organs. The intensity of color stimuli and the entire context in which they are perceived play a significant role.

SPATIAL COLOR EXPERIENCE SCHEME

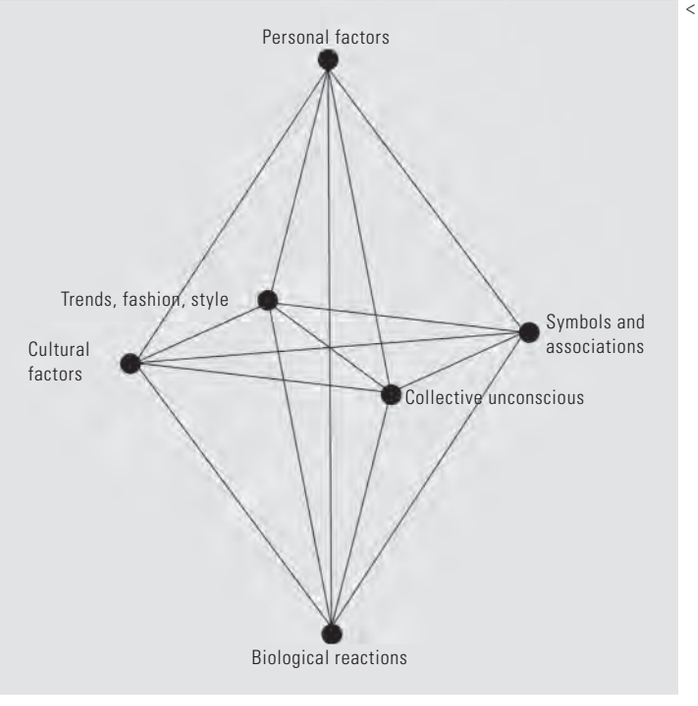
The complexity that influences our experience of color and provokes a reaction is difficult to summarize using a model. We can basically assume that six interdependent factors affect our color experience. These factors are illustrated in the "spatial color experience scheme." Their interplay is described in this spatial model.

Biological Reactions to a Color Stimulus

"Seeing" is not the only purpose of the collaboration between light, eye, and brain. Besides the "optical" visual pathway, there is also the "energetic" one, that directs incoming light and color stimuli directly to the interbrain, from where it affects the metabolism and organ functions. This explains why the pulse increases with a red stimulus and decreases with a blue one. Biological reactions occur on purely physiological levels. They are independent of how people think about a color or a combination of colors, or how they evaluate them aesthetically.

The Collective Unconscious

The collective unconscious is a part of our psyche, which has nothing to do with the conscious reactions we have collected through personal experience in our lives. The collective unconscious reflects primordial characteristics, latent images, original patterns, impressions and experiences. These contents are called archetypes. They are predispositions or potentialities for responding to or experiencing our world. Neuroinformatics shows that human beings have stored the knowledge of millions of years of evolution in the genetic map of their brain, and can improve this genetic map through the ability to learn. The archetypical, general primal relevance of color must therefore be considered in relation to our experience of and response to color. It originates from the time in our developmental history when people were still directly



Spatial color scheme

connected to the natural environment. The "personal unconscious" could also be taken into account, in addition to the collective unconscious. This would mean that a personal experience, which is associated with color and has been suppressed into the unconscious, would also influence the personal reaction to color. For example, after an accident a person may reject red, the color of blood.

Conscious Symbolism and Association

There are many examples of color impressions, symbols, and associations that most people will interpret in the same way. Yellow, for example, is associated with the sun and with light, red with blood and fire, blue with the sky and water, and green with nature. The human experience of nature produced fundamental associations, which have led to others over the course of evolution. For example, red stands for blood and fire, aggression, revolution, and war, but also life and love. Psychological aspects, especially concerning associations, are often called into question since cultural heritage and intellectual and aesthetic education vary from individual to individual. Research using different groups of people has shown, however, that there are in fact collective and individual responses to color associations, which are shared by a majority. Cross-cultural studies and comparisons have displayed astounding similarities concerning preferences, color-mood associations and connotations.

Cultural Influence and Mannerism

Even if there are universal reactions to colors, this does not preclude the existence of cultural and group-specific associations and symbols. These may be particular color statements of a cultural group or people regarding religion, philosophy, and tradition, and are especially significant only to them in this context.

Trends, Fashion, Style

Almost every year there are new trends in color throughout the world, particularly in fashion and consumer goods. In architecture and interior design, color trends develop somewhat more slowly. Yet even though short-lived, they still influence our color judgment and can temporarily awaken new associations. Trends in fashion and consumer goods might in fact be prepared and strategically planned for the economy, but this would be erroneous in the field of architecture or interior design. Responding to a trend would not respect the need for effective color design, which is based on applied color psychology. Short-lived variations in interior design follow a hasty, disposable mentality, and contradict serious and fundamental design philosophies.

Personal Factors

The overall experience of color is dominated by personal factors. These include:

_ Basic personal disposition
_ Personality structure and temperament
_ Physical and psychological constitution
_ Age and gender
_ Sensitivity to color.

It is also important to consider how long a color stimulus will affect people and the design context in which colors exist and are perceived. Our experience of and response to color, as well as our preference for or indifference to certain colors, are not constant. They are just as variable as any external influences or the course of our own, personal development. Our experience of and reaction to color are also determined by the dynamics of our internal and external world. It must be stressed that the different parameters of color experience should not be observed separately, but more or less interactively.

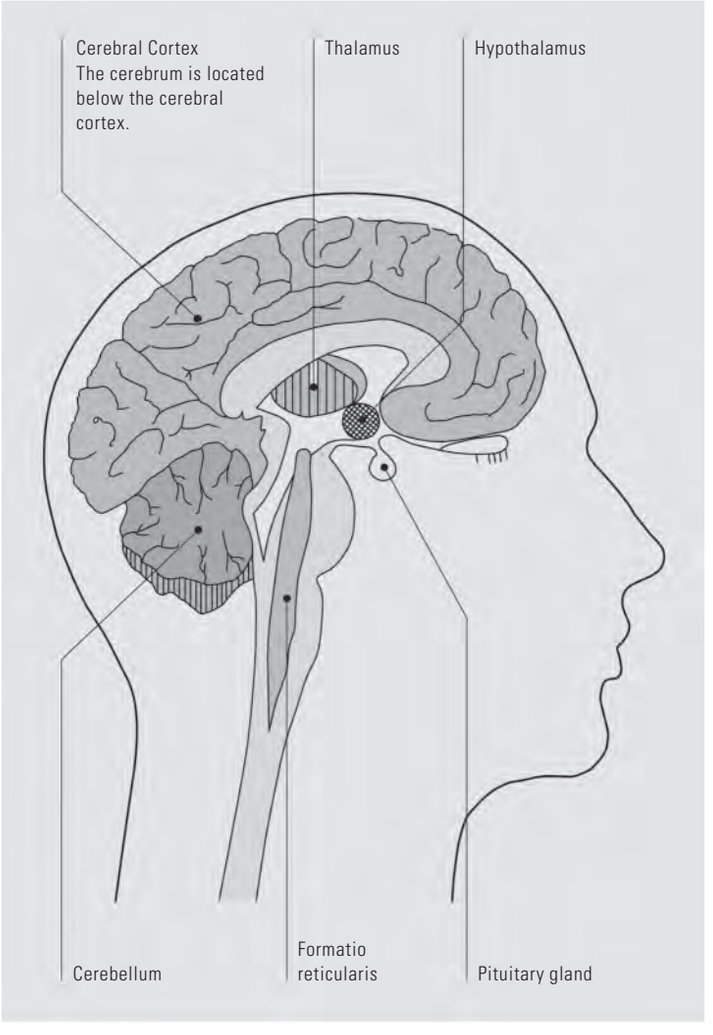
PHYSIOLOGICAL AND NEUROPSYCHOLOGICAL ASPECTS

The central nervous system, which consists of the brain and spinal cord, is responsible for human behavior as a whole. Every impulse or stimulus that reaches the higher centers of the central nervous system, passes through the "formatio reticularis" located in the brain stem, a type of control station for all incoming stimulation. The stimulating quality of color can be grasped in an activation of the reticular system. Consequently, color stimulus is always associated with other sources of stimulation as well. The formatio reticularis influences the standby state of the entire nervous system, and thus also contributes to controlling attention and awareness. Stimulation of the formatio reticularis by external and internal factors determines the degree of arousal. It can lead to a simple increase in attention or to visible behaviors. The formatio reticularis tries to maintain a condition of normalcy in a state of stimulation. Stress research has shown that states of sensory overstimulation or understimulation can trigger dysfunctions in the organism. This is often disregarded by designers. It is thus important to adhere to one of the most important, fundamental rules of design – that is, to integrate variation and stimulation into a visual order, and to create a balance between under- and overstimulation.

Understimulation – Overstimulation

Under- and overstimulation are opposite poles between which a certain perceived amount of information is experienced. The amount of visual stimuli (colors, patterns, contrasts etc.), extreme monotony and sensory deficiency can

Sectional view of the brain



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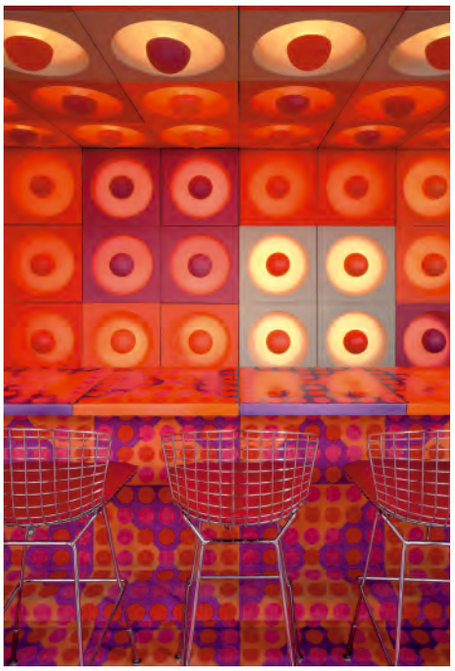
lead to understimulation, while an extreme surplus of stimuli can produce overstimulation. Overstimulation can trigger physical or psychological changes. On the physical level, breathing or pulse frequencies can be affected; blood pressure and muscle tension may increase. Studies have shown that people who suffer from understimulation displayed signs of restlessness, irritability, difficulties in concentrating, and perception disorders. For example, Rikard Küller (University of Lund, Sweden) performed studies in rooms that were painted different colors. It has often been assumed that white, gray, and black were neutral colors in spatial design. But it was shown that even these achromatic colors trigger psychophysiological effects.

Optical Patterns

A series of experiments involving factors such as size, color, contrast, and intensity were carried out to research "stimulation" through pattern. Berlyne and McDonnell discovered that diverse, unharmonious, and chaotic patterns led to an increase in the degree of stimulation. This means that, in the overall perception of intensely colorful and graphic complexes, the oversupply of information in a pattern can lead to overstimulation.

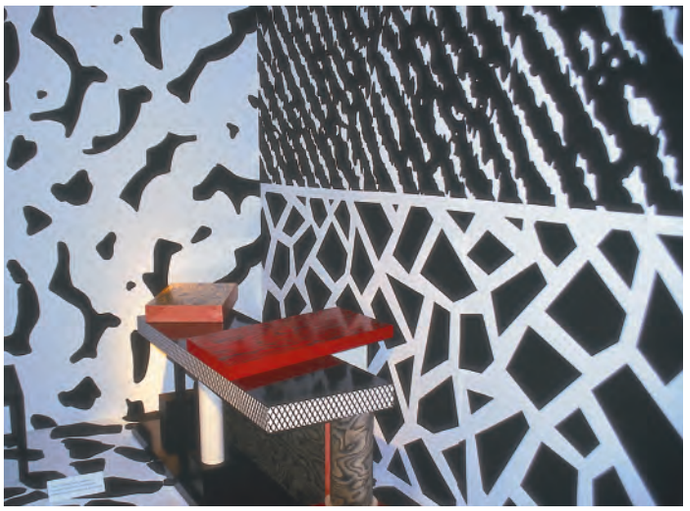
Physiological Effects

Whether red, green, yellow, or violet – every color transmits specific, quantifiable physical waves that our eye records as a color stimulus. These stimuli are directed along the energetic visual pathway to the interbrain and the pituitary gland,



Overstimulation by layering optical patterns

Spiegel-Kantine, Hamburg
Interior design: Verner Panton



Optical pattern
Memphis Design, Vitra Museum, Weil

Despite costly materials, a color scheme reduced to black, white, and gray produces an understimulating environment.

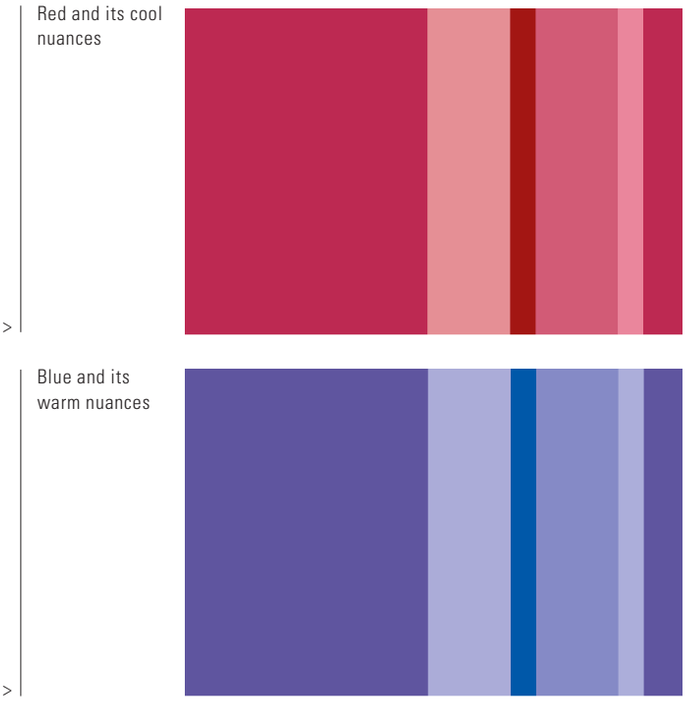
Deutsche Post, Bonn
Architecture: Helmut Jahn

which regulates certain functions of the rest of the body's hormone glands. Hormonal distribution works in collaboration with the nervous system and regulates the organs.

How the wave pattern of individual colors works is often the object of scientific research. One widely accepted opinion is that red is a stimulus that speeds up the heart and circulation, increases pulse and breathing rates, and raises blood pressure. Conversely, it is assumed that blue lowers blood pressure and calms the nerves. This basic experience has been confirmed experimentally. Thus, the theory that certain colors generate a physiologically quantifiable arousing or soothing effect can generally be accepted, but no false conclusions should be drawn.

Human reaction to color in space depends on many factors:
_ Hue and nuance
_ Amount and location of the color in space
_ Paint color and spatial function
_ The effect of color over time in the space.

It is a mistake to assume that we could strategically place color in a space so as to achieve specific physiological effects, such as lowering blood pressure for hypertonic patients. These stimulus-reaction experiments are not sustainable. Research on physiological effects from color stimulus concludes that physical reactions do not remain constant. After an initial increase, for example via red light, blood pressure normalizes again or even shows a counter-reaction. Designers can also, unfortunately, misinterpret experiments on physiological color effects, along the superficial lines of red stimulates, or blue calms. This creates erroneous color designs that either have unachievable strategic goals, or could even trigger an effect opposite to the one desired. A psychiatric hospital's design can serve here as a practical example: mainly blue tones were used as a calming element for the patients. This was not achieved, but resulted in spaces that were uniform and monotonous. From this it can be assumed that relaxed, calm, or stimulating spatial environments can only be achieved in line with neuropsychological aspects, in other words, established applied color psychology.



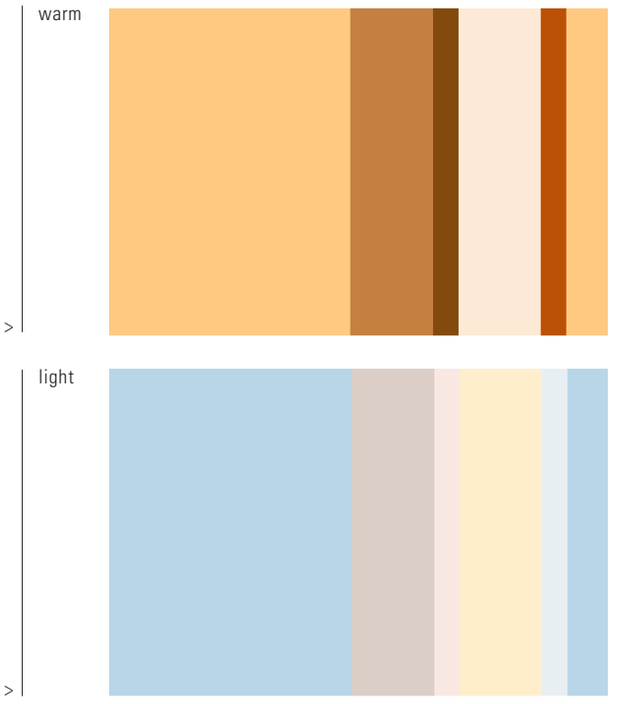
Psychological Aspects

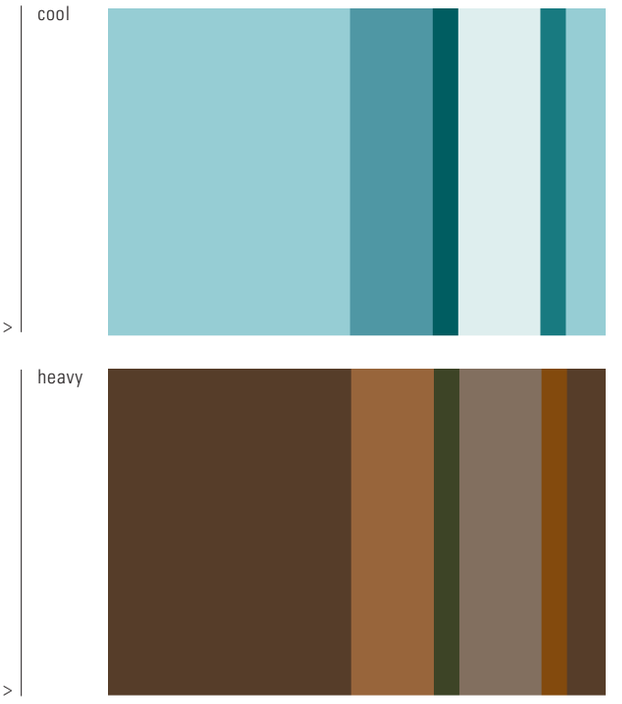
Psychology is the science of people's conscious and unconscious mental processes and behavior, including their thoughts, feelings, and dreams, and with everything that people experience. Color is a significant element of psychology, because its effect is based on conscious and unconscious processes. Color is also an experience that influences behavior. While the physicist regards color as wavelengths of electromagnetic radiation, the psychologist is concerned with color as a sensory stimulus, and with its effect on people. Color psychology examines the existence and the qualities of color experience, and its effect on people. Aspects of color psychology are:

_ People's experience of color
_ The emotional effect of color
_ The synesthetic effect of color
_ The symbolism of color and its associative effects.

Applied color psychology deals with implementing knowledge gained from color psychology in designing the environment. It is interdisciplinary and comprises aspects of physiology, psychology, psychosomatics, neuropsychology, visual ergonomics, and the psychology of architecture.

For the physicist, red is an external stimulus with a wavelength of 628–720 nm. For the psychologist, red is an internal process that is either dependent on or independent of a physical event. Here, independent means that color can be imagined even without external stimulus. To do so, we need only close our eyes and imagine a color. That means color not only depends on a stimulus from the world outside, but also on the power of our own imagination. Color impressions recorded in the external world are sensory-spiritual experiences and sensations, which trigger the memory and recognition processes. A green color stimulus can trigger thoughts about nature, maybe about a walk in the green countryside or a particular experience. The thoughts continue working, and can lead to the areas of memory, which in the end no longer have anything to do with the triggering "green stimulus." Colors have a cognitive and emotional content. The same phenomenon





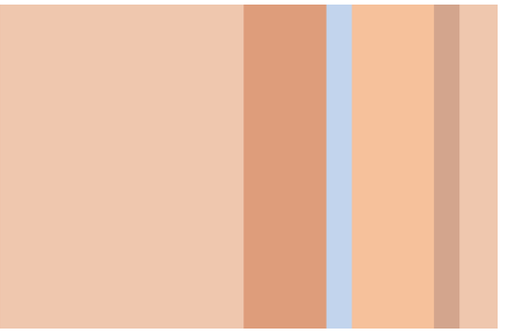
exists in other sensory perceptions, such as smell or hearing. How often are we emotionally affected while listening to music or inhaling a particular scent? All human perceptions lead to reactions. Perception of color addresses the areas of emotions, thought, and will, and also triggers memory. The color psychologist Faber Birren explained that a whole person, with body, mind, and soul, presents a coordinated unity, a microcosm, and that color permeates every one of these dimensions.

Synesthesia

Synesthesia is the coupling of different sensory sensations, or also the stimulus of one sense, that relays this to the other senses (Greek: synaisthanomai = uniting sensations). Colors appeal not only to the sense of sight, but, due to holistic associations and parallel sensations, also stimulate other senses such as touch, smell, taste, temperature, and hearing. This is why certain color nuances or color combinations are perceived as hard or soft, fresh or stale, sweet or sour, warm or cold. If a red tone is described as heavy and sweet, it has affected three other senses in addition to sight, that is, touch (weight), smell and taste. The synesthetic effects of color are applicable in a variety of ways. In spatial design, they can influence the perception of spatial dimensions, or compensate for certain stress factors at the workplace, for example, in industry. The expressiveness and effect of a color always depend on its respective color tone, which involves its particular saturation, intensity, and brightness, in other words, its hue and nuance. Thus, color tones that are normally seen as warm can be perceived as cooler, such as a very pale red; on the other hand, colors that are considered cool can be perceived as warm, for instance ultramarine. The impression of coolness and warmth is just as dependent on whether a surface is matt, muted, shiny, or polished. Sensing weight is very dependent on the degree of saturation and brightness. Thus, colors that are dark in terms of their own brightness can seem lighter in weight if they are made lighter in color (light violet = lilac); light colors in contrast seem heavier in weight when darkened (dark yellow = brown). For synesthetes, color stimulus can produce other, clear sensory perceptions via sensory channels, allowing them to hear, to feel or to taste colors.

Colors in the upper half of the color circle are considered lighter in weight than those in the lower half. If they have the same brightness and intensity, such as red and green, the warmer colors will seem heavier. Colors trigger very different sensations in touch. Synesthetic links between color and surface sensation depend on the quality of hue and its nuance, as well as its shift in temperature sensation. In this way, touch is also related to sensing temperature. Smell and taste can influence the perception of space – the sense of smell occurring more commonly in association with the perception of temperature.

soft / hard >



fresh / stale >

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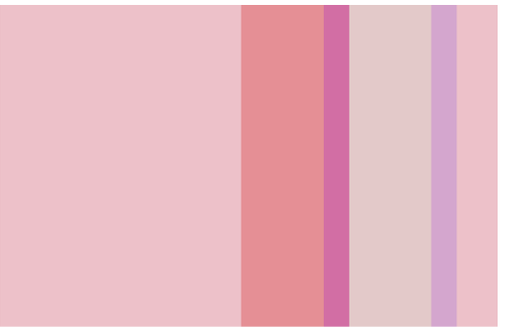
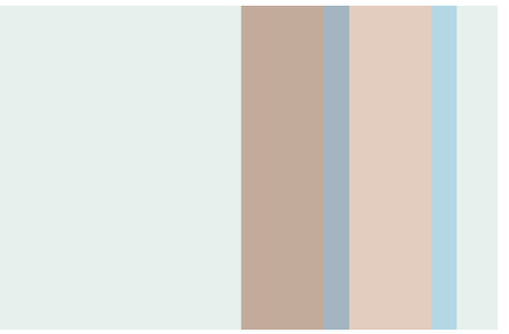


quiet / loud >



SYMBOLISM OF COLORS

A symbol is a picture that stands for something. It represents and signifies something. It is a medium for communicating messages. Many things can be symbolic – a word, a gesture, a color.

How can the symbolism of color be understood?

We can assume that the symbolism of color has developed out of the original human color experience. We must consider the entire span of experience that humans have had in the process of evolving, in order to develop color symbolism, its diversity and ambiguity. The human being's "primal experiences" of color in nature are stored as mutual, collective fundamental experiences, as primal images and archetypes, in our "genetic memory." They contribute to our personal experience of color. Color symbolism grew out of the generalization of color's effects on the emotions, and the tradition of meanings associated with color. Symbolic and psychological effects of color are thus closely linked. Eckart Heimendahl differentiated between ritual symbolism, traditional symbolism, and the aesthetic-emotional level of symbols, which can also be called the psychological level. These three levels intertwine, yet each possesses its own significance and expression. Although certain generalizations do in fact merge, in line with an "objectification" of colors, and are then conveyed as symbolic messages, the individual, human color experience still needs to be considered. Even if many connotations are identical, there are still cultural differences. Green is the color of life for people of desert cultures; it is a holy color in Islam, the color of paradise, and the sign of all material and spiritual things. For people living in forest or jungle, green equally represents life, but also represents a "devouring superpower." The symbolic meaning of a particular color can be interpreted very differently by people from different cultures.

The symbolic meaning of a color, as well as its psychological effect, depends on the hue's nuance. Even very slight variations can create significant differences in the symbolic reading and effect of a color. The context in which we perceive a color also defines its effect and the significance we attribute to it. Another important factor is a color's material: the same

Specific color
Cambridge University, Mass.,
MIT Stata Center, library
Architecture: Frank O. Gehry

color, connected with different materials, gives different impressions and effects. It would thus be false to assume that, for example, green is calming. The type of green and its nuances, and how they are expressed, have to be considered as well. Thus, a strong, saturated green may be stimulating, and a soft, pastel green, relaxing. Every color, experienced as an area or as a concept, is effective in a multitude of ways. Green spans the scale between a light, spring green to a dark, bluely green. The range of yellow spans between soft, golden yellow and brash lemon; blue between cold ice blue and warm ultramarine; red between tender pink and rousing red.

To understand the symbolic effect and expression of a color, we should also consider whether it is alone or its effect is in relation to something else. The effects of a color can be divided into two important categories:

_ The absolute or independent effect of color – color as light and luminous radiation

_ The relative effect of color – on color as a component of the material environment.

The effect of colors always depends on their interaction with objects, and their different design characteristics: the same color, associated with different types of objects, can thus lead to completely different interpretations and opposite impressions and effects. Color effect is polyvalent.

As different as the subjective reactions to color may be, color concepts can nonetheless be designed for specific objectives, to suit certain requirements and user groups on a general level. An objective examination of emotional human needs, functional requirements, and the effect of color is therefore unavoidable. In designing the environment, the actual effect of color depends significantly on its materialization, associated with the remaining active role played by environmental factors.

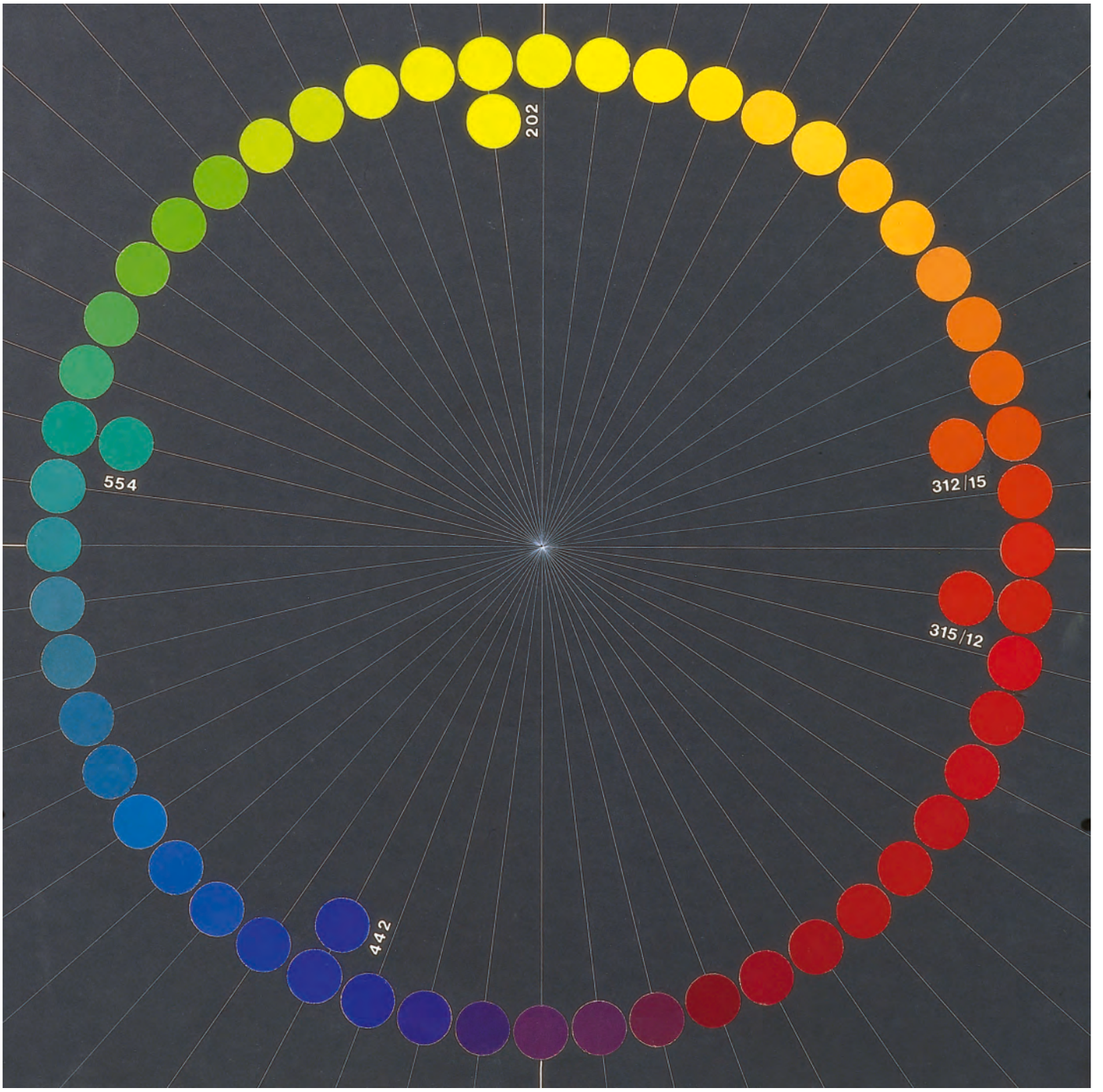
The table on next page shows the experimental and phenomenological emotions related to the main colors. It is not a dogmatic codification of the symbolic meaning of color.

Unspecific color

PERCEPTION AND SENSATION

	Impressions	Messages
	Soft, embracing, sunny	Gentleness, brightness, coziness
	Cheerful, radiant, exciting	Communication, openness, activity
	Muddy, moist, earthy	Tiredness, perishability
	Soft, warming, fruity	Excitement, comfort
	Loud, obtrusive, superficial, heated	Restlessness, excessive demands, speed
	Stabilizing, natural, resonant	Security, tradition, rootedness
	Aromatic, fruity, appetizing	Desire, excitement
	Provocative, fiery, lively	Passion, dynamics, joie de vivre, aggression
	Stabilizing, natural, resonant	Security, tradition, rootedness
	Girlish, gentle, fragrant	Playfulness, rapture, romanticism
	Dominant, strong, active, warm	Grandeur, vitality, prestige, festiveness
	Exclusive, resonant, celebratory	Esteem, quality, respect
	Sweet, perfumed, cheap	Ephemerality, assertiveness
	Dignified, sublime, pompous, narcotic	Ritual, power, splendor
	Majestic, solemn, ceremonious	Dignity, elegance, distinction
	Flowery, elderly	Artificiality, temporality
	Exclusive/valuable, heavy, solemn, deepening	Mysticism, contemplation, extravagance
	Dignified, noble, pompous	Ritual, power, splendor
	Relaxing, quiet, reserved	Calm, balance
	Calm, deep, concentrated, relaxing	Gathering, calm, sumptuousness
	Deep, distancing, untouchable	Ambivalence, instability, tradition, noble

	Impressions	Messages
	Cool, airy, light	Distance, expansion, opening
	Distant, cold, calming, reserved	Security, concentration, seriousness, aloofness
	Bottomless, receding, heavy	Seriousness, depth, security, noble
	Watery, icy, celestial	Openness, lightness, freshness
	Refreshing, cool, hygienic	Reservation, aloofness, cleanliness
	Dark, heavy, deepening	Aloofness, elegance, seriousness
	Fresh, light, swelling	Opening, revival, cooling
	Balancing, natural, calming	Balance, simplicity, security, liveliness
	Concealing, natural	Tradition, stability
	Spring-like, carefree	Lightness, playfulness
	Loud, obtrusive, superficial, unserious	Fast-moving, youth, joy of life
	Mossy, autumnal	Naturalness, tradition
	Refreshing, cheerful	Lightness, revival
	Stimulating, shining, revitalizing	Exaltedness, carelessness, alertness
	Swampy, old-fashioned, poisonous	Traditionalism, conservatism
	Open, vast, light, neutral,sterile	Purity, freedom, emptiness, indecisiveness
	Settled, fine, still, reserved	Unassertiveness, elegance, reserve, caution
	Heavy, hard, dominating, noble	Immovability, distinction, steadfastness, burden
	Valuable, ceremonious, radiant, warm	Luxury, pomp, prestige, power
	Noble, cool, distinguished, technical	Distance, elegance, clarity, status



^ Color circle with 52 sections, Gerhard Meerwein

COLOR FUNDAMENTALS

Every color can be defined by the following criteria:

_ Hue is the quality or characteristic by which one color is distinguished from another. The elementary hues that we differentiate are based on the spectral hues red, orange, yellow, green, blue, and violet. All colors are judged to be similar to one hue or a proportion of two of the spectral hues. Thus crimson, vermillion, and pink are close in hue, although they are different colors. Physically, hue is determined in wavelength. White, gray, and black are perceived as being colorless, not reddish, yellowish, greenish or bluish. They are therefore termed achromatic.

_ Saturation is the second attribute by which a color is distinguished. Also referred to as strength, intensity or chroma, it designates the purity of a given color, the quality that distinguishes it from a grayed-down color (less chromatic or intense). Two colors may be the same in hue (for instance two greens), and one lighter or darker than the other, yet still appear different in color strength.

_ Lightness, or its synonymic value, is the third dimension in the description of color, differentiating dark colors from light ones. The lightness of a pigment is the measure of how much light is reflected from its surface. Sometimes brightness is used as a synonym for lightness – which may be confusing. Brightness means the intensity of a light source or a luminous sensation when describing light, and it means highly saturated when describing color.

_ Nuance describes the intensity of a hue, that is its brightness, darkness, or proportion in color mixtures.

We always perceive these basic fundamentals of color as part of the overall visual sensation. Related colors display their relationship to a certain hue, such as yellow or blue nuances in red; and differentiated gradations of a certain hue by darkening with black or lightening with white (see color tone comparison triangle). Neighboring colors on the color circle (also commonly known as the color wheel) are related, because they share some proportions of hue.

The hue that is least similar to a given hue is called a complementary of that color, and is located diametrically across from it on the color wheel. Naming the complementary depends on the color wheel being used. This often leads to confusion for beginning students of color. For example, in some references the complement of red is identified as green and in others as blue-green. This is not a matter of differences in color, but in the divisions of various color wheels, and color identification. The twelve-hue color wheel, for example, is divided into red, red-orange, orange, yellow-orange, yellow, yellow-green, green, blue-green, blue, blue-violet, violet and red-violet, while the Munsell ten-hue color wheel divisions are red, yellow-red (orange), yellow, green-yellow, green, blue-green, blue, purple-blue, purple and red-purple. Therefore, Munsell will identify the complementary of his particular red as being blue-green, whereas a twelve-hue color wheel will show the complementary of their red as green.

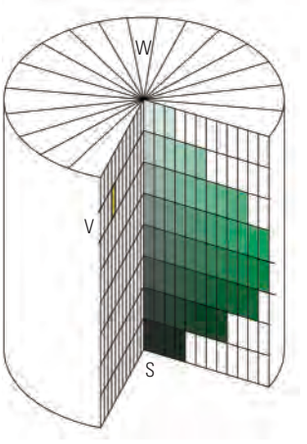
THE COLOR CIRCLE AND THE COLOR ORDER SYSTEM

Philosophers and artists have been making statements about individual colors and color groups since the beginning of recorded history. Yet an attempt to spatially order and systematize the "color world" came relatively late. Leonardo da Vinci began to understand colors as references: yellow-blue, red-green as polar pairs on one level and with black-white at opposite ends of a perpendicular axis. From this beginning, continued later by Leon Battista Alberti, a double pyramid or double cone shape began to emerge. In 1611, the Finn Aron Sigfrid Forsius published a color system in his book *Physica*, in which he uses a spherical shape to present a body of colors and the system underlying it. A breakthrough in the development of color systemization was first truly reached, in comparably quick succession, during the nineteenth and twentieth centuries. In addition to Goethe's studies of nature that led to his *Zur Farbenlehre* (Theory of Colors), published in 1810, color systems were being developed with very different approaches all over Europe. To name a few: around 1867, physicist Hermann von Helmholtz concluded his theory on a three-color principle with the parameters of hue, saturation, and brightness. In 1839, chemist Michel Eugène Chevreul published his color theory, *The Law of Simultaneous Contrast of Colours*. In 1810, painter Philipp Otto Runge published *Farbkugel*, a mixture color model that presents a comprehensive color system. At the same time (1810) philosopher Arthur Schopenhauer published correlations of compensative measure in the short essay "Über das Sehen und die Farben" (On Vision and Colors). In 1878, physiologist Ewald Hering published his physiological four-color theory in the essay "Das natürliche System der Farbempfindungen" (The Natural Color System). The actual developmental breakthrough came about in the twentieth century. In his book *Farbsysteme* (Color Systems) from 1960, Günter Wyszecki ordered the most significant systems into three groups:

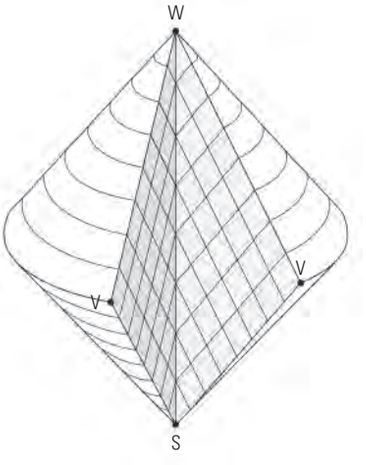
_ Systems based on additive color mixing: the Ridgeway System, Ostwald System, and the CIE Standard Valency System as the international standard;
_ Systems based on subtractive color mixing: the Plochere System and the Colorizer for pigment mixing; the Hickethier Color Order, the Villalobos Color Atlas, and the Wilson Color System for halftone printing;
_ Systems based on perceptually equal divisions: the Munsell System, the DIN Color Chart, the Hesselgren Atlas (precursor of the NCS System), and the RAL System.

Color systems are orders that aim to arrive at a predetermined number of color nuances, which are classified into a recognizable associative order. Many conceivable systems could fit this description. Color standards are a decisive element of a color system. This is the visible and applicable color pattern, which allows placement and identification within the system. A system should quickly offer a good and brief overview of the nuances of a full spectral color. Color systems are mainly based on color circles that already present an initial order principle. The number and the chosen succession of the fundamental color hues can be very different. Today's color systems are illustrated using double-spherical or cylindrical forms.

As a neutral example of color systems, we will now explain Wilhelm Ostwald's system. It is based on a 24-part, additive-mixed, outward-spiraling color circle. The circle's colors are full spectral colors, meaning that in relation to their wavelengths and their positions in the CIE system, they have maximum saturation and purity, also called chroma. The colors in the "warm" half of the color circle, each blended from two full colors, are ordered according to their appearance and arranged with equal spacing. The colors in the "cool" half are developed compensatively and placed on the opposite side. Ostwald was striving for the principle of "inner symmetry." He places the full colors on the circumference of the base plane of both spheres. Ostwald generally describes a color using three parameters: hue, white percentage, and black percentage. Today, these are known internationally as hue, lightness and chroma (equivalent to Helmholtz's hue, saturation, and brightness). If Ostwald were to cut through a color in his color circle into the double cone, he would reach a gray axis in the center, which connects the two poles of white and black. He called this cross section an equilateral triangle. Ostwald extended the nuances of this surface with black and white. Rows of colors with equal black content run parallel to the line of white, and rows of colors with equal white content run parallel to the line of black. Ostwald's system does not draw a po-



> Color system in cylindrical form (Munsell, RDS, ACC)



> Color system in double-cone form (Ostwald, NCS, Müller, Ridgeway)

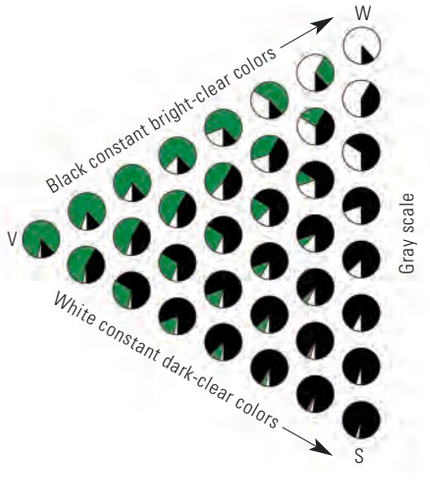
sition between the inherent optical brightness of the color and the degree of luminance on the gray scale.

When applying color systems, it is important to note that the entire color tone area of complementary color mixes have been filtered out of the system. Color is solely developed between black or white, and hue. Heinrich Frieling examined the possibilities of the presentation and realization of complementary/compensative color fields in his Color-Aktiv-Fünfeck (color active pentagon). Many large paint manufacturers use a color system. They have often developed their own systems or use systems that are not company-specific (NCS, RDS, Munsell, Color-Harmony). Using these systems, paint collections are filled into receptacles for practical use. They present a selection corresponding to fashion or trend criteria and are regularly modified. In the system of code numbers it often becomes clear that other colors are possible, which is necessary for the use of this as a tool. In addition to these paint collections, a reference should be made to the popular RAL card. It was created as a collection of single colors for the industrial consumer market (the military, railways, postal service, and fire departments). It was not developed according to a systematic, organizing frame of reference, which was first made really possible by the RAL design system.

Paint collections and color systems could be an initial help in deciding on a selection of colors. Ultimately, as a designer, one should be open to developing a color individually in the studio, or with a painter on site, to counter the quality of the industrially published, mass-produced with the quality of the unique.

Anyone working seriously with color will find it necessary to use some kind of color classification system. Color systems are an aid to composition, bringing order into the confusion of the color range. Colors are presented in sequence and in their relationship to each other, listed neatly by hue, saturation, lightness and interval.

In North America in particular, almost every designer and architect works with one or more of the paint color order systems devised by a particular paint manufacturer to specify interior or exterior color. All paint manufacturers have their own color systems related to their standard or custom-mixed colors. Most are adequate for their purpose; some are more elaborate than others. They should not be confused, however, with the color specifications systems discussed previously (Munsell, NCS, CIE, etc). Specifying color through a system such as Munsell or NCS might require the paint company supplying the paint to be used to have the specific coordinates in their system in order to reproduce that color. Most designers thus



> Monochromatic triangle according to Ostwald

adopt and work with a paint company's devised color system.

The superiority of one paint company's color system over another will depend on the number and variety of colors available, how the system is organized to facilitate design work, and the designer's individual preference.

THE EFFECT OF COLOR CONTRASTS

A knowledge of color contrasts contributes decisively to predicting color effect appropriately and to implementing a design objective. When combining colors, it is often effective to use several different contrasts, which arise when there are clear differences between two or more colors. Contrast effects exist between objective color properties, a well as between subjective color effects.

We distinguish the following color contrasts:

_ Light-dark contrast
_ Chromatic-achromatic contrast
_ Chromatic contrast
_ Complementary contrast
_ Intensity contrast
_ Quantity contrast
_ Flicker contrast
_ Cold-warm contrast

and physiological contrast phenomena such as:

_ Simultaneous contrast
_ Successive contrast

Light-Dark Contrast

Light-dark contrast appears in the difference between colors in relation to their degree of lightness. It is most clearly seen when combining the achromatic colors black, white, gray. Light-dark contrasts can be made using combinations of chromatic colors, as well as using colors of the same hue, yet with different degrees of lightness values. These are called nuance contrasts. Contrasts in lightness are ideal for creating spatial differentiation. Yet it should be noted here that prolonged exposure of the direct field of vision to very strong or very weak differences in lightness can strain the eye and have a tiring effect (loud-soft). Mid-range differences in brightness have a pleasant effect and are recommended physiologically.

Chromatic–Achromatic Contrast

A chromatic-achromatic contrast results when chromatic and achromatic colors come together. Chromatic, very pure and highly saturated colors, when interacting with achromatic colors, generate intense impressions and spontaneously stimulate attention. The degree of prominence of chromatic-achromatic contrasts depends on the intensity of hue and on brightness contrast. In a color combination, white weakens, and black increases, a color's luminosity. The polarity between highly intense hues and achromatic colors plays an important role as a signal in the artificial world of signs, such as pictograms. Chromatic-achromatic contrast is a principle widely used in interior design. White and gray nuances are particular-

ly applied as a neutralizing element and used in association with chromatic hues.

Chromatic Contrast

Chromatic contrast results from combining chromatic colors. It is most clearly apparent when three or more pure-hued, highly saturated colors come together. The less similar the hues are, the more pronounced and stronger the effect of the contrast is. The greatest possible dissimilarity, and therefore the most pronounced contrast, results from combinations that are located far apart from each other on the color circle, such as yellow, red, and blue. Chromatic contrasts using pure colors are very striking, vibrant, and powerful. They attract attention. In interior design, especially in spaces where people spend large amounts of time, chromatic contrasts should be used sparingly, for example to place emphases. Overstimulation caused by too harsh a contrast has adverse effects on the organism.

Complementary Contrast

Complementary contrast can be seen where there is a relationship between two colors that are as different as possible. Each color has only one complement. The relationship between complementary colors can be most clearly perceived in pure and highly saturated colors. They are located diametrically opposite one another on a color wheel and produce a neutral gray when mixed. Every complementary pair has its own special features. Yellow–violet for instance is not only a complementary contrast, but also the strongest light-dark contrast; orange–blue also is the most pronounced cold-warm contrast. Complementary contrast in reduced nuances is suitable for a balanced interior design; it precludes monotonous spatial effect and color experience.

Intensity Contrast

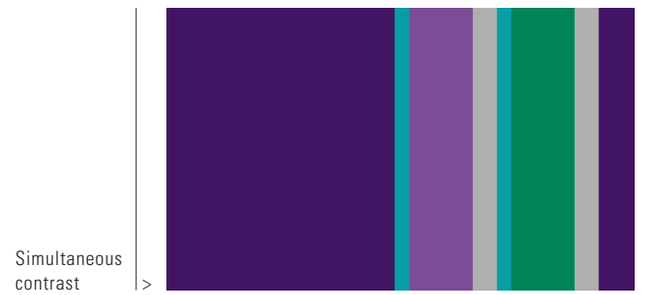
This describes the contrasting of colors with different saturation. Its effect is strongest when small amounts of pure color are placed as an accent between large areas of extended, muted colors. The individual color becomes an important element in the interaction between colors, and arouses particular attention. In a spatial context, intensity contrast is a good instrument for color dominance, subdominance, or accent. One particular form of intensity contrast is the nuance contrast mentioned above.

Quantity Contrast

Quantity contrast refers to the proportional relationship of colors and their interaction. Very different effects can be created if the proportions of colors in a combination are modified. For this reason, quantity contrast also plays an important role in interior design. Color proportions in spaces contribute decisively to the spatial impression and thus to spatial effect.

Flicker Contrast

If intense colors with the same degree of brightness or darkness are applied to a wall, a “flicker” contrast will often occur. If we look at this for too long, a confusing overstimulation will



develop. Flicker contrast can be avoided by eliminating an intense color by darkening or lightening it. A flicker contrast is evidence that a sensible contrast between figure and ground was not considered.

Cold-Warm Contrast

If we take the color wheel as a reference, some colors are considered cool or warm in the subjective psychological response to them. For example, red-orange will be classified as the warmest color, and blue-green as the coldest. Generally the colors yellow, yellow-orange, orange, red-orange, red and some red-violets are considered warm, whereas yellow-green, green, blue-green, blue, blue-violet are perceived as cold (although some blues are considered warm, according to the material on which they appear).

These diverse impressions show the versatility in the expressive and psychological effects of space. They also contain elements that suggest distance, thus becoming a medium for representing plastic and perspective effects.

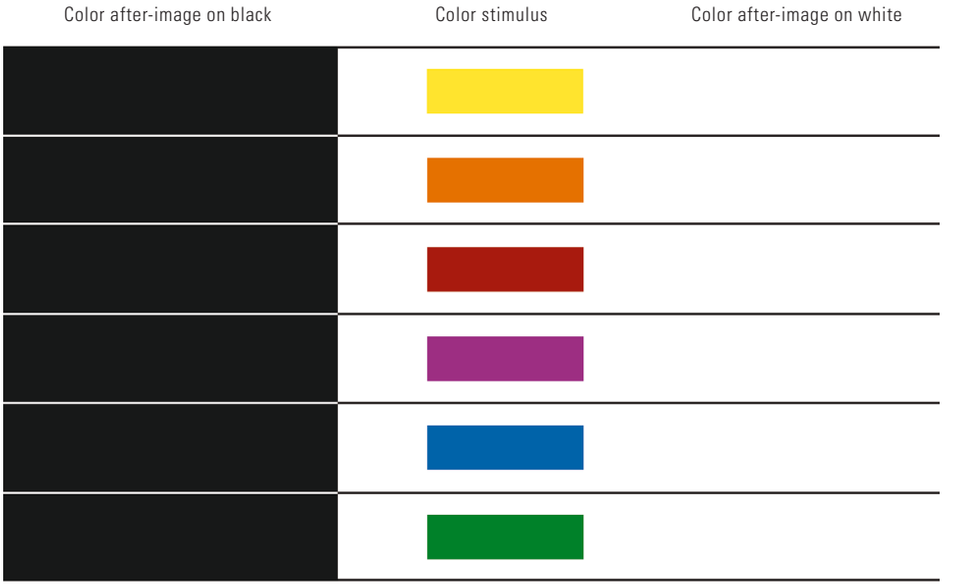
PHYSIOLOGICAL CONTRAST

Simultaneous Contrast

Simultaneous contrast shows the simultaneous, reciprocal and lasting impact of colors in relation to their color environment. The same colors look different when they appear on different-colored backgrounds or in different environments. This variance is caused by reflection. The perceivable changes do not really exist – they are a product of the viewer's color sensation. This can affect hue as well as brightness and saturation.

Successive Contrast

Successive contrast is the physiological prerequisite for simultaneous contrast. If a color stimulus is perceived for a certain amount of time, an after-image will appear in its complementary color (physiological complementary color). This phenomenon can be demonstrated in the following manner: if you look at the center of a red surface until your eye tires, and then look at a white surface, the physiological complementary color will appear, in this case, a faint green. This natural human disposition shows that all color perception is relative. Every color is subjective to its surrounding color. In the figure below, you can test for yourself the after-image that appears following a color stimulus. Look at one of the central colors, for example yellow. Cover the other colors. Focus on the color surface and after some time, focus equally on the black or white surface next to it. You will generally perceive a color that will emerge independently of the projection surface's color or degree of brightness.

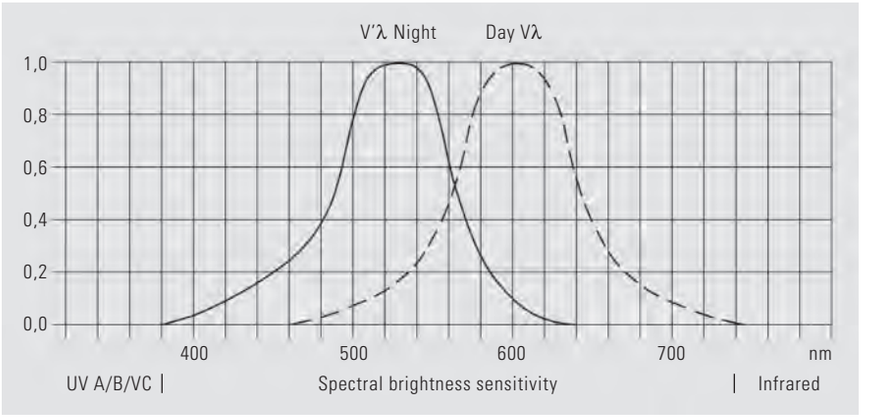


Successive contrast

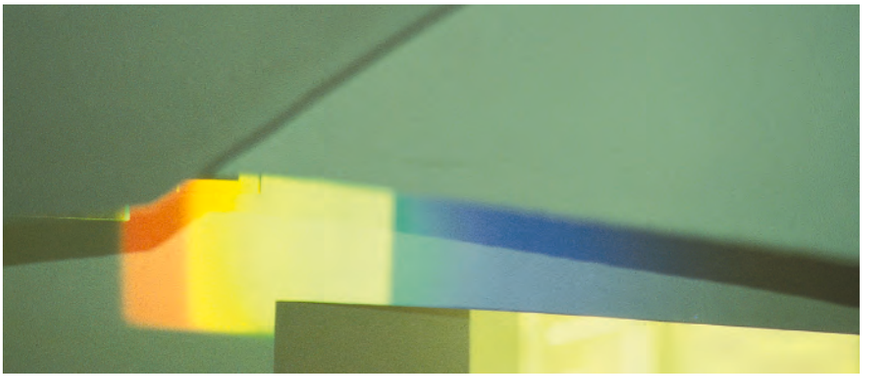
6
LIGHT AND COLOR

Light and color are inseparable partners in the process of perception. Together with the perception of form, they become part of the overall picture. As with color and its effect on the human organism, light is also associated with many disciplines and fields, and the interrelated effects are highly complex. It touches on psychology and physiology, biology and visual ergonomics, medicine and chemistry, electrical engineering and physics; it plays a role in architecture and is synesthetically linked with the perception of sound, and directly or indirectly with climate. Light occurs naturally in the form of sunlight, but there are also many different artificial light sources. Natural sunlight represents the entire visible spectrum of electromagnetic radiation from approximately 380 to 780 nanometers. The quality of light in a given space depends on the relationship between its area and the size of the opening permitting light to enter, the location of the light source, its location in relation to the points of the compass, the distribution of light in the space, as well as the atmospheric conditions. Light is the most important quality in the interaction between people and their environment. During the course of the day, the angle of light changes, which changes its quality, and ultimately the way in which it is perceived. The plastic qualities of a given space, the quality of hue and color nuances also change with the time of day. With the advent of conscious ecological planning, sunlight is becoming increasingly important as a source of light for workplaces and for spaces with particular dimensions. At the workplace, biological sources of full-spectrum light are receiving increased attention. In wide, high, or deep spaces, systems to channel light or direct it with lenses can allow a longer use of sunlight and thus decrease the amount of artificial light needed. Artificial lighting units are only good if all possible interactions are considered during planning and installation. Very often, however, planning is limited to purely technical and economic aspects, making the artificial lighting systems deficient and unsatisfactory both in terms of their design and physiologically. The reasons for this include:

_ Faulty lighting is seldom consciously perceived;
_ Adverse effects are usually registered very slowly and after a time lag;
_ Complaints are often general and not related to the light;
_ Energy-saving measures in lighting units often result in a loss of quality in color rendering properties.



Spectral brightness sensitivity



Spectrum at the Goethehaus in Weimar

In the future it will become increasingly important to plan light, color, and material in tandem. This is true particularly in cases where:

_ Intellectual demands on the workers are increasing;
_ The level of tolerance for disruptive factors is decreasing;
_ Surface reflections (mirroring, reflective materials on computer screens) disrupt the accuracy of perception;
_ Artificial light continues to replace daylight;
_ A space has little or almost no daylight, too small an opening for daylight, etc.

The architect, interior architect, and color designer must work together with the lighting planner to coordinate not only the technical and economic aspects of the planning, but above all the links between light–human perception–space and light–material–color.

THE TECHNICAL BASIS OF LIGHTING – MEASUREMENTS AND UNITS

Four basic terms are encountered in the evaluation of artificial light and the planning of lighting units:

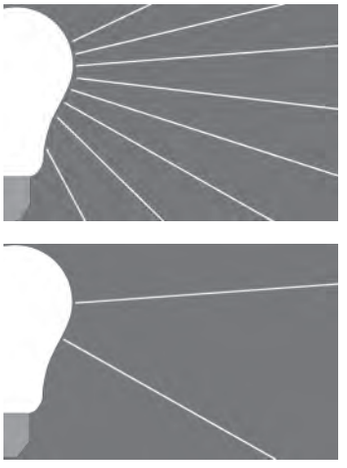
_ Luminous flux (measured in lumen, lm)
_ Luminous intensity (measured in candela, cd)
_ Illuminance (measured in lux, lx)
_ Luminance (luminous density, measured in candela per square meter, cd/m^2)

Luminous flux refers to the perceived power of light rays. It is weighted to take into account the sensitivity of the human eye to light of different wavelengths, a factor known as the luminosity function, or $v\lambda$. Luminous flux measures only light within the visible spectrum (visible light).

Luminous intensity is the luminous flux in a particular direction within a space. Luminous intensity distribution refers to its distribution in three dimensions.

Illuminance measures the luminous flux that falls on the surface of an object or a space. Illuminance is still used today as the foundation for most light planning, but it is not in fact a measurement of perceived brightness.

Luminance (luminous density) is the only measurement that describes the perceived brightness of a surface. The effect and the visual impression produced by a particular lighting unit can only be assessed by evaluating all the luminance values in a given visual field. Luminance measures the light reflected or emitted from a surface as perceived by the human eye. This is based on the assumption of a flat, diffuse surface.



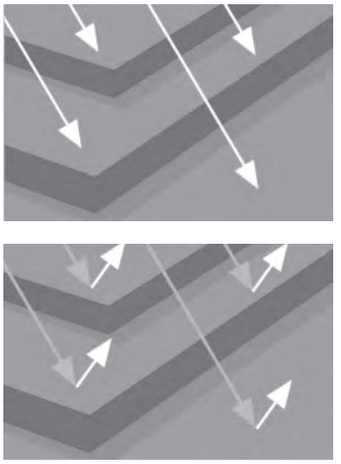
above: Luminous flux
below: Luminous intensity

According to engineers who currently advise in planning, the lux value or illuminance constitutes the most important factor of the four technical measurements above. In the European Standard, EN 12464-1, and German DIN Standard 5035, mandatory average values are prescribed for various uses of a space. In relation to a given task, close attention should be paid to two areas: the zone of the direct visual task and its immediate environment. For these areas, mandatory values are prescribed for maintained illuminance (Em). Typical values for illuminance range from 20 to 5000 lux. For visual tasks in the office (writing, reading, data processing), an illuminance of 500 lux (at 0.75 meters above the ground) is prescribed. Luminous efficacy measures the efficiency of a light source. Luminous efficacy indicates how much power is necessary to obtain a certain amount of luminous flux (of visible light). This is measured in lumens per watt (lm/W).

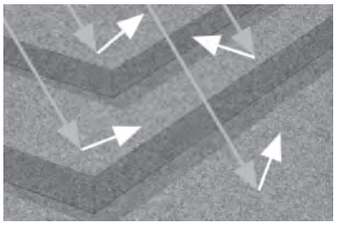
A high luminous efficacy in lamps and a high degree of efficiency in lighting will guarantee low-cost lighting units, but usually at the cost of design considerations and visual quality.

Typical standard values for luminous efficacy in commonly used types of lamps are listed below.

Unfortunately, these engineering and business considerations usually neglect the issue of light quality. The color rendering properties of a given light source, as well as the luminance (cd/m²), are decisive for the quality of color, material, and space. Luminance alone describes the perceived brightness, or defines the contrast. In light calculations, luminance does not receive the attention it deserves due to its visual importance, because it is difficult to measure and to calculate. What is decisive spatially is the span of the various luminous densities in a given area in relation to luminance adaptation, meaning the sensitivity adjustment of the human eye.



above: Illuminance
below: Luminance



Diffuse reflectance according to material properties

Basic light bulbs	10–15 lm/W
Halogen lamps	10–25 lm/W
Fluorescent lights	Up to 105 lm/W
Compact fluorescent lights	50–75 lm/W
Metal halide lamps	60–90 lm/W
High-pressure sodium lamps	50–130 lm/W
High-pressure mercury vapor lamps	60–70 lm/W
Light-emitting diodes	15–30 lm/W

LAMPS AND THEIR PROPERTIES

Light can be technically defined as: "What we perceive as artificial light is the result of a physical process. Whether light is understood according to quantum theory as a particle, or according to wave theory as an electromagnetic wave – it originates from electrons that have been stimulated by a light source." (H. J. Hentschel)

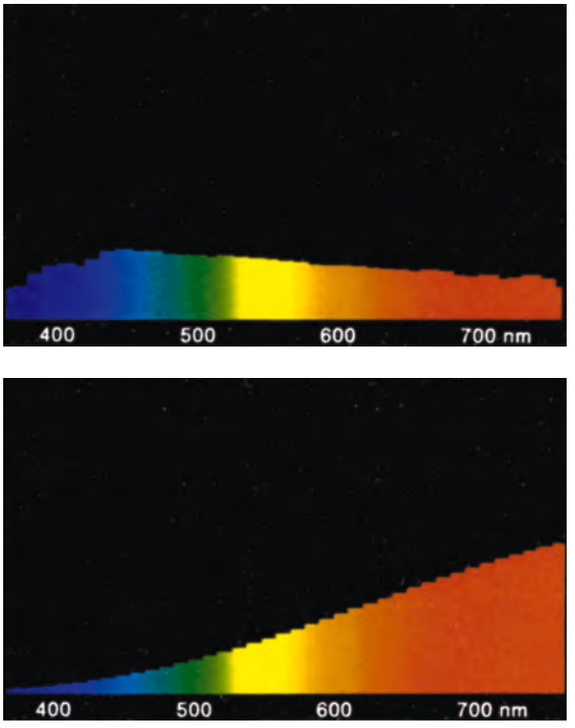
In general, this can be accomplished in three different ways:

- **Electron gas in solid bodies emits a continuous spectrum at high temperatures. The best example of this is sunlight. The same process occurs in a light bulb.**
- **Orbital electrons in gas and metal vapors emit a characteristic line-spectrum radiation when they discharge electricity. If rare-earth halogenides are added to these gas emissions, the line spectrum of mercury, for example, is complemented by the multiple line spectrum of the halogenide (for example in metal halogen lamps).**
- **Light can also be the result of luminescence if the ultraviolet light discharged by low-pressure mercury stimulates luminescent substances to emit light. Fluorescent lights are based on this principle, which produces a range of color temperatures from light-bulb warm white to daylight blue-white.**

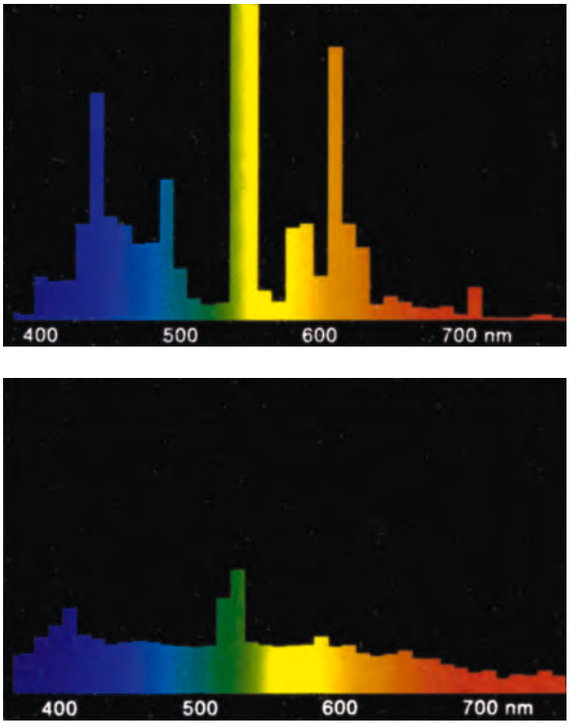
Light bulbs are still widely used today in private living spaces. These heat-radiating lights are not very economical, and are therefore increasingly being replaced by compact fluorescent lights. However, the color rendering index of both these types of lamps can vary greatly.

Low-volt halogen lamps use electricity more efficiently. They are used for spots, for prestigious lighting in commercial spaces, and also increasingly in private homes. Cold light reflectors can reduce the amount of heat radiated by about 66 percent. This not only increases the life of these lamps (2000 hours) but also changes the color temperature. Fluo-

> above: Daylight
> below: Light from a light bulb



> above: Light color: 11-860 LUMILUX Daylight
> below: HQI/D Metal halide lamps



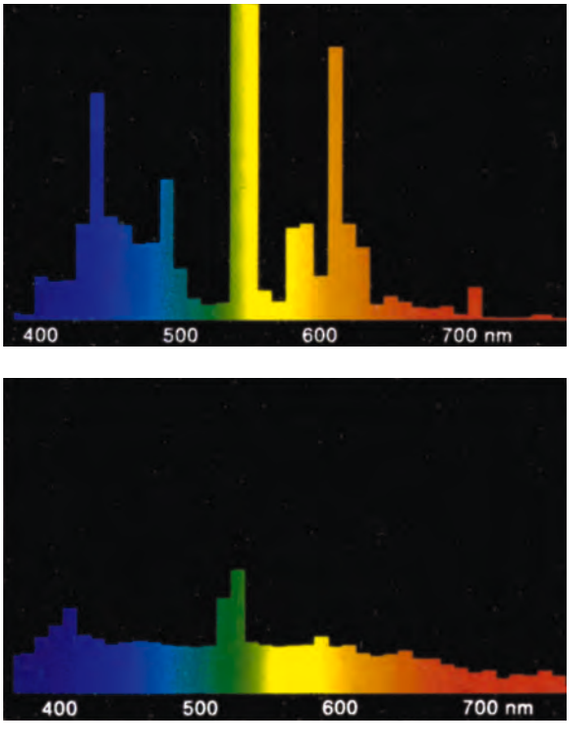
rescent lamps are available today in various outputs, circumferences, and white nuances. Color temperature describes the color of light. It does not affect the quality of color rendering. A preference for a certain color of light will depend on personal taste, cultural influences, and an individual color sensibility, and color temperature can be employed as a design element.

Metal halide lamps are high-pressure mercury vapor lamps with a better spectral constitution due to the use of halogen. Their color temperature ranges from daylight to warm white. The luminous efficacy of these lamps is very high and the color rendering properties are quite good. These lamps are used by trade fair and shopfitters, in commercial spaces, industry, exhibition halls, and sport arenas (for spotlights and floodlights). Other kinds of lamps with more moderate or limited color rendering properties, such as high-pressure mercury and sodium vapor lamps, are used primarily to illuminate outdoor spaces and for industrial and commercial buildings. In color planning, the spectral diagrams of the lamp producers should be used to test the color temperature and color rendering. Color and material sampling for a planned area should thus be tested under the chosen type of lighting. There are three main types of white light:

_ Daylight white (5400–6500 Kelvin)
_ Neutral white (approx. 4000 Kelvin)
_ Warm white (2700–3000 Kelvin)

Color rendering is a measurement of how recognizable and distinguishable different colors are. It is described by the color rendering index (Ra). This defines a standard for a given visual task (minimum requirements have been set down in standards). A lamp should allow for accurate color perception (as in daylight). The color rendering index is assessed using a test palette of eight unsaturated tones, four saturated, a special leaf-green, and a skin-colored tone. Green light and the light of the blue northern sky are used for comparison.

> above: SOX sodium high-pressure lamps
below: Light color LUMILUX warm white



To conclude, it can be said that for good lighting three elements must be taken into account:

_ Visual power (level of lighting, limited glare)
_ Visual comfort and color rendering properties (harmonious distribution of light)
_ Visual ambiance (shadows, color temperature, light direction).

The demands on light quality are derived from the visual tasks to be performed and expectations of ambiance.

ASPECTS OF VISUAL ERGONOMICS

Approximately 90 percent of our sensory impressions are recorded by the eyes. Vision and lighting serve to relay information. Lighting and visual conditions have a profound effect on our ability to concentrate, our productivity, our reaction capacity, and our general well-being. Optimum functioning of the eyes is directly related to the given light and space conditions. Both must conform to the physiological principles of the eye.

Color Ergonomics/Visual Ergonomics

_ Seeks a balance between extreme perception states;
_ Helps avoid under- and overstimulation via subtle stimulation;
_ Protects the eyes and the organism;
_ Aids precise perception;
_ Creates order;
_ Helps with orientation;
_ Aids concentration;
_ Reduces errors;
_ Promotes well-being;
_ Requires discipline in lighting design.

R1	Dusty pink	R5	Turquoise
R2	Mustard yellow	R6	Sky blue
R3	Yellow-green	R7	Violet
R4	Light green	R8	Light reddish purple
Additional saturated test colors			
R9	Red	R12	Blue
R10	Yellow	R13	Skin color
R11	Green	R14	Leaf green

Color rendering index test palette

Color rendering properties	Color rendering level	Color rendering index (Ra)	Examples of lamps
very good	1A	90	Halogen lamps, Lumilux de lux-fluorescent lamps, metal halid lamps, HQI/D
	1B	80–89	Lumilux-fluorescent lamps, metal halide lamps, HQI/NDL or WDL
good	2A	70–79	Standard lamps 10 and 25
	2B	60–69	Standard lamps 30
satisfactory	3	40–59	High-pressure mercury vapor lamps
unsatisfactory	4	39	Sodium high-pressure and low-pressure lamps

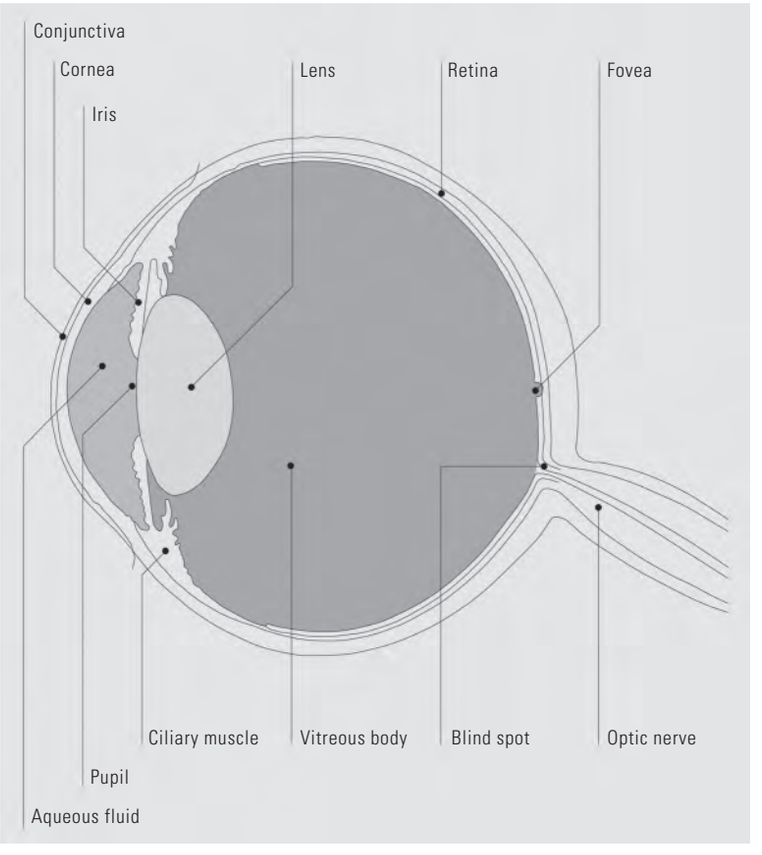
The Structure of the Eye

The essential parts of the eye are the cornea, the iris, the lens, and the retina. The transparent cornea covers the outer surface of the eye. Its curvature is responsible for the refraction that produces an image of the outer world on the retina. Light enters through the cornea and proceeds through the pupil, the opening in the center of the eye, and then to the lens, which complements the refraction of the cornea to project a clear image onto the retina. The iris is a ring of muscles that controls the amount of light entering the eye. The retina, that is, the internal surface on the back of the eye, contains light-sensitive receptors and retinal connections. This is where a highly complex transformation of light energy into nerve impulses takes place.

The receptors (light and color receptors) can be one of two different types: cones and rods. The cones (approximately six to seven million per eye) are able to perceive color and are only effective when the luminance is high. The fovea contains only cones, and is thus the prime location of color perception and visual acuity.

Rods, which are much more numerous (approximately 120 to 130 million per eye) and are found particularly in the peripheral retina, cannot perceive color. Their role is to sense light and dark. We use them to see when the light is bad, for example during twilight and at night.

When light enters the eye, each rod and cone undergoes complex phototechnical reactions and ultimately produces electrical impulses, transforming light energy into electrical energy. This first proceeds through the intricate cell system of the retina, then through the fibers of the optic nerve, and next through the optic chiasma and on to the higher optic tracts,



Cross-sectional view of the eye >

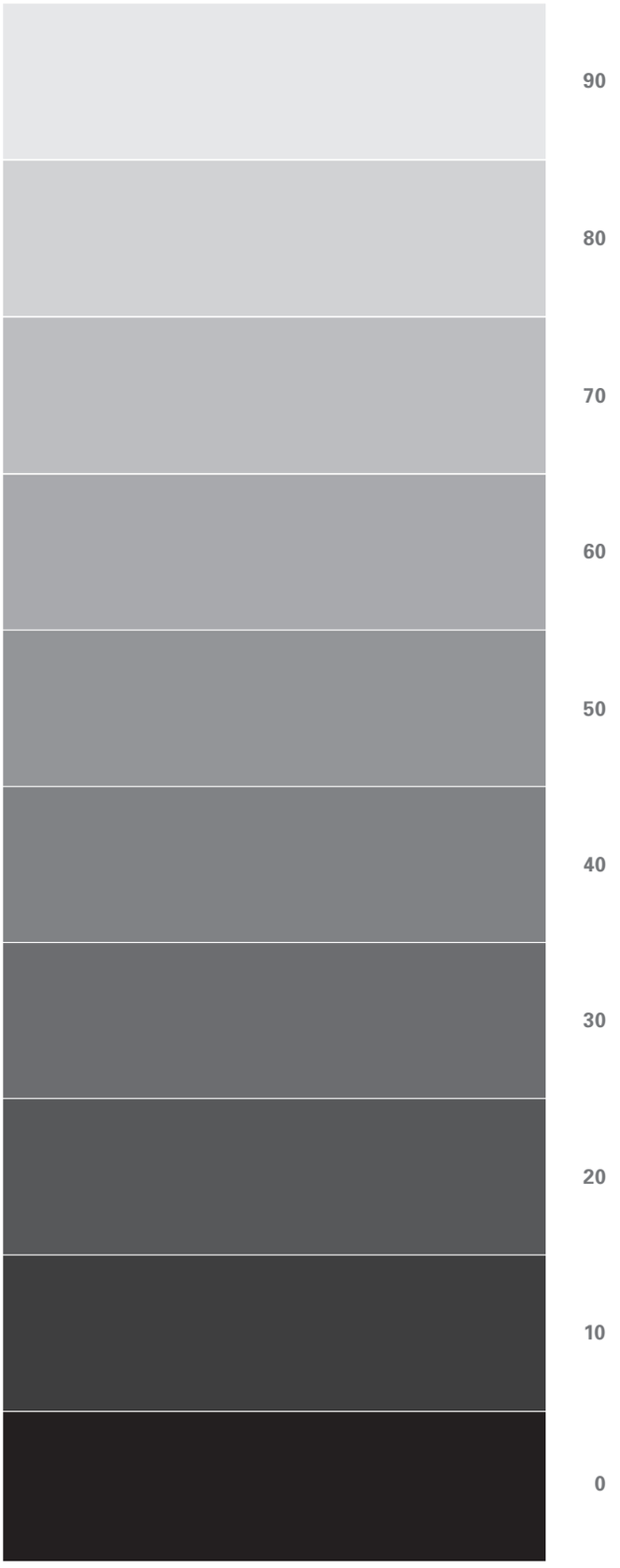
all the way to the visual cortex in the occipital lobe of the brain. Only then does the person begin to see.

Eye Muscles

The eye has internal and external muscles. The external muscles are responsible for the eye's movement. The internal muscles control the size of the pupil and the curvature of the lens (that is, they change the thickness of the lens). The changing thickness of the lens allows the eye to adjust to the varying distances of objects in the outside world, bringing the images they produce on the retina into focus. This capability is called accommodation and involves the ciliary muscles. During this process, the position of the eye's axes change in relation to one another. Both mechanisms require muscle power. If accommodation has to take place too frequently, the eye muscles may become strained. But work that requires one to keep the eyes focused at a constant distance and in a fixed direction can also cause fatigue, just as all static muscle strain does. The size of the pupil is regulated by the small muscles in the iris, allowing the eye to adjust to varying densities of incoming light. This property is called adaptation. A healthy eye retains this capability for a long time, but it decreases significantly in old age.

Glare and Brightness

Glare is the most common cause of vision problems due to lighting. All light that enters the eye either directly or indirectly by reflecting off a surface causes glare. The source of the glare produces diffused light in the eye's vitreous humor, which covers the retina like a veil. Reflective glare is often caused by light bouncing off polished or shiny surfaces. Sensitivity to glare increases with age because the vitreous humor becomes increasingly cloudy, which causes more dif-



Brightness reflectance in percent – sequence of colors and materials for comparison >

fused light. Direct glare from too high a light density or faulty positioning of lamps affects our well-being (psychological glare) and reduces visual capacity (physiological glare). This must be strictly avoided or at least minimized. Reflective glare is usually due to sources of daylight or artificial light. It primarily affects contrast in the visual field. Better lighting and better positioning of lamps can prevent reflective glare. Daylight sources should include a mechanism to regulate them (for example screens or blinds).

Differences in Luminous Density and Surface Color

Extreme light and dark contrasts in a room should be avoided. Differences in luminous density within a person's field of view affects the eye's adaptation to light and dark. During this adjustment, visual capacity is reduced. If the differences between the luminous densities within view are too great, the iris muscle is strained, causing eye fatigue. Studies have shown that appropriate differences in light density can prevent eye fatigue and raise visual acuity, and thus also productivity. Too weak a contrast should also be avoided because this leads to a loss in the quality of three-dimensional perception. A harmonious distribution of light and dark contrasts provides visual comfort in interior spaces. This means ensuring that the direction and conduct of light is optimal, and also providing areas where the light is less dense. Rooms that have uniform, diffuse light without contrast are monotonous. The direction and contrast in light, as well as color temperature, determine the ambiance of a given space.

BIOLOGICAL EFFECT OF LIGHT

A great proportion of our lives – living, studying, working, regenerating – takes place indoors, in artificially designed spaces and under artificial light. In contrast to natural light, artificial light remains constant, not changing throughout the day or with the seasons. Furthermore, artificial light is constitutionally different from natural light. Although there are lamps with a high output that guarantee good vision, the quality of color rendering across the full spectrum is significantly limited.

Daylight is the most balanced type of white light because sunlight reflects each hue in the spectrum equally. This light, however, does not have a consistent color of its own. The color temperature of daylight will vary according to how it is reflected and refracted in the earth's atmosphere. Daylight thus changes over the course of the day, as well as according to geographical location and season.

In recent decades it has become increasingly clear that sunlight has a strong effect upon the human organism. Rikard Küller writes in *Non-Visual Effects of Light and Color* (Küller 1981, p. 9):

"The reason for this is first that solar radiation was important for the genesis of life itself; actually, without light there would be no life. The second reason is that the development of higher organisms, and above all humans, still takes place under the constant influence of solar radiation, which affects living tissue from the single cell of the skin to the specially adapted, light-sensitive eye. Thus, the amount, the quality, the distribution, and the variations of light between day and night, winter and summer, are closely tied to human development."

Visible light, ultraviolet (just beyond the visible spectrum) and infrared light are crucial for human health. They affect the human organism through contact with the skin and via the

light entering the eye. The eye's perception of light is not just limited to the function of vision. Light is carried to the brain via two tracts: the optic portion of the visual pathway travels to the visual cortex and enables vision. It also activates the cognitive system and psychological reactions, as well as the energetic portion of the visual pathway that stimulates the pineal gland (epiphysis) and the pituitary gland (hypophysis). These glands regulate the production and secretion of hormones and thus control the body's chemistry.

It is through this pathway that light affects the body's circadian cycle, the biorhythm that repeats over a 24-hour period. The circadian system is a network of bodily cells, tissues, and fluids. It is synchronized by daylight and thereby governs the 24-hour cycle of day and night. This "inner clock" that induces many complex psychological and biochemical reactions is regulated by the hormone melatonin. Light suppresses the production of melatonin, and darkness activates it. Our bodies are thus made sleepy or awake, are activated or deactivated, by light. Various processes occurring in the skin depend upon the photochemical effects of ultraviolet light. One of these is the synthesis of vitamin D2, which promotes the metabolism of phosphorus and calcium. Studies indicate that the presence of ultraviolet light has physiological effects, such as a reduced pulse, lower blood pressure, changes in skin temperature, activation of metabolism, shorter reaction times, and resistance to infection. The warmth of infrared radiation on the skin causes blood vessels to dilate and thus affects body temperature. This in turn has an effect on a person's physical and mental performance.

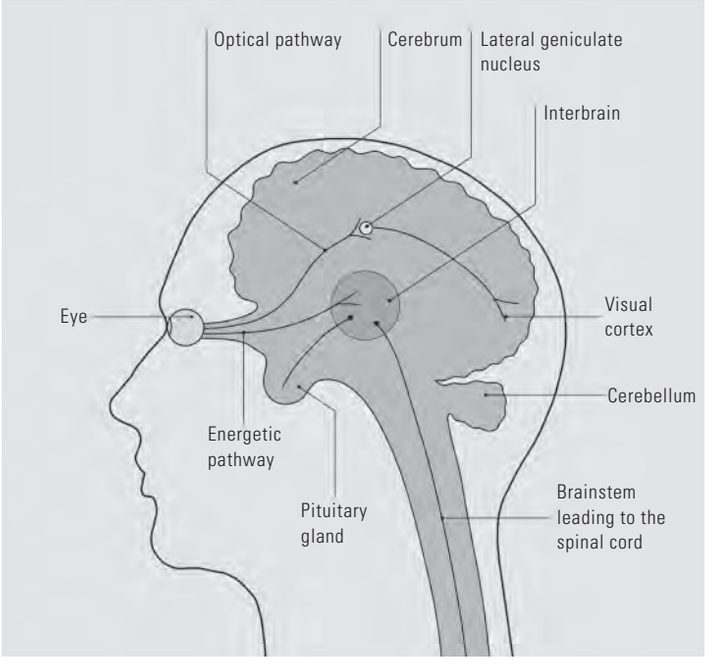
Many scientists thus question whether artificial light can really be a substitute for natural light in the physiological sense. This question is legitimate, as the following two considerations demonstrate.

Many standardized fluorescent lamps vary widely in their spectral make-up in comparison to natural light, and only very few lamps contain a balanced amount of ultraviolet rays.

Studies show that there are biological effects on the human body resulting from constant, standardized, artificial light. If sunlight is considered "normal," then artificial light is clearly limited.

Hollwich and his colleagues found that light with a higher level of illumination intensity, and which deviates from natural light in its spectral composition, produced stress-level amounts of ATCH and cortisol (a stress hormone). This finding

Optical and energetic visual pathway according to Hollwich

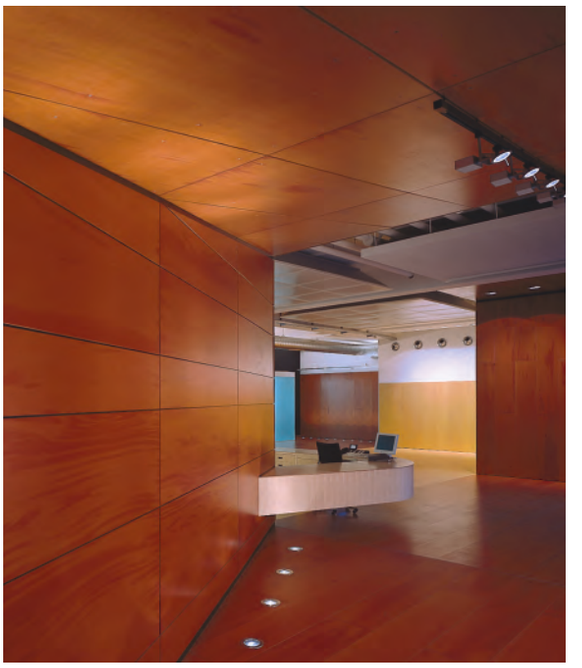


led Hollwich to deduce, among other things, that it may have an effect on children's hyperactive behavior at school, where they are exposed to artificial light almost all day. His hypothesis has since been corroborated by many other studies. As early as 1974, Mayron and his colleagues demonstrated that full-spectrum lighting reduces hyperactivity in schoolchildren. New studies, such as those by G. Grangaard (1993), have produced similar results. At least one study has indicated that there may be long-term effects. Sailors on American Polaris submarines who did not see natural light for 6 months developed symptoms such as sleep disorders, obesity, weak immune systems, depression, heart and circulatory weakness, muscle and joint problems, and more.

The Duro-Test Corporation in New Jersey, USA, developed a fluorescent tube with the name Vita-Lite, which is sold in Europe under the name True-Lite. This fluorescent tube is considered a full-spectrum lamp because it has a color rendering index of over 90, which corresponds to the spectrum of sunlight, and has a balanced ultraviolet radiation. Several other companies have since marketed "full-spectrum lamps," but some of them do not have a balanced amount of ultraviolet light. As regards visual aspects, lamps with a high color rendering index (above 85) are recommended. Hughes, Neer, and many other light experts, claim that this type of lamp allows better visual perception. This raises the question of whether a balanced UV radiation, which has a positive effect on human health, should be considered a necessity. In particular, bedridden patients or people who work all day in interior spaces (nursing homes or all-day schools), as well as people with insufficient, unbalanced diets, have been shown to lack exposure to UV light. The positive effects of administering UV radiation can already be seen when just 1/10 to 1/2 of a typical daily dose of natural light (eight hrs/day) is administered, a dose that causes the skin to redden only minimally (Thorington 1973). These amounts should not therefore be compared to the strong UV radiation in sunlight and its associated health effects, such as aging of the skin, sunburn, skin cancer, cataracts, etc. The use of lamps with UV radiation is not recommended for infants, given that precise studies have not yet been carried out to determine what levels of UV radiation newborns can safely absorb through the eye lens, or what levels are safe for their skin.

Zumtobel, Lemgo
Architecture: Bolles and Wilson

Zumtobel,
Spatial modulation using
lighting technology



7
MATERIAL AND COLOR

In addition to the use of light and of architectural forms, materials and colors are the key visual parameters for perceiving and experiencing space. While for centuries Asian cultures have cultivated a highly refined awareness of materials along with an advanced understanding of construction, there has been a lively debate since the early 19th century in Europe on the role of materials and colors in architecture and interior design. Architects and designers such as Jakob Ignaz Hittorff in France, John Ruskin in England, and Gottfried Semper in Germany proved that "white" classical Greek architecture was originally adorned with bright colors. The ensuing "polychrome dispute" over the theories of archeologist Johann Joachim Winckelmann subsequently engendered a wide range of movements in the 19th and 20th centuries. John Ruskin believed that "materials should be the only colors in architecture." Semper spoke of "material-color-surfacing" as the key characteristic, the "ultimate element" of spatial design. Around 1900, this served as a foundation for Art Nouveau and the New Realism of the Deutscher Werkbund. Abstract painting of the 20th century also changed perceptions of form and color in architecture. Dutch Neoplasticism (De Stijl, Piet Mondrian) and Bauhaus theories found their clearest expression in the Schroeder House by architect Gerrit Rietveld in Utrecht. At the same time, a radical avant-garde was also emerging in Russia, led by artists and architects such as Konstantin Melnikov, El Lissitzki, Vladimir Tatlin und Kazimir Malevich. The painterly interpretation of space exemplified by De Stijl and Bauhaus stood in contrast to a sculptural interpretation of architecture, as clearly manifested in Mies van der Rohe's Barcelona Pavilion and the style of his materials. We also find it in the Chicago "New Bauhaus" of Walter Gropius and Mies van der Rohe. Both positions are commonly found today, and this book aims to act as a link between them. Materials and colors serve a specific function. They have to fulfill the demands imposed by ergonomics, optics, aesthetics, and function. Materials as a substrate for color and color-coated surfaces are often elements of one and the same perceptual situation. They influence, enhance, or detract from each other. All elements of a perception influence one another: they are seen as a single entity. Ideally, the character of this perception is something new and greater than just the sum of its individual parts. Thus, a material and a color have to be placed together before they can create a specific effect. For an exact terminological description, it is recommended that readers consult László Moholy-Nagy. In his Bauhaus book "The New Vision, from Material to Architecture," published in 1930 (1928 in German), he differentiated between structure, texture, and processing methods. He elaborates:

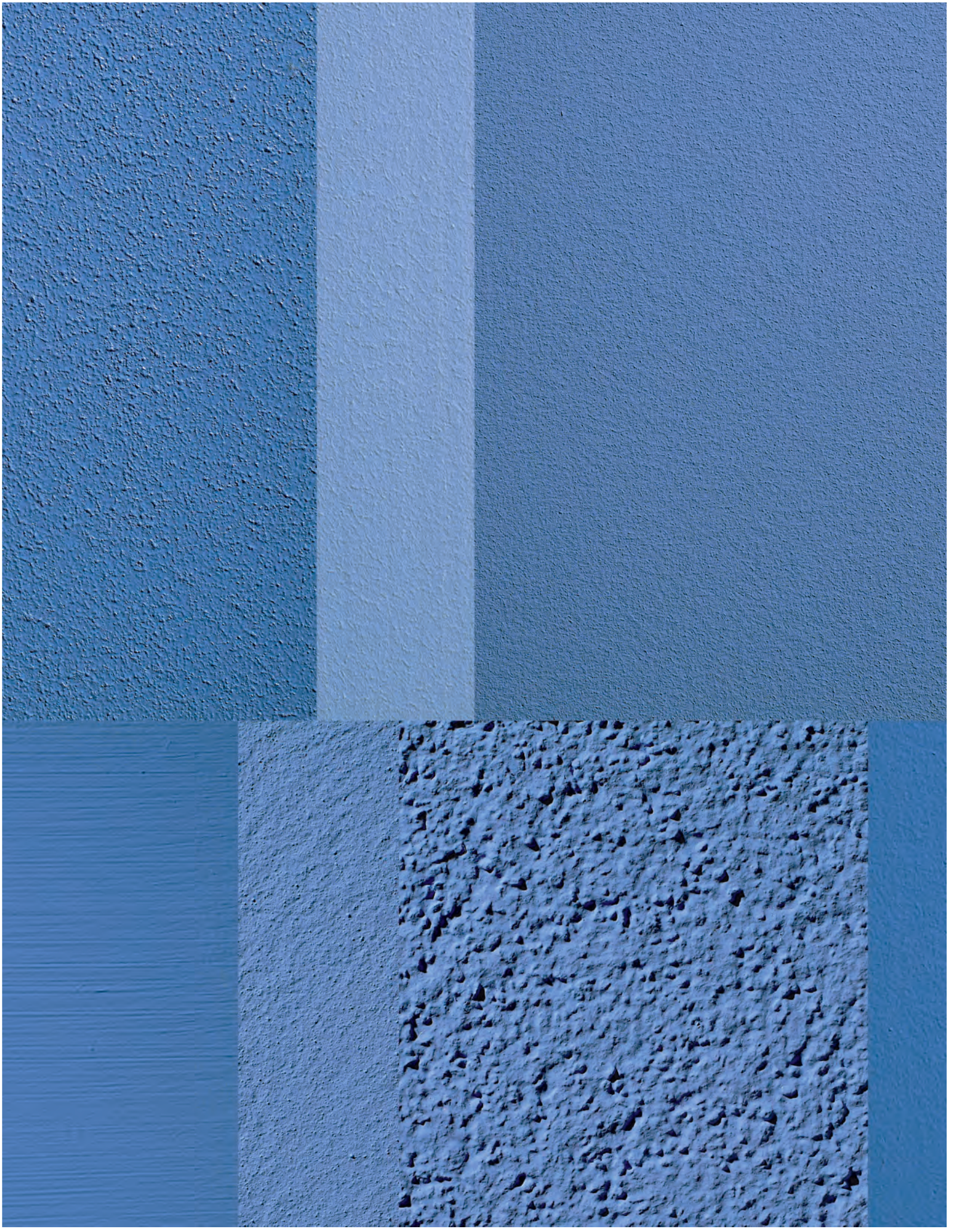
Structure — **is the immutable composition of a material, for example, the crystalline structure of metal, the cellular structure of wood, and the fibrous structure of paper.**

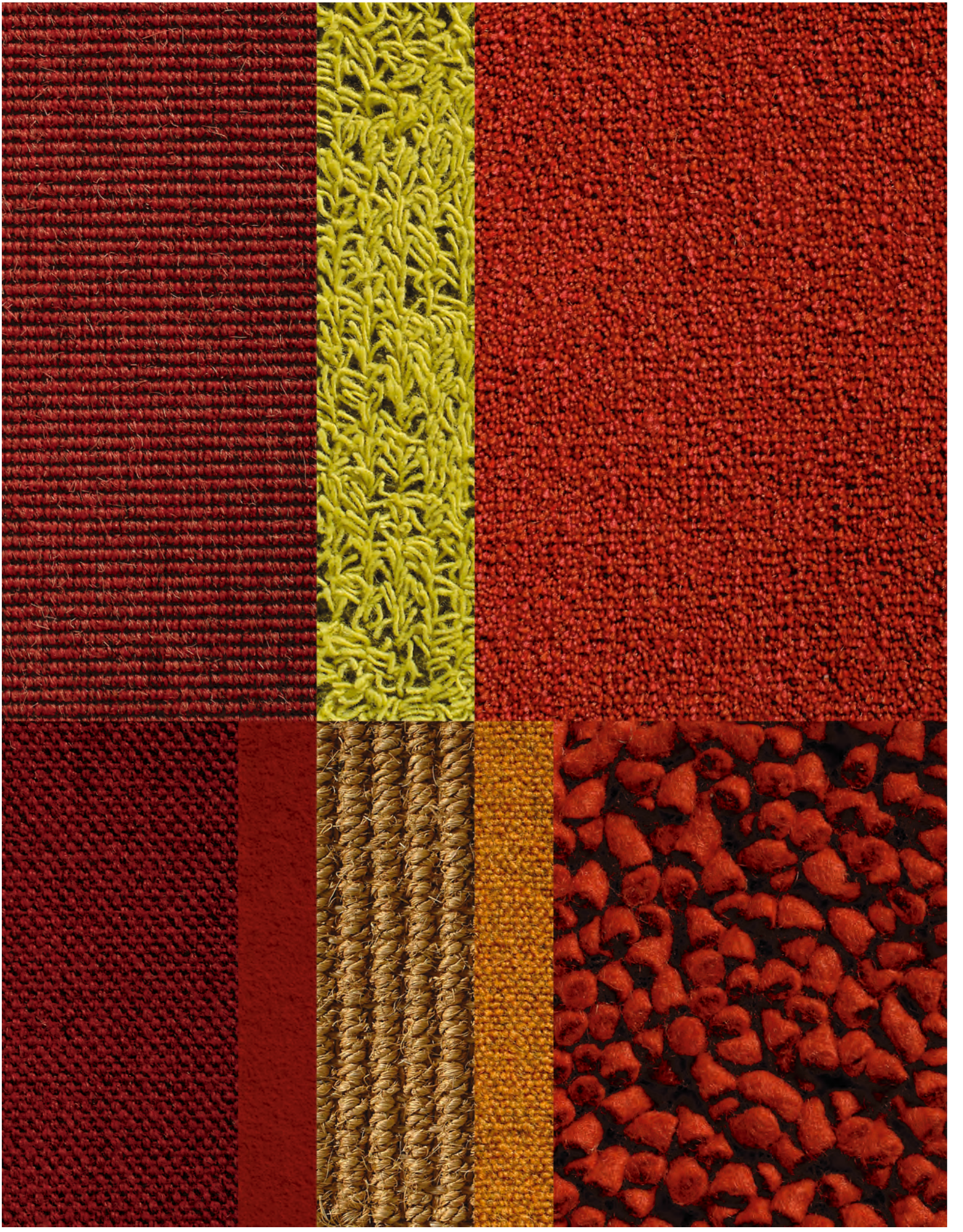
Texture — **is the organic surface area of any structure, as well as processed surfaces. This group includes the cross-sectional view and grain of wood, the granulate texture of granite, the stratification of marble, the woven texture of fabric, plaiting or yarn, and the fibrous texture of particle board.**

Processing methods — **are the perceptible expression of material processing. Highly diverse materials often have graduated processing steps that influence color, for example:**

Stone	Wood	Metal
quarry	saw	cast
sharpen	rough plane	draw
chisel	plane	press
fire	sand	forge
granulate	brush	hammer
rough-sand	rough or fine-sand	bend
plaster	fill pores	grind
fine-sand	finish	polish
polish	polish	

It is also possible to alter the natural color of materials. During the Renaissance, natural stone was dyed. This technique





is no longer common due to the wide range of colorful materials available on today's market. Binding agents and additives used in the making of artificial stone are often dyed. Wood is stained, glazed, or varnished to varying degrees of opacity. For ceramics and stoneware, there are stains and glazes with a variety of surface qualities ranging from smooth to textured, and from matt to high gloss. Metals can be galvanized or coated, for example, chromed, nickel-plated, brass-plated or anodized, but they can also be enameled or coated with epoxy resin. Each of these surfaces has a very different look and feel. The function and use of a material in interior design depends on whether or not it is intended to represent itself or serve as an accent in a composition, whether it should act as the dominant element of an ensemble, or harmonize as a single voice of a "choir." Materials can have a natural and characteristic color and texture, or they can be processed and fundamentally changed. With its individual character and unique color, as well as its own texture, each material represents a distinctive image. The inherent image of the material, its "visual value" or "aesthetics beyond its practical value," can be altered through processing. The effect this has and the atmospheric impression it makes on the individual – warm or cold, pleasant, luxurious or majestic – depends on the socialization of the individual. Hence, each material conveys a message.

Yet materials are more than just shades of color that make a certain image statement. They also directly enhance synesthetic perceptions. The senses of taste, smell, hearing, and touch are all stimulated to create perceptions that complement those registered by the sense of sight. We perceive materials holistically, as Hugo Kükelhaus says, with all of our senses, just as we perceive space with all our senses. Materials influence tastes, smells, sounds, and memories of previous sensations, perceptions, and the associations that they trigger. Acoustics – a muffled space or a space filled with echoes – can elicit sensations of warmth or cold. This image world of materials is complemented by colors, which underscore, tone down impressions, or create additional effects such as dominating, equal, subordinate, or accentuating elements.

Colors vary in their effects according to the application technique used and the material substrate. Many aspects of coating techniques are dealt with here. There is an abundance of specialized publications available that deal with technological issues.

Color applications (paints, glazes, etc.) are coatings of walls, ceilings, and floor surfaces, as well as objects made of a wide range of materials including wood, metal, plaster, mortar, masonry, concrete, plastic, glass, fabric, and paper.

Absorbency and surface structure (texture and processing method) have a major influence on how an object's color is perceived. Similarly to materials, surface characteristics in combination with the color itself, and its position in the overall color scheme, work to create a value, an image impression. Until very recently, only "immaculate" flat and opaque coatings were generally accepted as being suitable for architecture. With today's growing environmental awareness, however, traditional materials and application techniques are making a comeback. Using natural pigments and binding agents, glazes are becoming very "presentable." Old encaustic wax painting techniques and trowel lacquer applications offer interesting color mixing possibilities and, with their various colored layers, they produce rhythmically textured and vibrant surfaces.

By working with colored surfaces and natural materials, as well as color applications and material surfaces, designers have a wide array of possibilities to create exciting spaces. In the interest of each specific spatial function and atmosphere, however, it is recommended that they take a disciplined approach to the full range of possible effects. Often the individual value of a surface can best be enhanced by toning down its surroundings. Diverse textures and processing methods often detract from individual elements and can be visually overpowering.

8
ARCHITECTURAL ASPECTS OF SPACE

ASPECTS OF PERCEPTION

The changing appearance of the environment and changing subjective responsiveness go hand in hand. Physiologists differentiate between two models of perception that cooperate in reacting to the environment, a stimulus-response model and a "look-up" model. Christoph Schierz of the ETH Zurich (2005) explains as follows, "With stimulus-response, an external stimulus is directed or controlled by a network of 'interior switches' and triggers a response. With 'look-up' perception, mental concepts of possible environmental designs are already available as 'visual experience.'"

Mental concepts are experiences learned in one's own cultural or personal environment, or over the course of evolution, and in the development of postnatal experiences. Mental concepts guarantee constancy in perception. The subjective world of mental concepts comprises not only visual appearance (as pattern recognition), but also an emotional and affective coloration of the perceived. A mental attribution occurs on a mentally higher level.

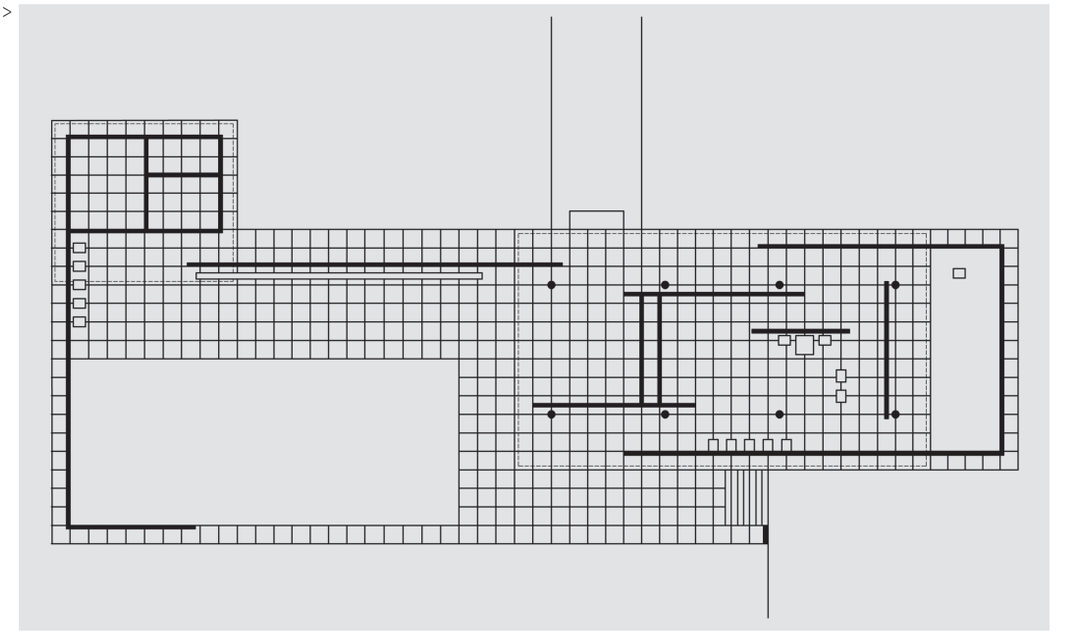
In this way, we create "an image of space" as a mental, spatial concept. Those features and patterns important to the context have to be stored and saved together with all of their associations. Archetypical patterns include lines, crossing points, angles, the end points of lines, contrast, and color. We construct the mental concept of an objective world using learned strategies of synthesis, which reveal our learned correctional processes or "constancy mechanisms." Hence, we generally do not perceive the altered visual experience of a color when we are wearing sunglasses.

Every stimulation has a rational and an emotional feature. We attribute emotional meaning to a combination of colors. We speak of aggression or of calming, of warm or cold colors, under- or overstimulation. Formal, three-dimensional constructs are also evaluated as being harmonious or unharmonious.

ASPECTS OF THE DESIGN PROCESS

Hugo Kükelhaus has said, "The relative point is the one in between." In addition to the repertoire of color design methods discussed above, it is also necessary to learn and consider a basic repertoire of architectural design methods. In order to effectively evaluate a spatial specification and its design quality, potential problems, design opportunities, and challenges, you have to know the "stuff" of which the spaces or rooms are made. A repertoire always consists of a number of elements and their laws of application. In comparison, a language consists of letters that form words, which can be joined to form sentences according to the rules of grammar.

Spatial design is a process, meaning a systematic construction of a design. "Design" is used generally for positive or negative volumes (interior space or architectural form). To design



Barcelona pavilion, floor plan
Ludwig Mies van der Rohe,
spatially organized form

is to implement a program, a task in a spatially organized form, or in a psychologically and physically perceivable form.

A design process must aim to apply the means of design – that is, a repertoire of problem-specific solutions to human life processes. The social relevance, the value of the design, is based on the interrelation between the user and the space. In this interaction, spatial perception and spatial experience trigger "behavior" in human beings.

WHAT DOES IT MEAN TO DESIGN?

To design is to realize an intellectual concept or idea. The Greek word "eidos" (the seeing, the beholding; appearance, form, beauty; idea, method, nature, essence), is very close to our word "image," in the sense of a "primal image" or "archetype." The idea, in the sense of the "internal image" of something, obviously needs an appropriate means of expression. During the planning stage, our ideas require means of spatial presentation that involve drawing, painting, and three-dimensional models.

If spatial design means designing the interrelation between people and space, then a distinction must be drawn between:

_ The formal aspects of the space (this affects color with regard to its aesthetic value as well as choice of color and material); and

_ The functional aspect of the space (here, color addresses educational, therapeutic, psychological, religious, and other factors).

Formal features define the space as it is, its architectural structure. Functional features define the space in relation to the task it is meant to fulfill, in other words, its performance and effect.

With architectural structural features we are dealing with objective, quantifiable factors. The performance and effect of a space, however, depend mainly on the user's subjective goals, personal experience, and expectations. This area of design is thus more difficult to plan and present objectively. The performance of a space can be described according to features of use, such as

_ Organization of processes

_ Assigning jobs and distances

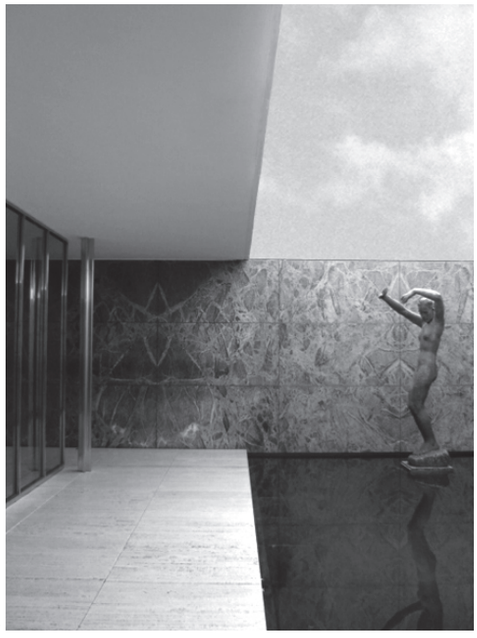
_ Conditions for lighting and exposure, acoustics, climate control, etc.

The effect of a space, the "perceptual space," the emotional aspects of its appearance, the environment, can be described by terms such as

_ Image

_ Identification potentiality

_ Originality



Barcelona pavilion, inner courtyard, psychologically and physically perceived form >

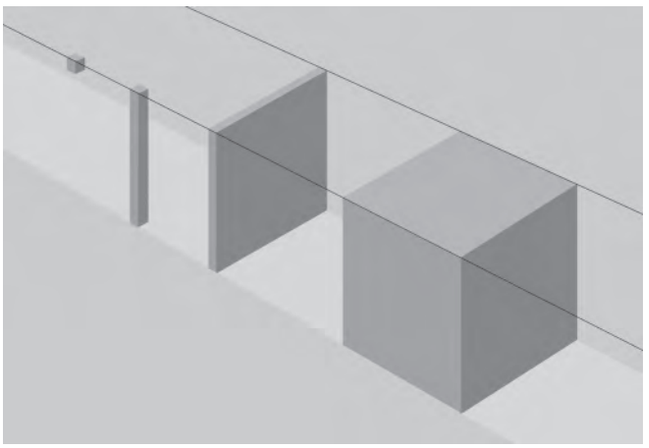
_ Symbolic value
_ Atmospheres, such as prestigious, comfortable, rustic, domestic, ceremonial, religious.

One danger is that the planning phase of the architectural form is rationally the easiest to achieve, while the "emotional value" of the space is often ignored, because here, planners would have to deal with the users' subjective opinions, social backgrounds, psychological sensations, and physiological structures. A brief, effective selection from the complex repertoire of the means of architectural design is as follows:

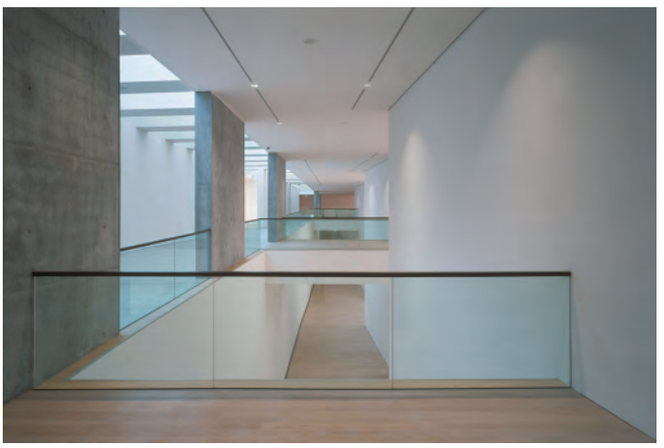
_ The properties of elements
_ The relationships of elements
_ The relationships between elements and the people who perceive them.

PROPERTIES OF ELEMENTS

The basic categories of dimensions that humans perceive are the point, line, surface, and body. A point, a line of points, a hole, a row of holes, or a group of holes can be used to accentuate or join surfaces. A "point for point" layout and arrangement of a space often deals with a "vertical exaggeration" of a space. An altar at the intersection of nave and transept and a baptismal font in a Christian baptistery serve to produce vertical exaggeration, dramatization, and mystification. They become symbols of authority. A line is geometrically the extension of a point in one direction. Some known linear elements are supports, columns, beams, girders, rafters, trusses, brickwork frames (pilaster strips), fireplaces, etc. These are all structural elements. Trellises, moldings, reveals, skirting boards, door and window frames, stucco work, traceries, or flutes are often associated with stylistic features of particular periods and are mostly used as decorative elements. In contemporary architecture, structural components are often developed decoratively and applied spatially. In his "Pedagogical Sketchbook" (1925) and teachings at the Bauhaus, Paul Klee introduced the difference between the active, medial, and passive line. The sections in his essays about "the active line between points" and the "medial line" correspond most closely to an architectural spatial context. The medial line describes format and surface plane, the line that describes the expanse between points. Passive lines produce planar impressions and surface textures. Geometrically, a surface plane is a field created by a crossing of lines. All spaces are created by surface planes. We experience these as walls, free elements in space, ceilings, floors, windowpanes, boards, hanging surface planes, mezzanines, platforms, and folding screens. The effectiveness of planar building components depends on their placement within the field of vision. According to Francis D. K. Ching, contours and design lines are the most



Properties of dimensions:
line, surface, form



Relationships between elements
Kunstmuseum Stuttgart, Architecture: Hascher and Jehle

striking identifying features of surface planes. The optical characteristic of a surface, its color and texture, affects its visual weight and the impression of stability. In architecture, surface planes delimit three-dimensional forms and spaces. The particularities of a spatial form are defined by the formal characteristics of surface planes (size, proportion, color, material, texture) as well as by their topological relationships to each other. Basically, three types of surface planes play a role in creating spaces – the floor, wall, and ceiling. The floor surface is the physical and visual base plane of architectural forms. It should be securing and grounding because it is seen as the fundament of human activity within a building. Form, color, texture, and pattern determine whether the floor appears as a securing, spatial border or as a backdrop for other spatial elements. Texture and hardness regulate sensations when walking on the floor surface. Wall surface planes are visually the most active of planar space-forming and space-containing surfaces. Interior walls define a space. Their optical characteristics – such as color, texture, and material –, their relationship to each other, as well as their size, distribution, and the openings in them, all determine the quality of the room or space and its relationship to other rooms. Wall surface planes can either blend "seamlessly" into floor or ceiling planes, or can be emphasized as a singular surface. They can stand alone or act as a neutral background for other spatial elements. Wall surfaces can be opaque or transparent, a point of focus or source of light. Material density contributes to the appearance of an interior wall's surface impression, and is illustrated by openings, windows, and doors. Walls can constrict or expand – they communicate notions of "private" or "public." We have physical contact with floors and walls. Ceilings, in contrast, are almost always experienced only visually, because of their distance from us. They are the umbrellas of architectural space. Ceilings can be either flat as an intermediate floor or shaped in line with a roof structure. They can also hang as free forms in the space. The form as spatial element has similar geometric dimensions in all directions and, optically, has a clearly legible volume. Physical elements can lean against linear or level plane elements, or stand free in the space. Furnishing a space mostly involves the physical elements in a room, but also structural elements such as stairs, elevators in halls, freestanding fireplaces, and other freestanding fixtures. The human being is the standard base scale for measuring the size, distance, and proportions of a space. Pierre von Meiss refers to the symbolic value of a human figure as a base scale: "Our body is the most important relative element in our subjective idea of the order of the universe […]. In comparison with it, we determine large or small, geometric and amorphous, hard and soft, narrow and wide, strong and weak, etc."

Relationships between elements and the viewer
Kunstmuseum Stuttgart,
Architecture: Hascher and Jehle

Medial lines in architecture
La Tourette, Le Corbusier

For this reason, the human figure has been used throughout history as a familiar proportional element for the assessment of space: Le Corbusier liked to use the Modulor, which he developed as a tool in his large buildings. In this context, two terms should be considered individually: absolute and relative scale.

_ Absolute scale is directly related to gauged units of measure such as the centimeter, meter, or inch. Familiar, ergonomic norms and standard scales such as those for tables, seats, windowsill heights, or door dimensions (often 76 x 200 cm or 88.5 x 200 cm) belong to the absolute scale category. We can make judgments and comparisons based on these "learned" scales if they are not distorted by perspective.

_ Relative scale is the opposite. There are distortions in scale and proportion for which no concrete solutions exist and which are difficult to relate to or evaluate in relation to space using mass, scale, length, width, or height.

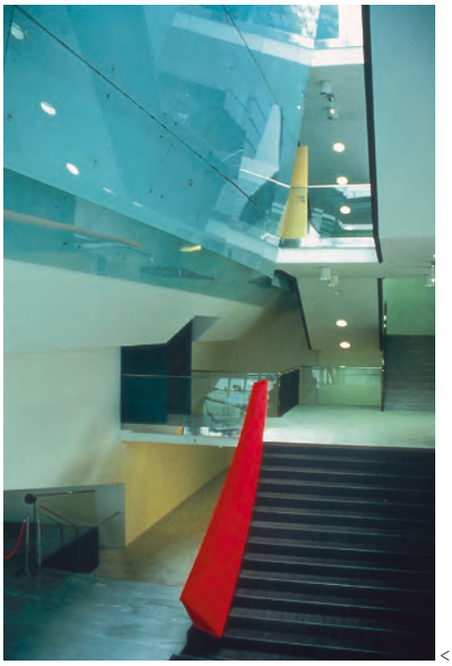
Independent of linear, level, or physical dimensions, there are other optical types of forms. First, there are the simple forms that we see as continuous. We record these holistically and in an unabbreviated manner:

_ Straight surfaces, boards, walls, windowpanes, supports, beams

_ Rounded or curved elements such as domes, barrel vaults, wave forms.

In contrast to this, we observe discontinuous forms such as framework and roof constructions, deviating and angled walls, and gothic vault ribs. These are interrupted and are often only perceived in sections. Both terms characterize mainly surfaces and linear structural components. Physical, structural components like cubes, spheres, cylinders, and pyramids are preset or regular and easy to define geometrically. They include simply designed furniture and fixtures. Irregular forms are difficult or impossible to define geometrically. These forms are common in organic architecture or the formal language of anthroposophic architecture and Art Deco. The work of architect Antonio Gaudí and sculptor Henry Moore provide good examples of this. Architecture often seeks equilibrium and balanced suspense. Yet the axial symmetry of the past is no longer the aesthetic ideal. Art of the 20th and 21st centuries has expanded our vision and we are now used to seeing even delicate explorations of different emphases and elemental characters as balanced. In addition to László Moholy-Nagy's concept of material structure, we also speak of structure in connection with architecture and space. It involves the following, different principles:

Interplay of lines, surfaces, and forms
La Tourette, Le Corbusier



Interplay of lines, surfaces, and forms
Opera House, St. Pölten
Architecture: Kada

_ Structural principles of how the components are joined
_ Static principles of the flow of forces
_ Physical structure of the shell, and of heat flow
_ Historical and stylistic principles of a certain age
_ Aesthetic criteria of a proportional relationship, for example, the golden section, Le Corbusier's Modulor, or the Japanese ken (the standard scale of the tatami floor mat).

RELATIONSHIPS BETWEEN ELEMENTS

Relationships between architectural elements are topological, positional relationships in space. As a rule, this concept involves the question of qualitatively describable positional relationships such as arrangement, penetration, and enclosure.

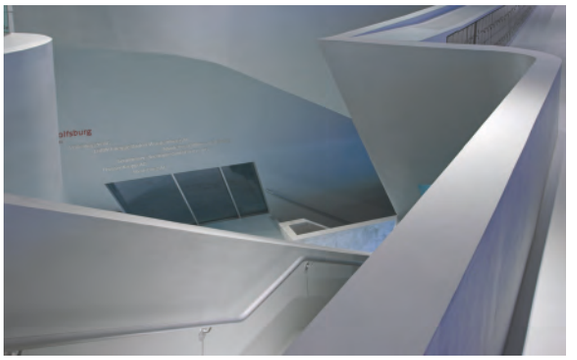
_ Arrangement is the simple addition of elements in loose relationships, such as next to each other, under or above, neighboring, lying nearby, group formations, piling, lining up, heaping. Loose relationships can continue until they meet an edge or a surface.
_ Penetration means interlocking, melting, connecting, overlapping, so that volumes pervade each other.
_ Enclosure means being contained in, being an element of, being surrounded by. These metrical relationships are qualitatively describable, positional relationships, which can be evaluated according to their dimensions, distances, angles, and radiuses. Relationships between elements in a space are determined by their positions within the visual field. This factor alone creates hierarchies within the spatial composition. Yet hierarchies, as Pierre von Meiss explains, are also formed by elements of equal value, by axial symmetries, by the value of dominance, subdominance, and accents of an element, and can be seen in the context of all spatially enclosing elements.

RELATIONSHIPS BETWEEN ELEMENTS AND THE VIEWER

People relate to the meaning of architectural elements in space according to their own spatial experience and, thus, the absolute or relative mass of these elements in relation to other surfaces in space and to the quality of mental concepts.

We perceive planes, lines, and forms in concrete dimensions frontally. We perceive walls, boards, sliding screens, and rows of columns "laterally," as structural components that guide or separate. They have relative proportions and dimensions, as in the two following positional relationships. We perceive floor surfaces, platforms, steps, sunken floors, stages, and mezzanines as "underlying." We see ceilings, canopies, arbors, balconies and galleries, ceilings, suspended ceilings, and roofs as

Continuous sequence of forms
Swiss pavilion, Expo 2000
Architecture: Peter Zumthor



above:
Discontinuous sequence of forms
Phaeno Science Center, Wolfsburg
Architecture: Zaha Hadid

below:
Regular and irregular forms
DZ-Bank, Berlin
Architecture:
Frank O. Gehry

"overlying." However, these relative dimensional relationships in the visual field are not structurally fixed; their meaning depends rather on the viewer's changing location and changing visual focus. The speed of perception, in other words, the recording of information per unit of time, determines the viewer's subjective interpretation.

Spatial experience is thus assembled like a news report; it is recorded visually and kinesthetically.

Wolfgang Meisenheimer once said, "A path is a series of places to be viewed in succession. Stations of different qualities of experience are arranged in a line and mark stations of different activity. Pathways can be defined by the floors, walls, or the ceilings."

Architectural space is a space of behavior, and its spatial model involves location, path, field, zone, area, and border.

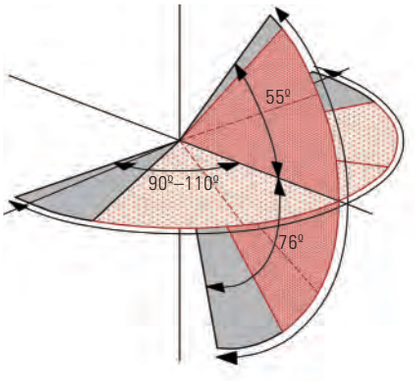
Developmental psychology points out that the ability to perceive space is developed in three stages:

_ A child's topological experience in spatial contact to the main parent
_ Projective recognition of spatial depth, foreground, and background
_ Euclidean recognition, which is geometrically characterized as right angles, parallels, and radiuses.

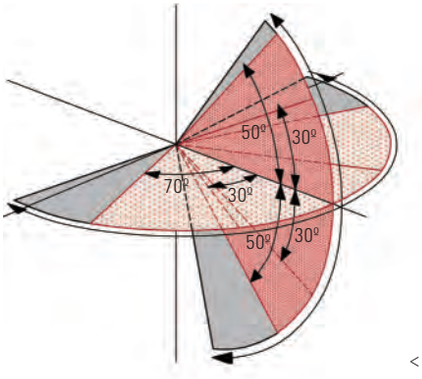
Meisenheimer is of the opinion that people seek simple Euclidean basic patterns, symmetrical axes, and central points. Even the relationship to discontinuous and irregular elements, with rounded, curved, or free forms, can be "understood" as aesthetically exciting, and a deviation only in the context of regular systems of order.

Hence, the line of vision becomes the composition principle of the architectural "musical score."

Spatial perception is similar to color perception in that both are subjective processes. With spatial vision, the two eyes form the visual field of the "spatial object." When standing still and looking straight ahead, the eyes can register horizontally an angle of 180 to 200°; vertically above, an angle of about 55°, and vertically below, one of about 76°. However, the center of focus is reduced to one central point and increasingly diminishes towards the periphery of a fixed field. The more we focus on a point, the more focused our vision. Yet it is important to consider that our color sight takes place in a much smaller space of perception, and that in the peripheral areas our sight is always moving between perception of light/dark sensations and color vision. This can be an important aspect when positioning color spatially (for example, in a hospital ward where there is restricted spatial experience).



< Field of vision: light/dark



< Field of vision: color

9
COMMUNICATION: PEOPLE – COLOR – SPACE

INTERDISCIPLINARY ASPECTS

Space, both material and immaterial, is a fundamental basis for human existence, development, and evolution; space comprises the outer shell within which life takes place in all its variation. People are directly and inseparably connected to the space that surrounds them. "Lived space," a term coined by philosopher and educator O. F. Bollnow, refers to the close connection between people and the spatial environment. The human life cycle, from its beginning in the womb through to death, unfolds in a wide variety of spatial environments and is subject to specific conditions, is in relation to them, and in exchange with them – that is, as part of a mutual relationship between people and their social and material-spatial surroundings. The characteristics of space are among the conditions of life that affect the course of human development, the quality of life, and the human condition in the different phases and spheres of life. The creative statement, symbolic effect, and impression made by an architectural space determine how people feel within it, to what extent the space appeals to them, and how they identify with it. It also affects how they appropriate it, behave toward and within it, and how they act individually and socially. Space is always an immaterial and intellectual space as well. It encompasses the atmospheric, experience-related dimension and the social and communicative dimension of interpersonal encounters and relationships. A variety of scientific disciplines have focused on the significance of space with regard to its effect on people.

O. F. Bollnow believes that people by their very nature are determined by the space surrounding them, and that their nature changes according to the character of these surroundings. "Experienced and lived space" can both facilitate and impede people's relationship to life. An important aspect of "lived space" is the atmosphere and the quality of the impression that emanate from it, both of which affect the psychological relationship between people and their surroundings. By virtue of its design, a space can, for example, appear cool, distanced, austere, festive, or cheerful. These kinds of moods and impressions appeal to the emotions. They convey messages that impact people's feelings, thoughts, desires, behavior and actions within a certain space.

Although people are influenced by spaces and the quality of moods emanating from them, it is important to realize that this is not about a simple transfer of moods. Indeed, it must always be kept in mind that people also react subjectively, and vary in how receptive they are to spatial environments. Although atmospheres are closely linked to forms, materials, light, and colors, the possibility and intensity of the influence these exert also depend on people and their personal mood in the "here and now."

Hugo Kükelhaus studied the psychosomatic aspects of spatial experience. He asserted that the corporeality of a person means he or she depends on a world that is a built, designed, and shaped down to the very last detail. According to Kükelhaus, people need the biological fields of tension, elements of contrast, and stimulation provided by variety. Kükelhaus believes the absence of such fields of tension produces dysregulation triggered by understimulation, such as brightness without shadows (absence of differences in luminance), lack of variations in temperature, and surfaces without any structure, etc. Restricted movement and monotone materials or colors can also cause dysregulation.

"Not taking advantage of the potential of our organs, switching them off, or suppressing them is what exhausts us … Strength is gained through development, development and

critical interaction with a world that challenges me in my entirety, and through the existence of the world" (Kükelhaus). According to Sune Lindstrom (quoted in Hesselgren 1987), all architecture provokes a spontaneous emotional reaction that is important to us. Psychosomatic studies have shown that the mind and body affect each other reciprocally, meaning that physical illness can be psychological in origin and vice versa. Emotions influence the body: stress can cause headaches, fear can increase the pulse rate, and anger can upset the stomach. High blood pressure is one example of psychosomatic illnesses that can be caused by psychological factors.

Psychoneuroimmunology assumes that emotions can even influence our immune systems. Biochemists and immunologists have discovered networks of nerve fibers and molecular "bridges" that maintain a constant connection between the body and the mind. It is becoming increasingly clear that emotions exert an influence that often extends to the very last cell of our organism and thus strengthens or weakens our bodily defenses. Neurobiologist David Felten points out that the interaction between mind and body "[starts] at the very moment we begin to perceive sensory stimuli."

From a psychotherapeutic point of view, architectural space may have significance as a therapeutic framework. This means that architectural space and furnishings are regarded as important factors that support the therapeutic process, the rebuilding of self-acceptance and self-esteem, as well as social relationships.

Bruno Bettelheim describes the development of milieu-therapy in a psychiatric clinic for children and adolescents. He states that one of the most significant experiences from his psychiatric work is related to the fact that every person needs "free space" *(Freiraum)* to which they can retire and "scope" (*Spielraum*, literally: "playing room" in the sense of "leeway") to make their own decisions.

In the field of medicine, special importance is attached to the influences of environmental design on people and, in particular, on the development and health of children. There is no doubt that the individual and constitutional moments that play a role in the genesis of autonomic and psychological disorders are first sparked by the environment. Accordingly, environmental design is regarded as the primary means of preventing these disorders. From a socio-ecological point of view, architectural space is a fundamental principle of socialization and relates to human dignity; space must be designed to allow emotional occupation and appropriation.

A key role in the relationship between people and architectural space is played by the following related components, which should also always be considered in the broadest sense when developing color designs for architectural space:

_ Quality of impression
_ Invitational character
_ Conciseness
_ Appropriation.

Quality of impression refers to the psychological relationship people have with architectural space, to their psychological, emotional experience of space. The impressions our environment makes are a source of profound psychological forces; they exert a lasting influence on our physical and psychological well-being.

Invitational character describes how the energy and quality of a space directly affect an individual's acceptance or rejection of it. Invitational character also signalizes certain possi-

bilities for action. A user's cognitive evaluation of a particular space will mean this character facilitates or impedes actions.

Conciseness is an important factor in functional color design; it describes how clearly an architectural expression mirrors a space's functional significance. Concise design illustrates the functional goals and intentions of an architectural space in a clear, specific, and characteristic manner.

Appropriation, according to environmental psychology, is a mechanism that encompasses all possible courses of action that serve to adopt or take possession of a space. Appropriation refers to the act of identifying with a space because it addresses certain personal needs; the individual can relate to a space when it provides for his or her personal needs. There are many different forms of appropriation. They range from the attempts of newborns to comprehend their surroundings and explore them through their senses, to people's efforts to personalize their spatial environment in order to identify with it and feel comfortable. Appropriation is not only a personal act; it is also socio-communicative. Groups, such as school classes, can appropriate a shared room by participating in its design, thus making the space their own.

With a few exceptions, personal space can most easily and best be attained in private spaces such as houses or apartments. This is where appropriation can be manifested best, provided the spaces correspond to the true needs of the user.

Modern people generally spend more than 80 percent of their time in closed spaces. Developing an awareness of how important it is to live under the best conditions in these surroundings is the primary goal of effective design practice. For the development of color concepts, this means:

_ Holistic thinking and analysis with regard to people–color–architectural space
_ Sound knowledge of scientific research on the topic of "color"; willingness to consider peripheral areas of research in this field; remaining open to empirical findings
_ Combining these with intuition, creativity, a sense of aesthetics, and professional know-how.

Hesselgren summarizes the requirements for a positive relationship between people and architectural space as:

_ The emotions that perceiving a space triggers must be positive.
_ Architectural space must fulfill particular formal and aesthetic requirements to be experienced as beautiful and interesting.
_ Architectural expression must be experienced as true from an ethical standpoint.
_ A space must provide satisfaction in terms of functionality.

HUMAN NEEDS RELEVANT TO DESIGN

In addition to satisfying their physiological needs, such as light, air, food, sleep, and sexuality, people have additional basic needs that are of interest with regard to interior design. One of the most fundamental of these is related to experiencing one's own existence, the experience of "I am." Through the sense of touch, of contact, people learn how to distinguish between their bodies and the outside world and, in doing so, experience themselves. This experience is also supported by the boundaries, objects, and materials of architectural space. Another human need is that of orientation: in one's surroundings as well as in planning and shaping one's own life. Architectural design that is geared to people can thus communicate meaning and build values. The need for orientation also

includes the need for control, which means being able to cope with situations and achieve goals. The desire for control is related to the desire for room, for leeway, to carry out one's actions. The designed environment can create an important framework that helps people cope with their situation. Understanding something is "a first, important step along the path to control" (Wolfram Kurz).

According to Lenelies Kruse, the need for control can be seen, in particular, in control over

_ The flow of information
_ Stimulation through environmental stimuli (sensory perceptions)
_ Social interactions.

Another basic human requirement is the need to communicate. This encompasses the need for social bonding and a connection to the objects in one's surroundings, as well as the need for identity. Identity develops from our fundamental, early childhood experience of security, confidence, and trust, followed by an upbringing that supports initiative, activity, and autonomous behavior and actions combined with appreciation. Extreme experiences and changes can unsettle an individual's sense of identity, but can be countered by outside support and one's own actions.

It is important to design spaces that convey a sense of trust and whose expression can be understood – spaces that encourage people to engage with objects and that are open to and provide room for social relationships.

The complete system of our senses plays a major role in the process of the human-environment relationship. Psychology regards the following types of needs as effective:

_ The need for impressions: allowing oneself to be impressed by one's environment
_ The need for expression: being able to express oneself
_ The need for exploration: exploring and understanding one's surroundings.

In addition, people inherently seek harmony and beauty.

Below is a catalog of needs and requirements related to spatial environment:

Activation	Calm	Beauty	Affection
Challenge	Contact	Boundaries	Atmosphere
Closeness	Encouragement	Concentration	Attentiveness
Communication	Environmental compatibility	Exchange	Being accepted
Consolation	Feeling at home	Fostering a sense of identity	Clarity
Control	Finding a balance between the real and virtual worlds	Freedom	Creativity
Coziness	Hygiene	Freedom to develop	Dynamism
Debate and discussion	Independence	Incentives	Friendliness
Genuineness	Leeway	Nature	Harmony
Joie de vivre	Light	Pre-order	Openness
Order	Naturalness	Privacy	Participation
Relaxation	Orientation	Quality of material	Protection
Rituals	Respect	Recognition	Respect
Safety	Self-determination	Spirituality	Structure
Self-realization	Self-esteem	Stability	Thirst for conquest
Variety	Stimulus	Tenderness	Tolerance
Warmth	Well-being	Touch	Vitality

near

far

narrow

wide

high

low

Color effects in architectural space

ASPECTS OF COLOR PERCEPTION IN ARCHITECTURAL SPACE

The physical-optical fundamentals described above result in a principle of perspectival color perceptions in architectural space:

- Warm, highly saturated, and bright colors (orange, ocher, sand yellow) advance to the foreground.
- Colors that are neither clearly cold nor warm (green, violet, purple) are located in intermediate ground.
- Cool and bright colors (light blue, lime green), as well as dark, warm and dark, cool colors (dark brown, dark blue) recede into the background.

The relationship between figure and ground is critical to using color to create the illusion of space. For example, black can be placed in front of white if black is functioning as the figure rather than the ground. Otherwise, white is placed in front of gray, and gray in front of black, although surface proportion also plays a role.

Colors can be employed to create meaning based on the rules of color perspective. They can generally be used to influence the effect of room proportions, such as wide, narrow, high, low. Here, the synesthetic (intermodal) quality of experience (light or heavy in terms of weight) plays a role. Bright colors are experienced as being light in weight, and dark colors are experienced as heavy.

Concerning hues of equal brightness:

- Passive colors (e.g. green, green-blue) seem lighter in weight, and
- Active colors (e.g. red) seem heavier.

Within a range of colors, brighter shades appear lighter than saturated ones (pink seems light in weight, whereas red seems heavy). However, the effect of heavy or light in weight in architectural space is clearer if we compare wall and ceiling colors. Light blue on a ceiling, does not in itself appear light in weight if it is next to a white wall; but it would appear light in weight in relation to a sand-colored or dark wooden wall. The spatial effects of intense, saturated colors are only infrequently employed in interior design. In the reality of architecture and interior spaces, it is the more muted shades that are used (lightening and darkening). We should point out that the effects of colors in architectural space, on the floor, wall, and ceiling, always depend on the brightness and saturation of a color.

Every color is qualified through its nuance and the material with which it is associated. The following table lists basic feelings elicited by color effects in architectural space, summarized from many decades of experience in teaching interior design and educating color designers. Of course, feelings deviating from these that are based on individual experiences are also possible.

	Floor	Wall	Ceiling
	Sandy, light	Warming, expanding	Light, closing
	Not resonant, motorically arousing	Arousing to irritating	Shining
	Resonant, earthy, sure-footed	Oppressive, restrictive	Burdensome
	Powdery, light, soft	Warming, stimulating	Light, closing
	Arousing to irritating, provocative, garish	Shining, warming to heated, aggressive	Exciting, irritating
	Supportive, secure, familiar	Stifling, restrictive	Enclosing, oppressive to burdensome
	Foreign, delicate, charming	Delicately scented, flowery	Oppressive, warm
	Festive, majestic	Dominant	Obscuring, burdensome
	Noble, enhancing, valuable	Decisive	Bombastic, interventional
	Bottomless, charming	Fragrant, flowery	Delicate, scented
	Valuable, majestic	Mystical, artificial	Mysterious
	Luxurious	Magical, mysterious	Reserved
	Floating, icy	Cool, retreating, calming	Sky-like, cool to airy
	Retreating, watery	Cold, foreign, distanced	Heavy, cramped
	Deepening, bottomless	Claustrophobic, distanced	Cooling, burdensome, powerful
	Floating	Expanding	Neutral, closing
	Natural, safe	Circumscribing	Closing, oppressive
	Sure-footed, solid	Decisive	Oppressive
	Bottomless, foreign, empty	Neutral, free	Open, wide, light
	Deepening, abstract	Restrictive	Oppressive, burdensome
	Sure-footed, neutral, solid	Claustrophobic, massive	Covering, oppressive

10
THE PRACTICE OF COLOR DESIGN

Color design of spatial elements, the relationship and interplay of colors and space, is extremely important. Color design is not an end in itself; it only fulfills its purpose when all elements of interior design harmonize and complement one another. Color design requires a professional and qualified analysis of the effects of colors in a spatial context, taking into account physiological, ergonomic, psychological, functional, and aesthetic demands. The colorful appearance of spaces where people work and spend time is a decisive, holistic influence. As a result, the spatial environment needs to be systematically analyzed and planned. Architectural spaces, perceived and experienced in their entirety, have to meet the requirements of color design. This is the only way to achieve a design that is tailored to people's needs. An environment that conveys information about spatial function, provides space for individuals, and contributes to the quality of life enhances our well-being, behavior, and actions.

This is true for all areas of interior design, in:

_ Educational institutions
_ Sports and recreational facilities
_ Workplaces
_ Healthcare
_ Retirement homes
_ Restaurants
_ Private homes
_ Areas that are not dealt with here, such as cultural and religious institutions.

These areas have highly diverse color design requirements due to their wide range of specific functions and uses, as well as different interior and exterior conditions. Consequently, there are no dogmas or simple rules and recipes for these environments. Nevertheless, we can identify fundamental aspects for developing color designs that form the basis for a more detailed discussion.

ASPECTS OF INTERIOR ARCHITECTURAL COLOR DESIGN

In order for color to be used effectively, i.e. to serve the needs of people, the architectural space, its function, and its elements, the following interrelated aspects are of key importance:

_ Relationship of people to color
  _ physiological requirements
  _ psychological requirements
_ Relationship of color to building and spatial function
_ Relationship of color to space and its elements
_ Orientation
_ Environmentally friendly materials and paints that are also safe for human health
_ Aesthetic qualities.

Relationship of People to Color

Design focuses on people. Thus, the most important aspect of design revolves around our sense of harmony and space. Although individual solutions can be found to meet personal needs in private living areas such as homes or apartments, the design of public buildings and spaces has to serve the needs of heterogeneous groups of users and residents. As part of the design process, a target group analysis is used to identify common environmental requirements that form the basis for the design.

The design plan should create the best possible and least visually intrusive conditions for each individual. This requires an objective examination of users' needs and the views of decision-makers. It also requires dialog and a readiness to com-

municate and cooperate. When creating solutions to design problems, consultants and designers have to avoid subjective ideas about color. During the planning process, specification and acceptance profiles help to verify and assess color designs, and can be used to evaluate the design of standardized spaces for large-scale projects.
A conscientious color design, i.e. one that includes material and light design, must meet the following requirements:

Physiological Requirements
In addition to the use of safe materials, physiological requirements focus primarily on the physiology of sight and visual ergonomics, with the aim of reducing the impact on the eyes and the organism. Light conditions and color schemes should avoid causing visual disturbances, difficulties concentrating, or fatigue. These symptoms can be the result of glare, reflections, low-contrast situations, harsh light and dark contrasts, intensive color stimuli covering a large area, or irritating patterns in a direct line of vision. Extensive exposure to such conditions can lead to severe visual fatigue. Lighting plays a key role in color design. The following criteria are essential:
_ Protection from disturbing brightness, reflective glare, and direct glare
_ Adequate lighting, keeping in mind that a person's lighting requirements increase with age
_ Balanced distribution of luminous density
_ Natural shading
_ Suitable illuminant chromaticity
_ High color rendering.

Psychological Requirements
Physiological requirements are closely related to psychological ones, and concern the mental effects of the color environment, symbolic messages, associations, impressions, and the overall atmospheric effect. The impact of visual surfaces has a decisive effect on each individual's personal level of acceptance. The interplay of color and spatial organization has a subjective effect on our well-being.

In addition to personal likes and dislikes, our ability to perceive colors and color combinations in spaces as pleasant or unpleasant, and judge them as positive or negative, depends on the following basic, interrelated factors:
_ Degree of chroma and contrasts
_ Color proportions
_ Relative amount of surface to color, and form to color
_ Location of colored surfaces within a space.

It is important to take into consideration the amount of color stimuli (degree of colorfulness) and stimuli variations (contrasts) that are beneficial to the individual. Alternating impressions from our surroundings correspond to our natural perceptions and rhythm of life. It is crucial that we respect this fact when designing spaces in order to avoid subjecting people to a monotonous environment that can unbalance and overstress them. Monotony and understimulation (sensory deprivation), for example, through shadowless brightness, a lack of difference in luminous density, textureless surfaces, and dull color schemes can also lead to health problems, just as an excess of environmental stimuli (overstimulation) can create potentially dangerous stress levels. Thus, the objective of effective color design is to find the right combination of balance, diversity, and stimulation to avoid creating a stressful environment and integrate these elements into a visual arrangement. Subtle stimulation through color is a basic means of counteracting under- and overstimulation. Color families (commonalities) and color contrasts (differences) play an important role in this

context. Contrasts convey corporeal forms and are a key factor for experiencing a space and orienting ourselves within it. A monotonous, simplistic color scheme has a disorienting effect and conveys no clear spatial identity.

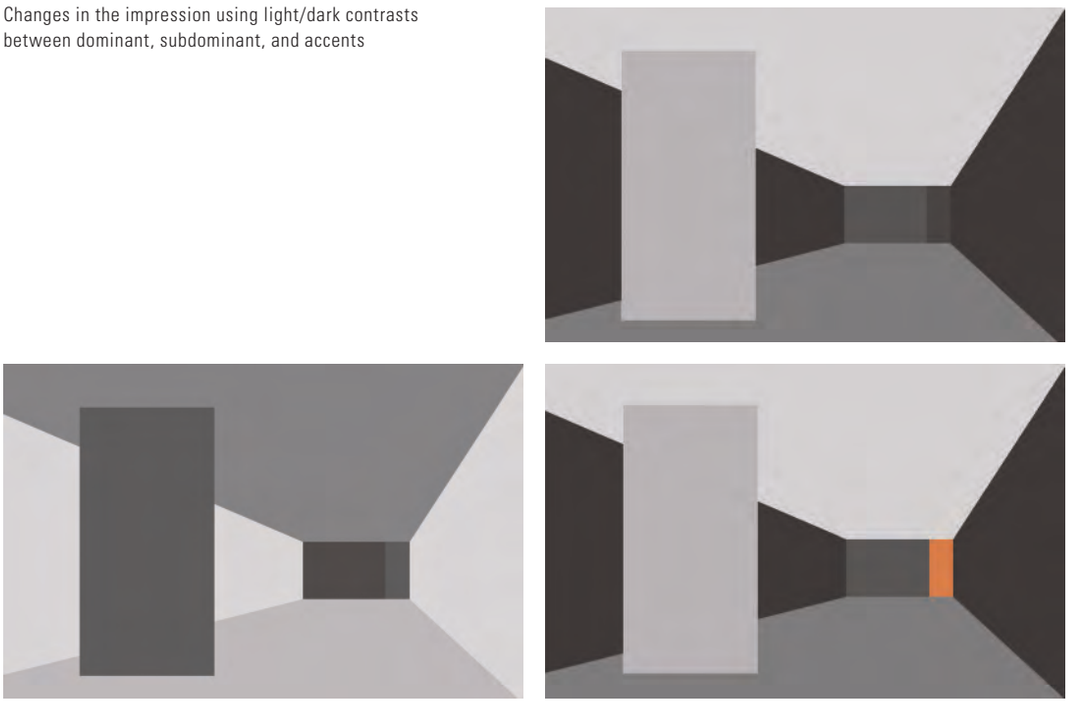
The main means of achieving contrasts are through

_ Differences in color tones (contrasts in chroma)
_ Differences in saturation (contrasts in color intensity)
_ Differences in brightness (contrasts in degree of luminosity).

In interior design, color combinations are usually effective with a number of different types of contrasts. Attention should also be paid to color proportions, since the size of the surfaces and the relative amounts of color in a space are important. Identical color combinations used in various proportions produce different spatial effects and impressions. We differentiate between dominant, subdominant and accentuating colored surfaces. The dominant colored surface (predominant color in terms of sheer quantity) establishes the basic spatial atmosphere. Dominant colored surfaces should not overstress the eye, and color schemes should have only a moderate proportion of bright hues and tones. The subdominant color is the aesthetic complementary color. It harmonizes with the dominant color and serves as a contrast. Color accents clearly contrast with the dominant and subdominant colored areas and accents. It is important to use saturated color accents only in small proportions. Accents attract attention, trigger reactions, and inspire people. They are ideal for highlighting spatial elements, especially accessories.

For a balanced color design, it is also important to give equal attention to the proportions of area and color as well as form and color. The larger the surface area and the more varied the form, the more subtle the color statement should be. Ultimately, the color schemes of spaces where people spend large amounts of time should be unobtrusive yet expressive enough to accommodate the personal design preferences, imagination, creativity, and freedom of each individual user. Instead of overpowering us, colors should serve our needs. We should find them stimulating, not annoying. There are no disadvantages, however, to selecting intense, extremely bright color stimuli for large spaces that are used for only relatively short periods of time.

Changes in the impression using light/dark contrasts between dominant, subdominant, and accents



The location of colored surfaces and their surface qualities should also be taken into account. Colors produce different effects according to their position (on floors, walls, ceilings). We perceive and evaluate the color of flooring based on our natural experience of the floor. However, the floor's material properties have a greater impact on this perception than the color itself. In general, it is recommended that architects and designers select flooring that is neither as light as nor significantly lighter than the surrounding walls, as this can make people feel ill at ease.

Walls are particularly important for our perception. They can feel cramped or open, warm or cold, depending on the color scheme and material characteristics. Nuances of warm colors have a close effect, while nuances of cold colors have a distant effect.

Depending on the hue and nuance, ceilings can feel light, heavy, or even oppressive. Ceilings always have a lighter effect when they are painted lighter than the wall color. Ceilings that are darker than the surrounding walls appear lower.

These observations on the brightness and nuances of color selection demonstrate the instruments that can be used to influence spatial proportions. Color schemes should reflect the relative degrees of brightness that people experience in nature; the color of the ceiling should tend to be lighter, and the color for the floor should tend to be darker than the wall color. Taking into account physiological and psychological requirements, it should be noted that, in most cases, nuances of warm and cold colors are ideal for spatial applications. This stimulates and has a positive effect on the autonomic nervous system. Adhering to these recommendations will generally produce interior designs that meet people's psychological needs. However, there are a number of spatial functions and design objectives that deviate from these principles.

Relationship of Color to Building and Spatial Function

One of the main objectives of effective design is to create a suitable framework for specific functions. The overall design of a building and its spaces should reflect a clear purpose. Based on their symbolic meaning and associative effect, colors are able to symbolize functions, thereby giving each building and space utilization an appropriate purpose-oriented at-

< Balanced, low-key color schemes are beneficial for spaces where people spend long periods. Panama Werbeagentur, Stuttgart

< Highly saturated color stimulation and intense contrasts are only recommended for spaces where people spend short periods. Panama Werbeagentur, Stuttgart

mosphere that corresponds to the users and activities that (should) take place in a given space. According to J. Pankoke, color symbolism essentially uses colors to transfer subconscious messages by linking impressions and associations with our intuitive conceptions of color. On this level, it is possible to establish relationships between users, their activities, and the architectural space. Color links these factors, thereby establishing an identity. It affects our body and mind deeply, influences our well-being and "psychological comfort." Color atmospheres send signals that direct our actions.

Color can thus be classified with the otherwise primarily physical factors of spatial surroundings (such as temperature, ventilation, humidity, air quality, light, noise), which are modified to enhance our comfort. We can define comfort as the state of equilibrium that is achieved when the combination of these factors matches the physiological and psychological needs that govern our well-being.

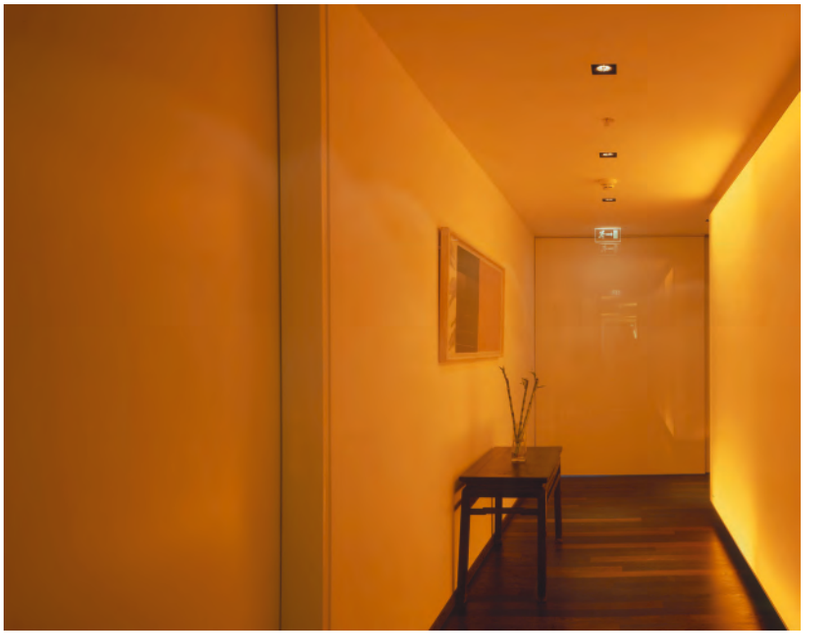
Different design areas (for example, private homes and residential apartments, hotels, educational institutions, workplaces, retirement homes, hospitals) have their own specific functions. It thus stands to reason that they have diverse requirements regarding the design of the color environment.

Color can also help connect people with their surroundings. Whenever exterior conditions become stressful and hectic, taking refuge in a deliberately low-key color environment can enhance a sense of inner calm. In surroundings that tend to be monotonous, effectively situated contrasting dashes of color can create inspiring impressions.

In addition to respecting uniform architectural conventions, designers of buildings with a variety of spatial functions are recommended to use colors to differentiate diverse areas, while maintaining an awareness of the color dynamics that are beneficial to the human organism. This produces a spatial ensemble that is generally more stimulating and exciting. The experiential dimension of the human-space relationship is a crucial aspect that should not be overlooked. Mere functionalism alone is inhuman. It diminishes the human race as a whole.

Relationship of Color to Space and Its Elements

Color is an ideal means of visually differentiating or linking architectural and spatial elements. Viewers find it easier to comprehend the different functions of spatial elements and furnishings when they are color-coded. Thus, colors improve our orientation. By using color to link groups of structural compo-



Summary color design of different spatial elements
Intelligent House Solutions, Berlin

nents, spatial elements, and furnishings made of the same materials or performing the same function, color becomes an element of organization, and consequently enhances the "readability" of spaces. This is particularly important in complex facilities. Different hues and nuances can be used to establish visual priorities and structures, differentiate between important and unimportant elements, attract people's attention, and guide them.

In the interest of this type of diverse approach to design, one that also conveys different experiential qualities, it is important when selecting surface treatments to retain the "living" structure and texture of the materials and material colors. This is true of all natural materials. Opaque surface treatments alter the character, statement, and impact of materials.

Orientation

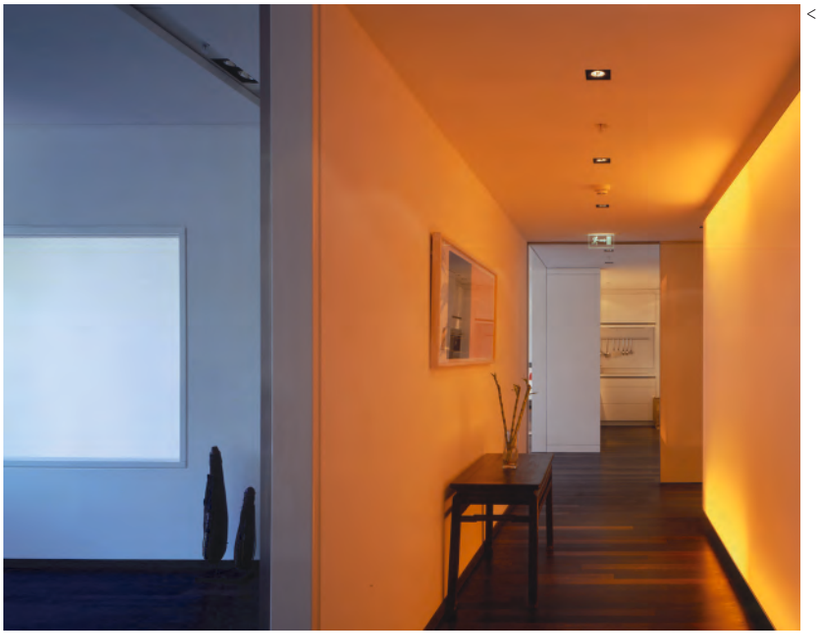
Orientation plays a key role when we have to navigate through large architectural complexes and clearly differentiate between areas with various spatial functions. We depend on visual orientation and guidance systems that correctly, accurately and clearly identify all paths, places, and "addresses." At the same time, diverse design elements of spatial areas allow us to recognize separate functions. Visual aids that use colors help us quickly and easily orient ourselves in buildings and spaces.

Environmentally Friendly and Safe Materials and Colors

When selecting materials and colors, it is important to ensure that they are safe for people and the environment. In buildings and their interior designs we should strive to use materials that have a positive effect on the spatial surroundings and enhance people's well-being. The use of safe materials should now be standard practice, as should environmentally friendly and safe pigments, coatings, thinners, and binding agents.

Aesthetic Quality

Interior design should aim to achieve a holistic aesthetic. This is created through atmospheric, informational, functional, and aesthetic qualities; through a logical and balanced interplay of forms, materials, structures, light, and colors. Furthermore, the interaction of color elements is essential to a balanced and aesthetic color design. Color relationships, contrasts, and proportions are aspects that need to be considered. They should produce a holistic relationship structure that corresponds to the purpose of the design. The idea is to



Color-based differentiation makes for good orientation.

create conscientious color harmony, not random and arbitrary colorfulness.

In order for a building and its interior spaces to maintain a holistic character despite design diversity, building specifications are recommended that serve to link different aspects and functional areas in both interior and exterior spatial areas.

Aesthetically balanced and effective color designs are timeless. They do not depend on trends. The aesthetic quality of color design is also an identity and image factor in all areas of architectural and interior architectural design.

Ideally, architectural color design should be perceived in conjunction with other design components. It should appeal to people in all three dimensions of our existence. Color design should stimulate, delight, and inspire us.

SPACE AS A STIMULATING ENVIRONMENT

Spaces that enhance our well-being, and stimulate and heighten our senses, require a subtle and balanced stimulation of every aspect of our sensory organization. The following factors relating to each individual sense should be taken into consideration for all design discussions and decisions:

To stimulate the sense of touch, there is a wide range of materials available with diverse surface structures, including forms that provide tactile stimulation and floorings that convey an impression of stability.

The sense of life/comfort is positively stimulated by light sources, materials, and color selections with an energizing effect, by an atmosphere that conveys physiological and psychological comfort, and by environmentally friendly and safe materials.

The kinesthetic sense is enhanced by color dynamics and contrasts in spaces and spatial contexts. This is also true of flexible furnishings and furniture arrangements that promote movement and social dynamics.

The sense of balance requires visually well-balanced arrangements and a state of equilibrium between diverse, stimulating impressions, effective orientation, and spatial dimensioning on a human scale.

The sense of smell prefers natural materials with a pleasant scent, or unscented materials.

The sense of taste is stimulated by high-quality materials, holistic and aesthetic compositions that meet user needs and functional requirements, as well as by the authenticity and appropriateness of the design solution.

Positive stimulation of the sense of sight requires taking into account all physiological, psychological, ergonomic, and aesthetic aspects. Designers need to include effective quantities of light and color, appealing amounts of colorfulness, contrasts, and color proportions, a positive atmospheric statement, and finely tuned nuances.

Heat perception requires that the physical atmosphere of a space create a need-oriented, variable balance between "warm" and "cold" elements (material, light, color) in order to convey:

_ Safety, trust, warmth, and security
_ Peace, relaxation, concentration
_ Contact, communication, and/or
_ Intensity, dynamics etc.

(The "temperature" of a space is determined by spatial function and user requirements.)

The sense of hearing requires positive acoustic conditions through materials, appropriate proportions, and the establishment of relationships that harmonize with design elements to create a total effect.

The sense of speech is served by a clearly interpretable and coherent synthesis and conciseness in design expression (message conciseness).

The sense of thought seeks to convey "authentic" messages concerning the design intentions and objectives by renouncing "dream worlds" and "illusions."

The sense of ego is enhanced by an atmosphere of familiarity, by allowing the viewer to identify with his spatial surroundings, by an "open" atmosphere, and a communicative and supportive environment.

METHODOLOGY

We develop color concepts for the design of buildings and spaces in a series of stages. These include the following steps:

Initial assessment

_ Review of planning documents
_ Inclusion of previous decisions
_ Analysis of current situation
_ Summary/conclusion: objectives

Analyses

_ Functional analysis (project function)
_ Target group analysis (users)
_ Situation/location analysis
_ Building analysis – exterior
_ Building analysis – interior

The analyses can be conducted using various semantic, differential rating scales.

Exposé

Assessment/assessment study (if required by the customer)

Preliminary design

_ Development of a material and color plan
_ Material and color collages and spatial representations
_ Presentation of the preliminary design
_ Extra step: design of standardized spaces
_ Acceptance analysis (semantic differential)

Design

_ Material and color planning based on the preliminary design
_ Detailed sketches, models, material and color collages
_ Design presentation

Floor plan & materials catalog

The floor plan & materials catalog lists all design decisions (colors, materials, products) as part of project implementation.

Call for tenders

Awarding contracts

Construction & project supervision

SEMANTIC DIFFERENTIAL

In order to determine the current impact of a space, it is recommended that a survey be conducted using the semantic differential method developed by Charles E. Osgood. The survey consists of pairs of bipolar adjectives, with seven possible ratings for each pair. Towards the center of the rating scale, the numerical value declines to zero. A value of three carries more weight than a value of two or one. The value zero in the middle of the scale represents neutrality between the two poles. Objectives (requirements) can also be determined using the same method. The following semantic differential, check list, and floor plan & material catalog are merely an example and would need to be adapted to meet the requirements of each design challenge.

The main objective of spatial color design is to select effective color areas and contrasts that meet the needs of users, functions, and specific situations. Dominant, subdominant, and accentuating colors, and their respective proportions, should be planned according to the elements that link or differentiate them.

When developing a color design, consideration should be given to:

_ The spatial relationship, its position with regard to other spaces (the size, shape, and compass orientation of the room)

Semantic differential to determine the spatial impact
Survey of current situation

Project:

Space name:

Space user:

	3	2	1	0	1	2	3	
Trendy								Timeless
Luxurious								Modest
Exciting								Boring
Inviting								Uninviting
Playful								Functional
Understated								Florid
Cultivated								Common
Natural								Artificial
Fashionable								Old-fashioned
Unobtrusive								Obtrusive
Ordered								Chaotic
Diverse								Monotonous
Cheerful								Sad
Cozy								Uncomfortable
Familiar								Unusual
Straightforward								Ambiguous
Merry								Serious
Soothing								Unsettling
Expansive								Cramped
Active								Passive
Hard								Soft
Bright								Dark
Loud								Quiet
Liberating								Oppressive
Light								Heavy
Warm								Cold
Airy								Stuffy

Semantic differential to determine the spatial impact
Survey of an objective

Project:

Space name:

Space user:

	3	2	1	0	1	2	3	
Trendy								Timeless
Luxurious								Modest
Dynamic								Reserved
Accommodating								Neutral
Playful								Functional
Stimulating								Relaxing
Simple								Fancy
Natural								Artificial
Innovative								Traditional
Unobtrusive								Striking
Ordered								Haphazard
Personal								Impersonal
Friendly								Severe
Cozy								Prestigious
Familiar								Exotic
Straightforward								Complex
Merry								Serious
Concentrating								Dissolving
Soothing								Stimulating
Expansive								Enclosing
Functional								Multifunctional
Hard								Soft
Bright								Dark
Loud								Quiet
Light								Heavy
Warm								Cold
Airy								Earthy

CHECK LIST OF CURRENT SITUATION

Project:

Space name:

Stress factors/situations:

Indoor air

humid/dry

dusty/stuffy

Temperature

cold/drafty

hot/oppressive

Lighting

daylight/natural light

artificial light

Associations, taste/smell

sweet

sour

intoxicating

musty

bitter

Other

Under-/overstimulation

Required characteristic colors currently present

Required signs

Emergency exits

Safety regulations (danger of explosion, etc.)

Visual ergonomic aspects

Activity description, e.g. tiring, rapidly changing, etc.

Age range

Availability of break areas

Additional observations

FLOOR PLAN & MATERIAL CATALOG ENTRY

Project:

Space name:

Material/color:

Walls

spatial partitions

moveable walls

screen walls

built-in cupboards

Floor/mounting

Ceiling

Doors/leaf

headpiece

frame

fixtures

Windows/fixtures

Curtains/dimming

Heating/radiators

Daylight

Lighting

Tables

Seating

Special comments, e.g.

Special furnishings

Machines

Devices

Sports equipment

Technical equipment

Objects

Fittings

etc.

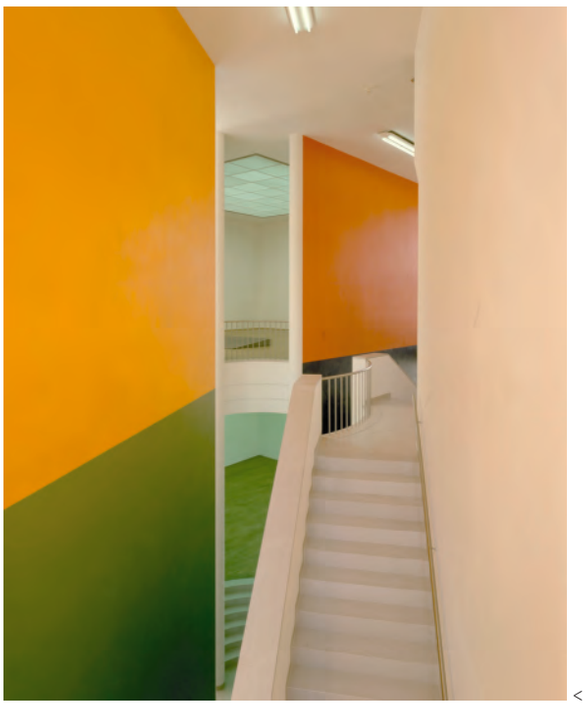
_The lighting conditions (type of light and lighting)
_The furnishings
_The materials used
_The interplay of colors in space.

Colors in space are not perceived independently. As a result, attention should be paid to the various interactions and consequences of using color in a design, for example, the simultaneous contrast, the successive contrast, and the reflection of colored surfaces on other surfaces.

The requirements, demands, and conditions of color design vary from project to project and always present new challenges. Light, material, and color should always be planned as an integrated component of an overall architectural and interior design concept aimed at achieving a humane and environmentally friendly objective; a synthesis of economy, ecology, ergonomics, and aesthetics. This objective can best be achieved through continuous, interdisciplinary teamwork right from the start.

Mega Plex Kino, Vienna
Architecture:
Rüdiger Lainer;
color design:
Oskar Putz

Color reflectance of the orange wall
on surrounding elements,
Museum für Moderne Kunst,
Frankfurt/M.
Installation: Günther Förg



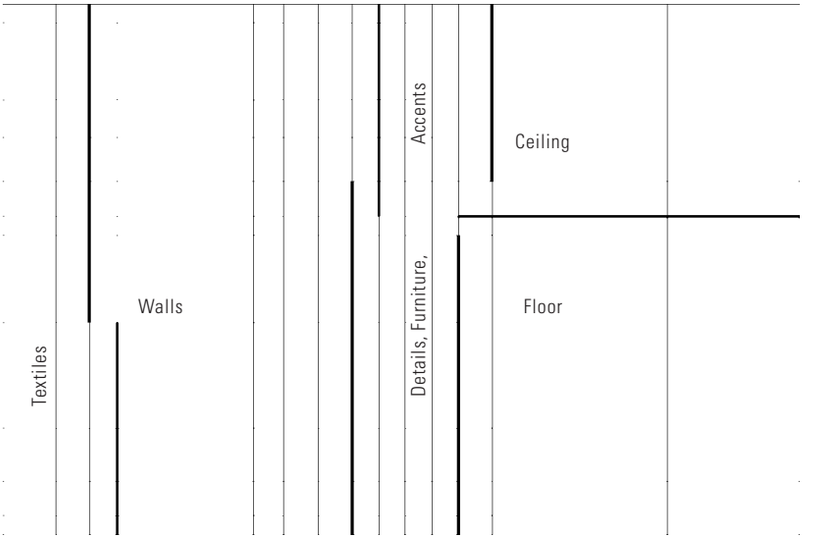
11
FIELDS OF DESIGN

The following chapter will describe individual fields of design together with their potential color concepts. We will present examples, illustrated with photos, and make proposals in the form of collages. These color-material collages represent only a few of many possibilities. When deciding on different color designs, the ideas and advice provided in earlier chapters should always be taken into account.

EDUCATIONAL INSTITUTIONS

Educational institutions are the visible manifestations of the "learning culture." They provide information about philosophical perspectives and "notions of humankind"; about the concepts of teaching and learning, which form the base for education; as well as architecture, and interior design. These buildings' spatial appearance refers to the teaching and learning activities taking place within them; they also indicate whether the chief objective of educational and creative intentions is to teach assimilation and subordination, or rather autonomy, creativity, and respect for humanity. The use of color as an element of design in educational institutions is a topic that focuses on individuals and their educational environment. It thus pertains to a sphere of activity that demands great responsibility and humane design. Material and color designs determine how conducive the spatial framework of these institutions is to ways of learning and living that are stimulating and supportive, that foster identification and well-being, support individual and social processes of development, as well as pedagogical attitudes and actions.

Learning processes depend on an individual's previous knowledge, level of development, learning aptitude and capabilities, as well as needs, interests and motivations. This rais-



The collages in the following chapters are organized schematically (above/adjacent)

es the question of how children, adolescents, and adults learn and what they enjoy learning. Here, attention must be paid to learners' many expressions of living (i.e. behavior and actions) that can and cannot be influenced pedagogically, as well as to their grasp of reality, care and affection, needs, and interests. Hugo Kükelhaus sees learning as a process that makes demands on the entire organism. People need a built world that is shaped down to the very last detail. Breathing, circulation, the musculoskeletal system, and the senses are affected. Many different stimuli are necessary for the development of sensory organs.

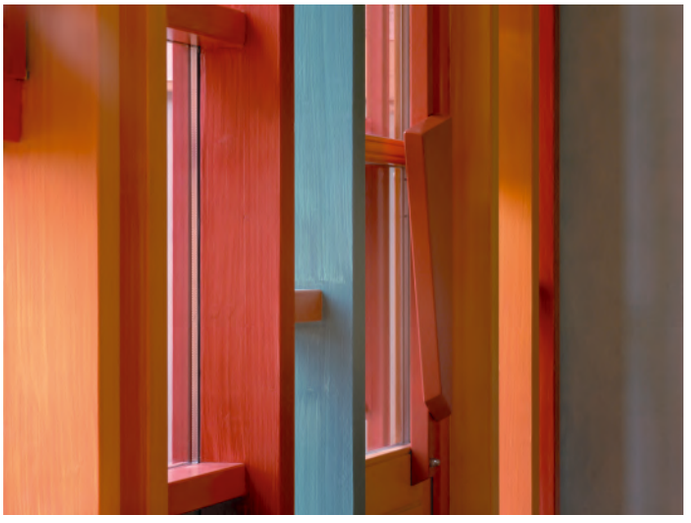
PRESCHOOL

Preschool is a place for play, learning, and community. It is an institutionally organized environment for children between the ages of three and six. It aims to help children develop their personality, as well as their emotional, cognitive, sensorimotor, and social skills. In this context, one overarching goal is to facilitate the development of sensory perception as a basis for emotions, cognition, and thought, for activity and creativity, and for independent, responsible, and social actions.

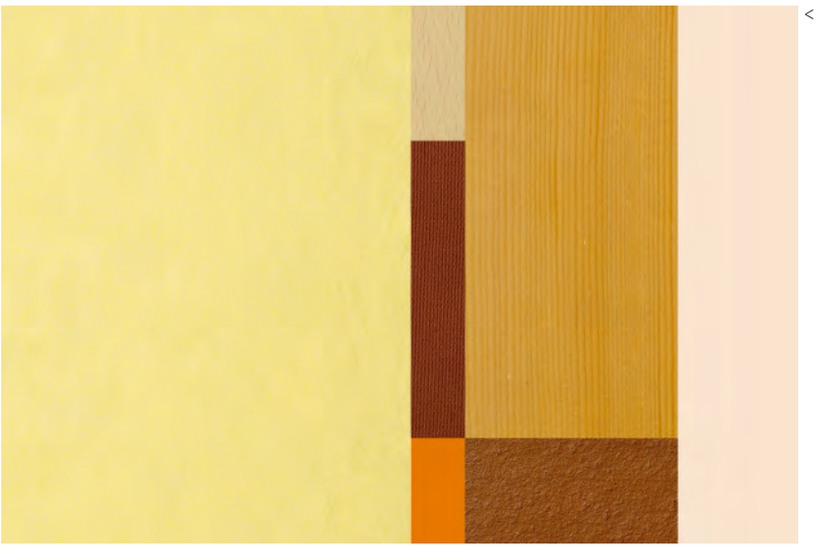
There are important links between a child's cognitive and emotional development and the complexity of his or her surroundings. A stimulating environment can, for example, motivate children to gather diverse emotional and intellectual experiences. At first, this contact with the environment takes place as part of a child's interactions with his or her mother or other attachment figures. Starting in the third year of life, however, independent activities begin playing an increasingly important role in the child's comprehension and experience of the environment.

The material environment is a "background variable" in childhood development. Its effect on the process of development depends on the individual dispositions of the child, as well as on social processes of communication. Unfavorable environmental conditions result from under- or overstimulation. Adults, who are still largely responsible for the dependent child, have a duty to establish a positive balance between the child and his or her surroundings.

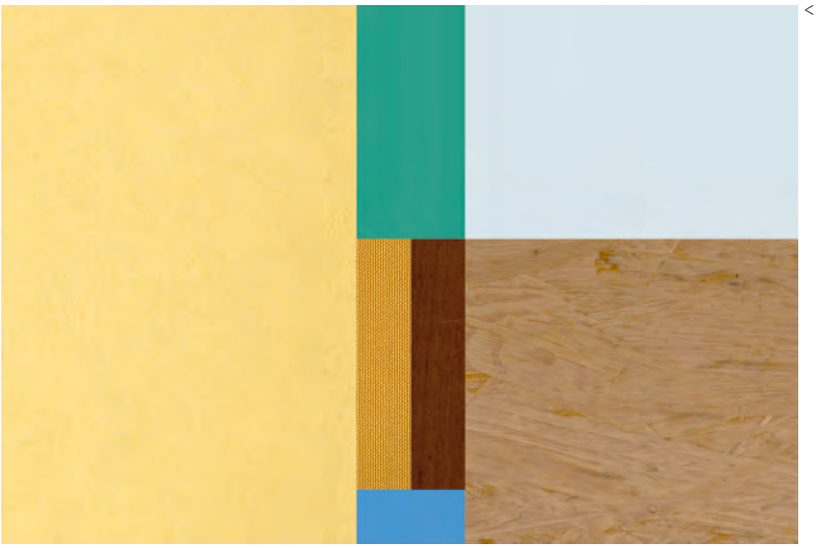
Preschool children in particular need an environment that conveys a sense of security and confidence, opens them up to relationships, stimulates their mind and senses, and supports responsibility and creativity. An environment like this fosters individual development and enables children to plan and



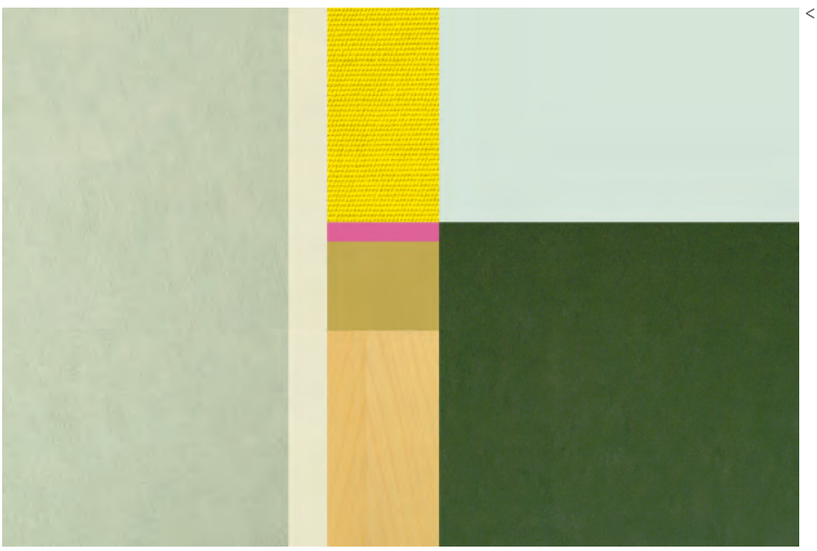
Detail, Waldorf Playschool, Mainz
Architecture: M. Riker



Preschool,
group room 1



Preschool,
group room 2



Play hallway/
common room

shape their own lives independently. The impressions gained in the process influence how children identify with their spatial environment; they also affect children's well-being and behavior. Any surface that can be seen or felt leaves lasting impressions.

SCHOOLS

Schools are social institutions, social situations, and places of learning. This is where the pedagogical foundation is laid for a university education and later career. Schools operate within the framework of society's possibilities and boundaries. Societal aspects, school constitution, pedagogical objectives, as well as school planning, architecture, and design cannot be regarded separately. Despite a new focus on humanizing schools, the aspect of design is often neglected.

School systems divided into years or grades can be found everywhere in the world, ranging from elementary school to secondary school, from vocational training to special education. Educational goals and pedagogical methods and intentions are of key importance to a school's design.

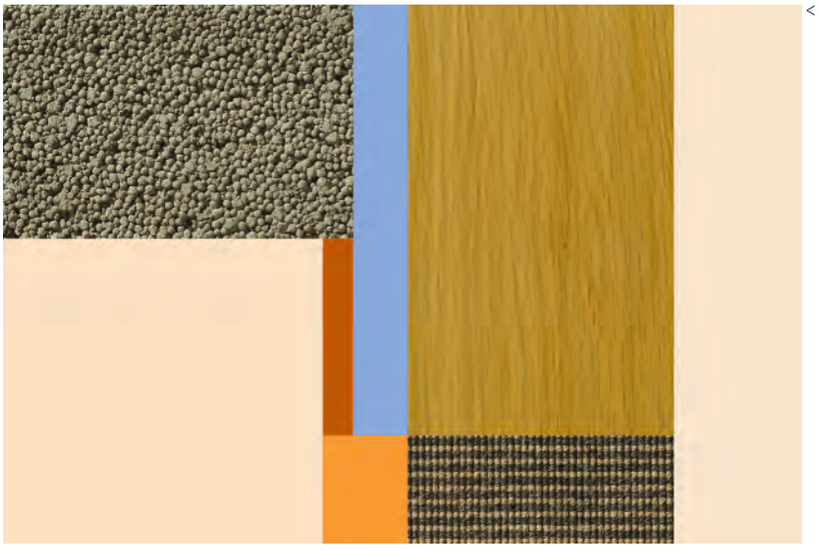
When children begin their schooling, a foundation for formal education must be laid that also includes an aspect of socialization. The key difficulty is trying to satisfy the needs of all of the children, which is a field of tension between:

_ Focusing on the needs of the individual child vs. satisfying standardized scholastic requirements
_ Differences in children's previous knowledge and levels of development vs. the common goal of laying a solid educational foundation
_ Pedagogical mission vs. the demands and obligations of society.

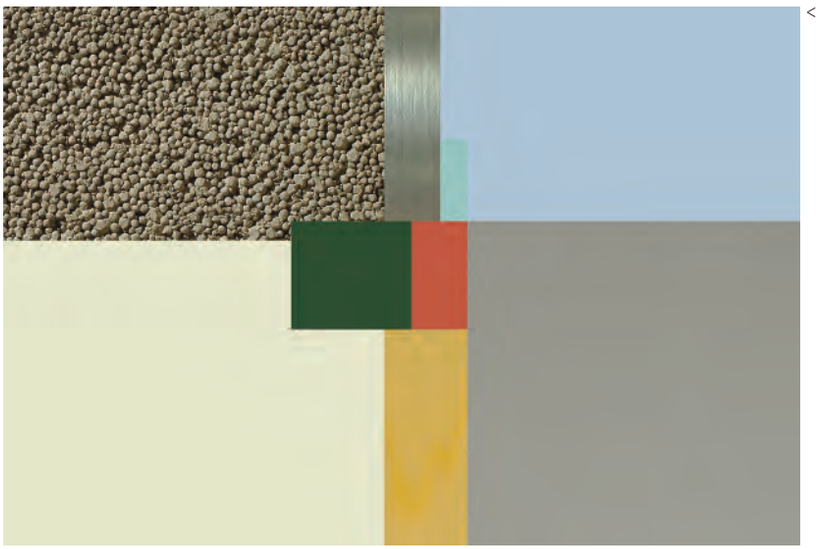
Developmental psychologists point out that children, particularly those in their first years of school, do not explore the world in a rational or distanced manner, but directly, through actions and emotions. Direct personal interest and the participation of the senses play a major role in learning processes.

These challenges apply to children in their first few years of school and are less daunting in the upper grades and institutions of secondary education. In educational processes, different pedagogical influences and methodological and didactic measures are needed, according to the students and their age distribution.

Throughout the history of pedagogy, the connection between the classroom space and learning has been pointed out many times, for example by Johann Heinrich Pestalozzi, Peter Petersen, Hermann Lietz, Claude Freinet, Maria Montessori, and the anthroposophist Rudolf Steiner. Studies of school design and furnishings (Sommer and Olsen) have shown that students participate more fully in lessons and discussions among each other in "soft classrooms," which have carpeting, comfortable seats, pleasant lighting and convey a homelike

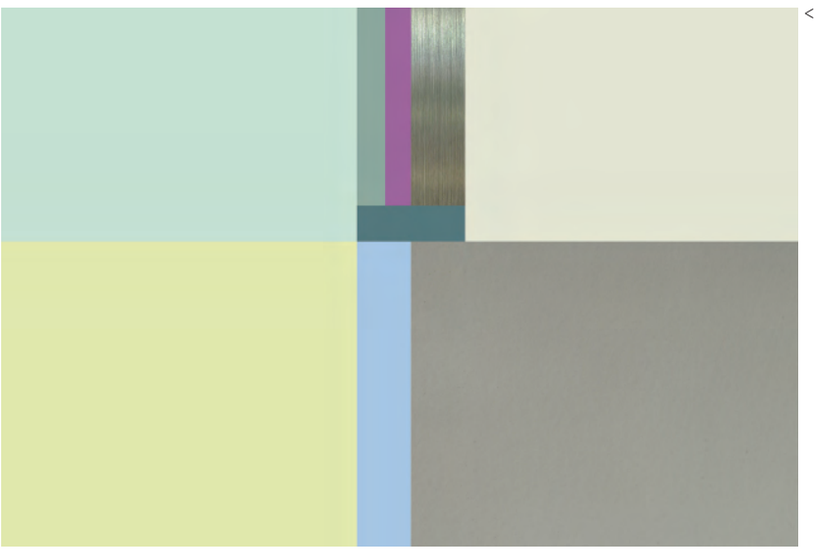


< Hallway as a space to spend time in

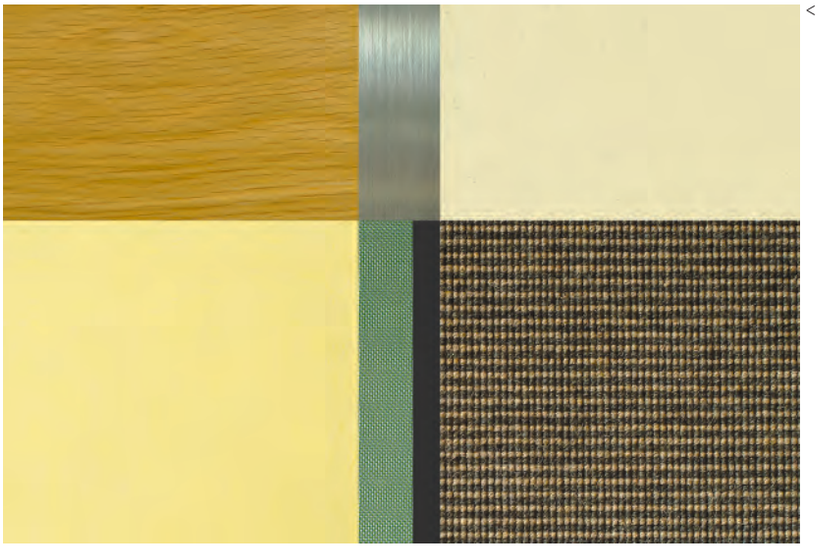


Classroom 1

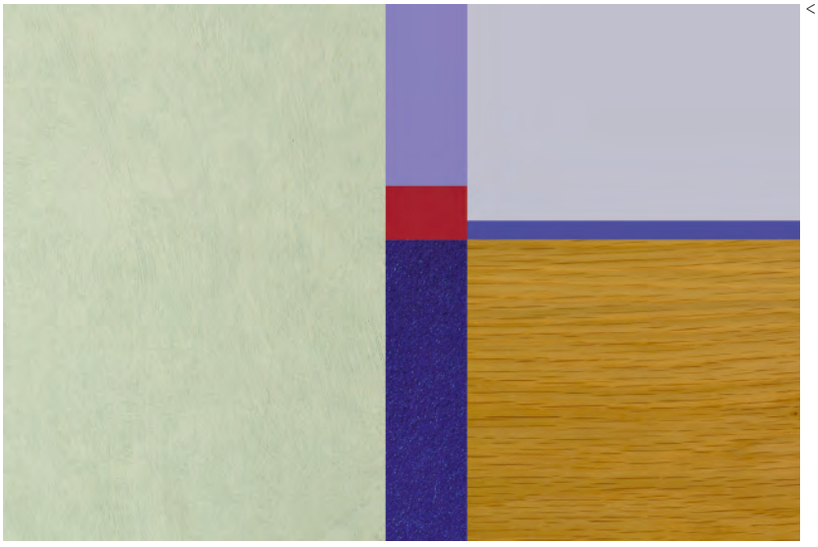
Classroom 2



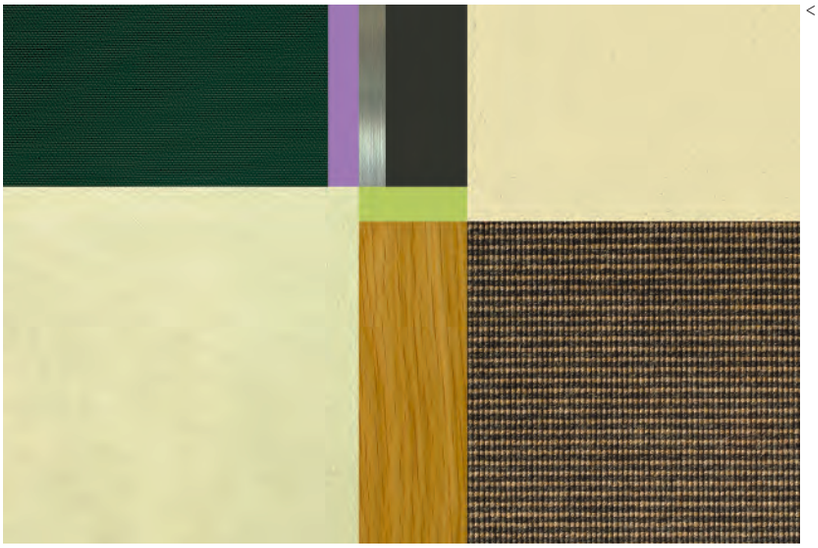
Natural sciences



< Library



< Music room



< Staffroom

atmosphere. The authors attributed this behavior to aesthetic qualities rather than changes in traditional seating arrangements: enhancing a space through design affects students' behavior and self-image, as well as their attitude towards school, teachers, and fellow students. In general, it can be said that architectural design affects

_ School climate and classroom atmosphere
_ The psychosomatic health of teachers and students
_ Pedagogical behavior
_ Individual learning and social behavior
_ Group learning and actions, social behavior in groups and with each other.

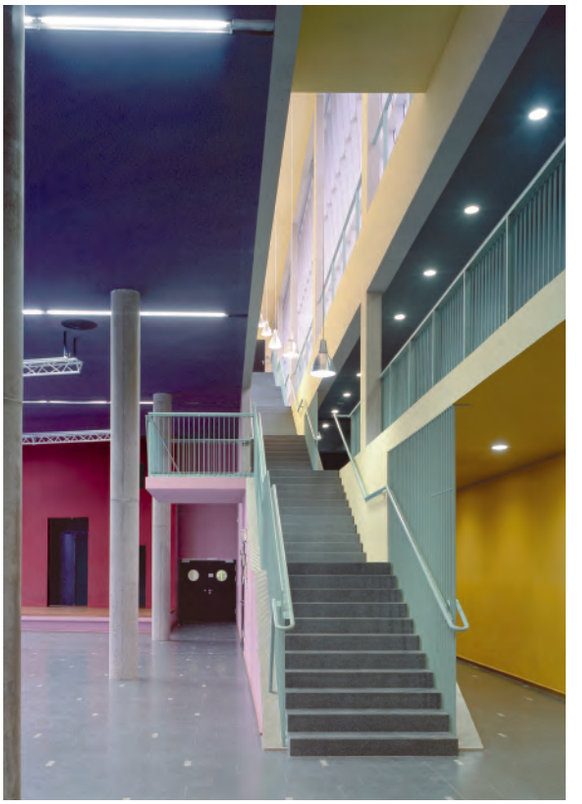
SEMINAR ROOMS/ADULT EDUCATION

Adult education has come to play an important role in the educational landscape. After completing their formal training and/or university, adults in today's world often wish or have to engage in continuous education. To date, however, adult

Facade of the Montessori School, Aachen
Architecture: Kasper-Klever
Color design: Friedrich Schmuck >

Cafeteria >

Classroom >



^ Multipurpose hall and main stairs

educational theory has focused on methodological and didactic topics and the social conditions of learning processing, neglecting the determining factors of material and space. As in school, disinterest, fatigue, poor concentration, and a lack of motivation can be traced back to inadequate, understimulating interior designs. Just as the spaces used for adult education must fulfill certain functional requirements in terms of equipment and furnishings, they also need to take the emotional needs of their users – the teachers and students – into account. If they do this successfully, they can contribute to an atmosphere that fosters well-being and the development of creative potential. We need spaces that make lifelong learning an enjoyable experience.

Margret Fell emphasizes that interior design must fulfill the requirements listed below to be pedagogically meaningful. She divides these requirements into three levels: "the level of educational theory (pedagogical goals), the level of practical education, and consequently the level of architectural, didactic space." She advocates a flexible educational space that fosters development and

_ Motivates learners to work together and as equal partners in a sense of dialog and democracy
_ Dismantles hierarchical structures
_ Fills learners with enthusiasm for dialog and thus also for tolerance
_ Stimulates the senses
_ Supports exploratory learning
_ Encourages action-oriented learning
_ Fosters didactic autonomy in interior design among teachers and students
_ Supports self-directed learning processes
_ Helps in the differentiation of aesthetic awareness
_ Sparks creativity and imagination
_ Enables a return to the original meaning of educational institutions as places that allow time for leisurely contemplation without obligatory action (Fell 1999).

An educational space should provide its users with a positive experience involving a high degree of perceptual stimulation and lasting memories.

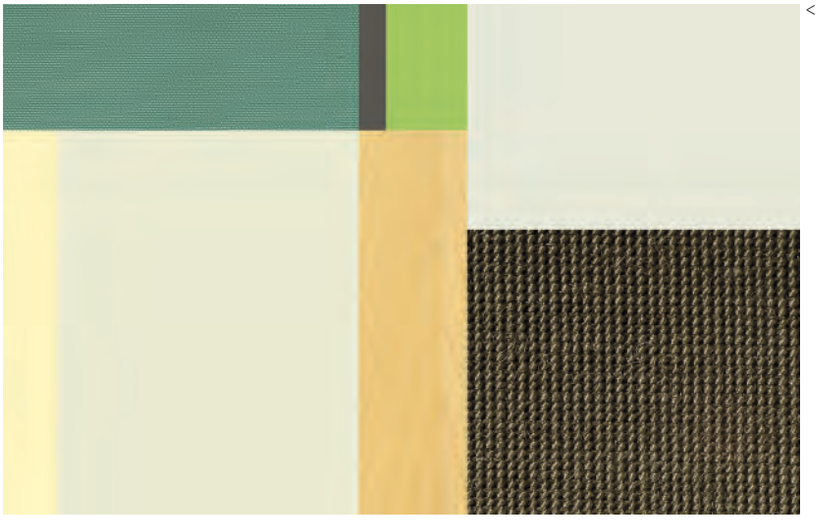
USER PROFILE

User group profile analyses provide information about the users of a space and their needs. The following observations are based on universally accepted experiences, which, in individual cases, should be supplemented by concrete analyses of the actual situation in question.

Small Children

Children between three and six years of age attend preschool. They comprise a heterogeneous group with different backgrounds and different patterns of socialization. The children differ with regard to their

_ Communicative abilities and social behavior



< Adult education seminar room

_ Psychomotor skills and perceptive abilities
_ Self-awareness, self-expression/self-assertion, and independence
_ Creative behavior
_ Experience of things.

Thus, children also differ in terms of their individual needs and interests. To begin with, they have a pronounced need for attention, security, protection, and stimulation. They need room to play, as well as space where they can rest or withdraw. They also need small spaces within large ones – niches, nooks, and crannies. For their development, children need to have the chance to experience a wide range of materials, and they also need room to maneuver and gain experiences in nature.

Schoolchildren and Adolescents

Schools are usually attended by children and adolescents aged between 6 and 18. Children begin a new chapter in their lives when they first start going to school; the first day of school is a decisive turning point in their lives. This change demands a process of reorientation that can claim a large amount of a child's psychological energy. Students often differ considerably with regard to their level of psychological, cognitive, and social development, as well as their previous knowledge. The needs of children in preschool and those just starting elementary school are very similar, although in preschool the playful element is given priority over the communication of knowledge. As they get older, students often have very different needs. The world outside of school becomes more interesting to them and sometimes competes with the demands of school life. Ultimately, all students require a school environment that appeals to their personality as a whole, conveys a sense of security and trust, is able to help them establish affective relationships, fosters identification, and can thus become part of a supportive and integrative world of learning and life.

Adults in Further Education

Adults pursue further education out of interest and of their own volition, or because they are required to do so by their employer. Their motivations can therefore vary significantly. There is, however, no doubt that adults, just like children and adolescents, learn best in a stimulating environment that contributes to their well-being, sparks their interest, and challenges their creative abilities.

Educators

Educators in preschools, schools, and adult education institutions each represent a heterogeneous group of individuals characterized by differences in age and gender, number of years worked, professional experience, social and family background, personality structures, pedagogical beliefs, attitudes and behavior, teaching and educational methods.

Educators in preschools are important attachment figures for children, alongside their family. They have considerable influence on a child's development before grade school begins. In addition to their regular duties, educators must be able to respond to the children's many spontaneous needs and remarks, to act and react with understanding and sensitivity, and to decide when to give children leeway and when to set limits.

Educators at grade schools bear a great deal of social responsibility for their students' future educational careers and life paths. They are subject to significant physical and especially psychological stress, which according to medical studies is often neglected or managed inadequately.

Educators at adult education institutions have very diverse educational and career backgrounds. This group of teachers is comprised of salaried and contracted employees, as well as freelancers. Adult education, whose aim is further education, demands a high degree of professional competence and commitment, as well as a profound ability to empathize with the often very disparate group of adult learners.

In summary, looking at educators as a group, we can state that teachers, just like learners, need an appealing work environment that exerts a positive influence on their psychosomatic well-being and thus their pedagogical behavior. In addition to good working conditions, it is important to provide this user group with areas for relaxation.

IMPRESSION AND VISUALIZATION

Aside from architecture-related color criteria, which will differ from one case to another, color design concepts for educational institutions should be crafted so that colors and materials correspond to certain basic motifs, such as:

_ A sense of security, familiarity
_ Communication
_ Stimulation, differentiation, and sensitization of perception
_ Motivation
_ Attentiveness, concentration
_ Relaxation
_ Movement
_ Creativity.

In addition to material and color requirements specific to each building, the individual rooms should also be assigned colors that match their respective function. Educational institutions need to be proportionate to the dimensions of the people using them; as colorful worlds of experience, these institutions will appeal to their users if they can be understood in their entirety and thus appear completely self-evident.

The prevailing mood of the spatial environment should be characterized by openness and warm tones; it should convey a sense of security and trust, and appear friendly and forthcoming. Color and material concepts for educational institutions must achieve the following:

_ Interior design based on a system that is legible
_ Easy-to-recognize spatial relationships
_ Quick orientation
_ Atmospheric information that exerts a positive influence on one's well-being.

Color and Material Design of Major Functional Areas

The principles of color design for several important rooms and areas will be described below using the example of a school.

Facade/Foyer:

The first impression of a school is shaped by its external appearance. In terms of town planning and landscaping, the building should be integrated into its surroundings in such a way that it conveys warmth and trust: it should be inviting. In addition to the design of the building itself, the design of open spaces plays an important role. For very large schools (complex school centers), it is essential that they be arranged in a straightforward manner, allow quick and easy orientation, and do not convey a sense of anonymity.

Corridors:

Corridors, circulation areas, and connecting rooms, as well as common areas, should be distinguishable from one another in terms of color. Colors are a way of marking different functional areas; they can vary according to the age of the students and serve as a means of orientation and organization (e.g. visually differentiating between the stories of a building). A simple system of organization and orientation can also be realized using doors and similar architectural elements.

Classrooms:

The classroom is an area shared by teachers and students, and is the place where most of the time at school is spent. It is a space for teaching, learning, and working, a framework for individual and group learning and actions, and for communication and cooperation. Its atmosphere should convey a sense of security and familiarity and foster concentration. This can be achieved by using natural materials, such as wood, parquet flooring, cork products, and textiles. These materials can span from hard to soft between plaster and concrete surfaces. There should be a good balance between bright, warm shades and contrasting, cool colors of the materials and painted surfaces. For reasons of visual ergonomics, it is important that the contrast between the blackboard and its surroundings be kept to a minimum. Sunshading installations that use intense colors create reflections that distort the colors of surfaces in the rooms. Because of the extensive amount of time spent in classrooms, it is important to exercise a certain amount of restraint when choosing which colors to use, despite the differentiations in design described above.

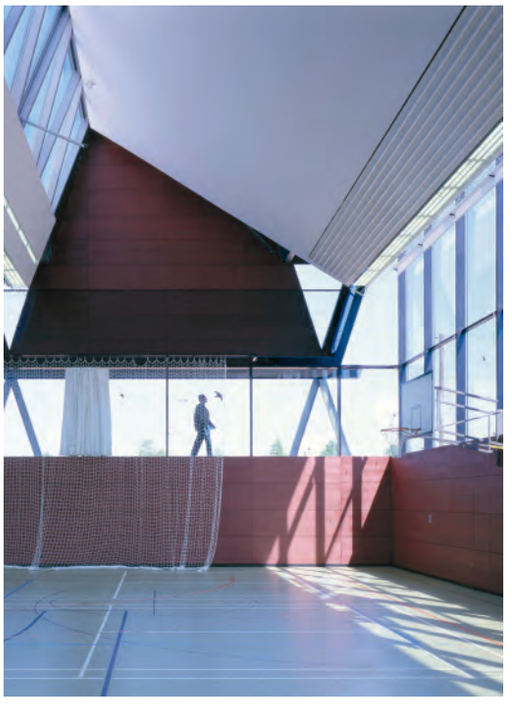
Staffroom/Administration:
The staffroom and administrative offices usually comprise self-contained functional areas within a school building and can be treated as one unit with regard to color design. In terms of color, their quality of impression should differ from that of the classrooms. The spatial environment of the staffroom should be calming, relaxing, and refreshing.

When planning school facilities, it is helpful to ensure that the different groups of users (students, teachers, parents, and school boards) are able to participate in the process of development and design by forming small committees. This pedagogical principal boosts acceptance and motivation.

SPORTS FACILITIES

In antiquity, sports, games, and tournaments were held in open arenas. Sports were valued in every ancient culture, but lost their sociopolitical significance with the advent of Christianity. They gradually regained this status in the 19th century, as a backlash to industrialization, and as a sign of emancipation and enlightenment. Contemporary sporting events developed out of this movement and are often held in indoor sports arenas. Along with the move into indoor arenas, participants increasingly began to think in terms of units, such as rankings, goals, point systems, time periods, etc. This tendency to regulate subsequently fueled the need to perfect sports facilities, to create international, standardized tournament conditions in right-angled, functionally specific buildings. Relatively little attention was given, however, to the importance of sports as a casual means of self-development through play, leisure, and recreation, or to the fact that sports, more than any other activity, involve all social classes, temporarily overcoming social barriers in the interest of achieving a common objective.

The development over recent decades in indoor sports arena construction has been influenced by different factors:
_ Growing interest in indoor arena sports
_ Increase in available space and training opportunities
_ Increase in the diversity of the school system and improved school sports opportunities
_ Increasing need for community facilities (sports clubs).



Indoor sports arena,
Markt Grossostheim
Architecture: Dierks,
Blume and Nasedy >

IMPRESSION AND VISUALIZATION, COLOR AND MATERIAL DESIGN

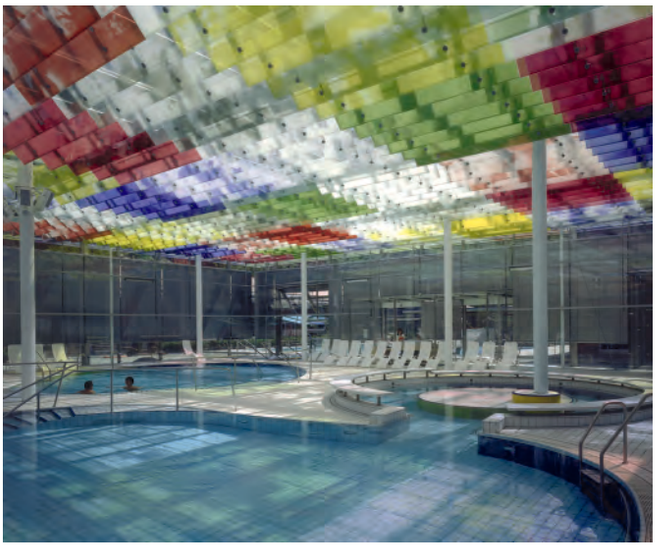
Indoor sports arenas are very important for socializing within a group. Participating in team sports builds self-confidence, allows players to work off aggression, measures strength in a fair way, fosters integration, and is a healthy activity. Based on a color design in this larger context, the quality of the spatial experience in the arena should be significantly improved. It should project a sense of effortlessness, visually enhance dynamic activity, and achieve a synesthetic temperature equilibrium. It is recommended to choose a balance between cool and warm nuances of color and material. By carefully considering the spatial dimensions of a given building, wall surfaces can be made more dynamic, creating a stimulating, delightful, and fun atmosphere. A lack of knowledge of the correct use of colors is no excuse for forgoing their pleasurable, refreshing, rhythmic, and fanciful effect in sports architecture.

SPA FACILITIES

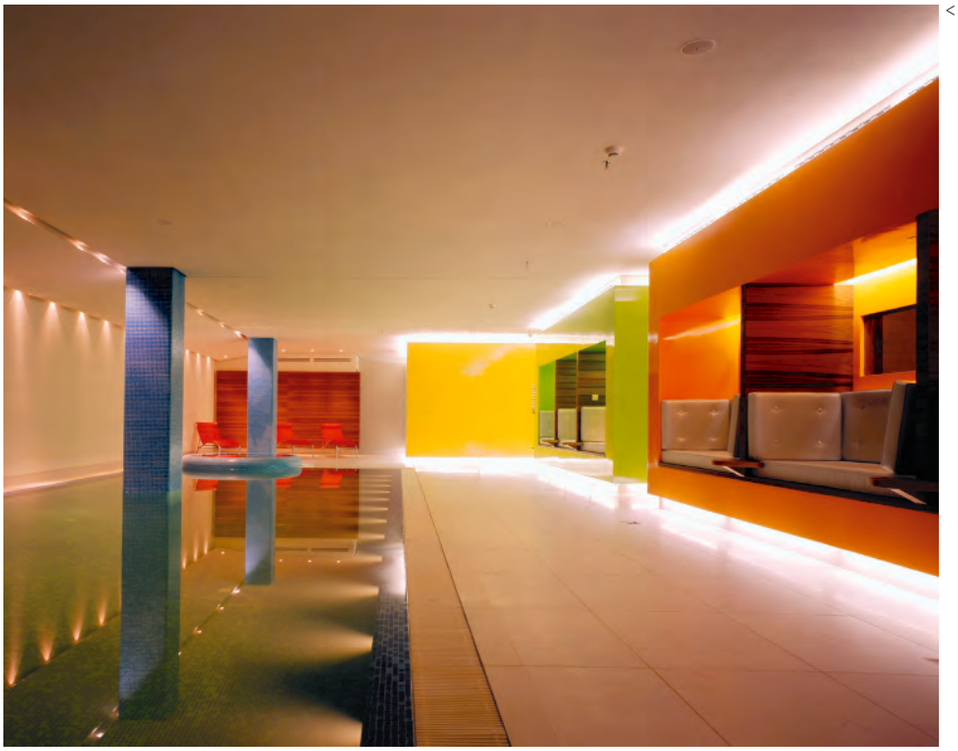
Spas are dedicated to enhancing our well-being. The word spa is an abbreviation of the Latin "sanus per aquam," which means "health through water." The spa culture that is gaining significance worldwide includes bathing, physical activity (fitness), physiotherapy/massage, beauty treatments, rest, and relaxation. Hotels and health and recreation resorts have integrated their fitness areas into in-house spa centers. Well-designed spa facilities are sensory and sensually stimulating oases for body- and health-conscious people, where they can get away from everyday pressures, enjoy themselves, regenerate, and restore their energy. In addition to the devotion and attention of staff, spatial design plays a key role in creating the right spa atmosphere. Guests come to indulge the body, soul, and spirit, gather positive energy, engage in physical activity, and enjoy a pleasant atmosphere and subtle stimulation of the senses. These requirements have to be considered during the planning and design phase.

Spa culture should be introduced into all areas of life, even schools, workplaces, therapeutic institutions, and retirement homes – and should not be limited to spa centers.

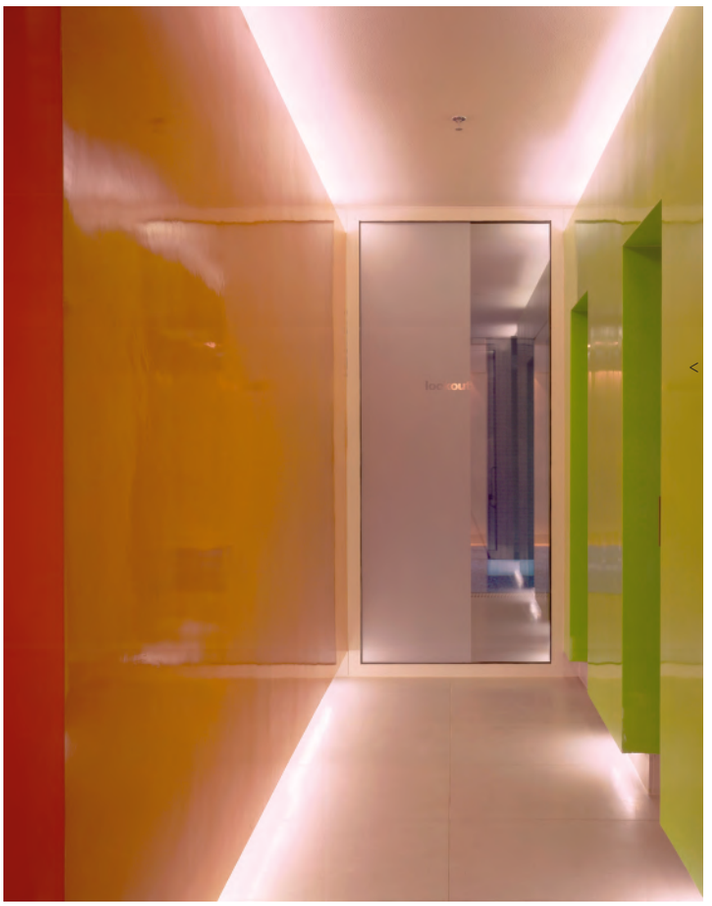
Vollmersbachhalle Idar-Oberstein
Architecture: Ulrich Pasucha,
color design: Gerhard Meerwein



Swimming pool, Bad Elster
Architecture: Günther Behnisch,
color design: Erich Wiesner



Spa, Side Hotel, Hamburg
Interior design, Matteo Thun



IMPRESSION AND VISUALIZATION, COLOR AND MATERIAL DESIGN

The individual areas of spa facilities should convey experiences with a strong emotional impact. The varying functions of different rooms and spaces are reflected in the material construction, providing an exciting array of spatial experiences. Lighting should create different moods, and materials should primarily transmit different haptic and visual impressions. Surprising combinations of materials could be used here. The spatial environment should remain "abstract" and not employ illusionist, decorative elements.

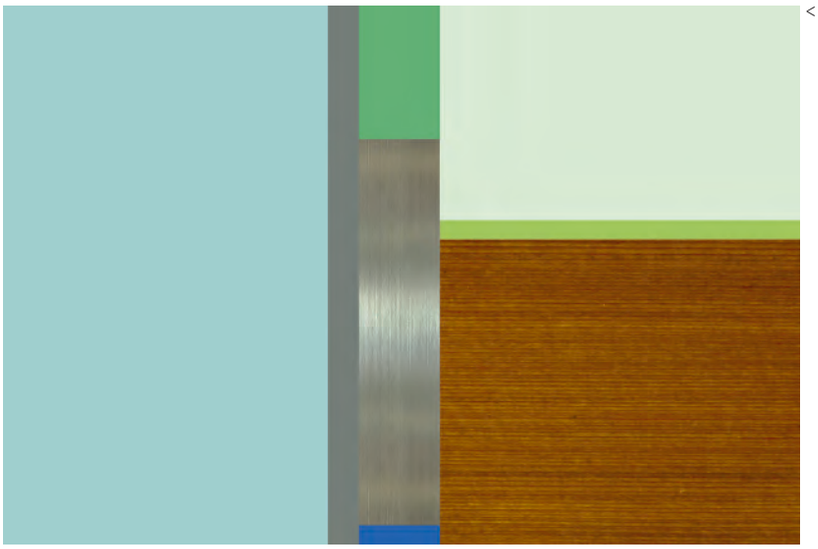
WORKPLACES

ASPECTS OF ENVIRONMENTAL PSYCHOLOGY

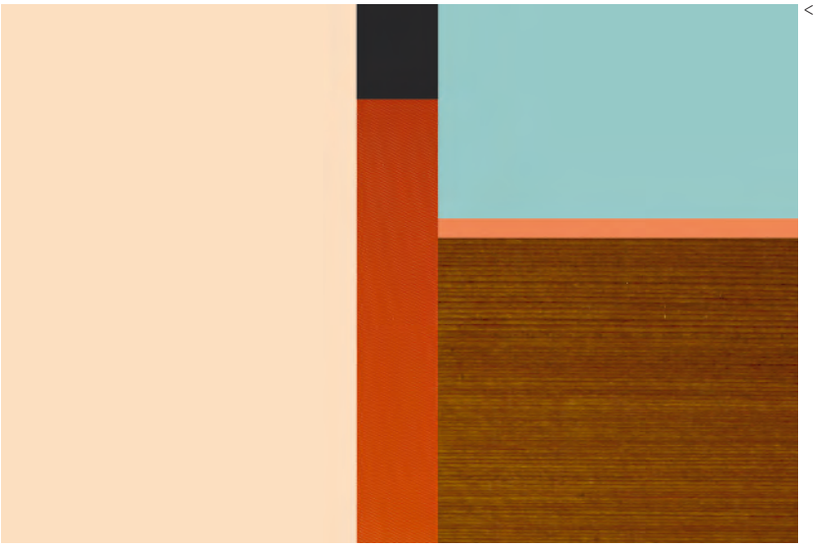
Spatial, material, social, and organizational aspects of environmental psychology have a decisive influence on the workplace. While industrial and organizational psychology focus on the influences of organizational and social conditions, environmental psychology deals primarily with the spatial and material situation, as well as conditions in the workplace and their effects on the people who work there.

Applied color psychology and environmental psychology are devoted to aesthetic criteria and visual ergonomics. Visual sources of disturbance and their associated physiological and psychological impairments should be avoided. Workplaces are the immediate environment for work activities. Our place of work has a direct effect on communication and stress. In the communication process between people and their surroundings, visual and auditory sensory modalities are of primary importance for receiving information. There is a limit to both stimulus and reaction in the exchange of information between people and their work environment. When these limits are exceeded through an excess (overstimulation) or lack of stimulus (understimulation), the effect on work performance is detrimental. According to Hugo Schmale, insufficient cognitive and sensory stimulation in monotonous work surroundings leads to a reduction in vocational, professional, and communicative skills, and eventually a breakdown in individual personality. From an ecopsychological perspective, when designing a work environment, we can assume that the human organism not only reacts to but also acts upon environmental stimuli. It is therefore important to keep in mind that people actively change their environment through their work. They pursue objectives and make evaluations. People seek to structure their workplace and strive to achieve the greatest possible degree of influence and freedom of choice in helping to design their surroundings.

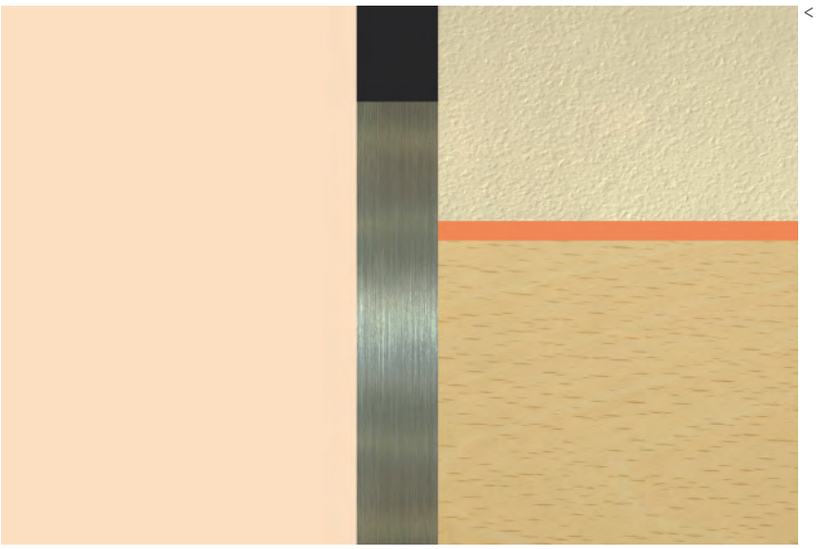
Over the past few decades, significant progress has been made in the debate on industrial and office architecture, and totally new problems have emerged (ecological issues, for ex-



Gym for sports equipment



Massage/quiet room

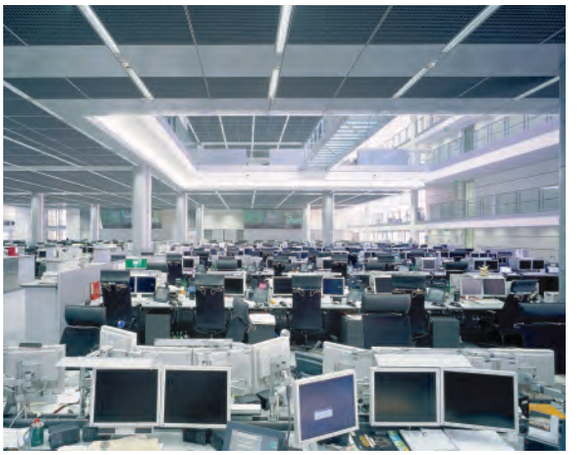


Massage/exotic-Asian

ample). Many companies are using a variety of approaches that reflect today's growing awareness of the importance of corporate design and corporate identity and meet the objectives of a new corporate culture. Industrial and office architecture are a reflection of social conditions, just like fashion, art, and music. Companies are increasingly recognizing that expressing their business objectives through design is a vital corporate culture statement. Within such marketing strategies, a company can develop a unique profile that is conveyed through architecture, workplace design, and products. This profile stands for the company's commitment to society, customers, and employees. Design thus becomes a means of communication.

An early example of visual corporate culture is the administrative building built by Peter Behrens in 1924 for the Hoechst chemical company in Frankfurt. This was the first definitive corporate identity concept in industrial history. More recent concepts have been introduced by companies like Renault (corporate color), Vitra (architectural park), and Braun-Pharma (architectural collage and color concept). Today there are also cool, technological industrial spaces and offices that rely on raw materials like steel and concrete to produce an aesthetic and pseudo-intellectual effect. In reality, however, these are erroneous designs, from both an ergonomic and a psychological perspective. Even in spaces where everything appears to be technically sound, important workplace criteria are often neglected. Ergonomic, organizational, sociological, psychological, physiological, medical, and ecological aspects all have a bearing on the workplace. In addition to factors such as climate, acoustics, and lighting, visual ergonomics and the spatial experience are key stimulating and motivating criteria. Comfort is created by a balanced stimulation of the senses. The spatial design of workplaces creates the framework for work activities. It qualifies work as an important human "asset." Today's trend towards greater mechanization in the working world increases the mental demands made on people. This reduces their tolerance threshold for disruptive environmental influences. Employees are rarely aware of flawed color schemes at the workplace, and they have difficulty verbalizing their objections to design schemes. Stress symptoms resulting from physiological and optical strain, such as visual disturbances, difficulties in concentrating, signs of fatigue, circulatory disorders, restlessness, and irritability usually appear only gradually over a long period. Employers rarely at-

Detail, Hoechst AG,
administration building
Architecture: Peter Behrens



Open-plan office, bank trading room,
Frankfurt/Main
Architecture: JSK-Architekten

tribute these dysfunctions to the optical spatial surroundings. Initial probable causes cited, in addition to workflow and the pace of work, are usually temperature, climate, air quality, lighting, and of course acoustics. This makes a well-thought-out and planned approach to color a vital necessity. Color is an important aspect of functional workplace design and essential to visual communication during the work process. It is crucial that the color design of the workplace be integrated into the overall concept of the entire commercial operation, into spatial surroundings, such as hallways, break rooms, cafeterias, and common areas. Work spaces vary in their function and size. It thus stands to reason that they require diverse color dynamics. Large spaces (open-plan offices, industrial production plants) should all have space partitions that create smaller visible entities to improve orientation and visual differentiation. The design needs to take the macrostructure, i.e. the open-plan, and subdivide it into microstructures. By using an appropriate color design approach, "spaces" can be created within a hyperstructure, manifested as specific workplaces, or as general spatial dimensioning. Design elements can render work and organizational areas recognizable over large distances. In addition to formulating building specifications, it is recommended that architects use color dynamics to design various functional areas that complement work areas, for example, recreational zones. This effectively differentiates between work and leisure areas. Warm and cool color nuances should be used to stimulate the autonomic nervous system. Designs in the working world should aim to achieve a holistic effect. All design areas are of equal value and influence each other. Color designs should never be developed in isolation or produce contradictions; they should be integrated into the corporate design as an identifying factor that corresponds to the company and its objectives. Color designs are thus also an image factor. A company's image is built upon its look and reputation, the quality and impact of its overall appearance, and the way it presents itself, both internally and externally. This is directly manifested in its corporate color culture. Based on the boldness of these impressions, a company determines the quality of employees' sense of identity and responsibility, and enhances their enthusiasm, personal esteem, and motivation. This objective is achieved using a humane social approach that respects the individual, an approach that boosts motivation, stimulates the mental and creative abilities of employees, and generates a positive attitude toward work. In addition to a socially responsible selection of materials, the visual environment needs to be socially acceptable. High de-

IKB-Bank, Luxembourg
Architecture: RKW, color design: Gotthard Graubner
The exciting, vitalizing, and prestigious color composition in the entrance foyer is followed by an aestheticized, cold, and dull work milieu.

mands on productivity need to be balanced by high quality in workplace design. The company's responsibility toward employees should be reflected in an appropriate aesthetic approach to the workplace, producing a synthesis of ergonomics, economy, ecology, aesthetics, and quality. All of this is an expression of designed corporate culture. Hamburg-based independent researcher Horst W. Opaschowski says: "If you want to enhance employee motivation, you have to make sure that they enjoy life at work and not just afterwards."

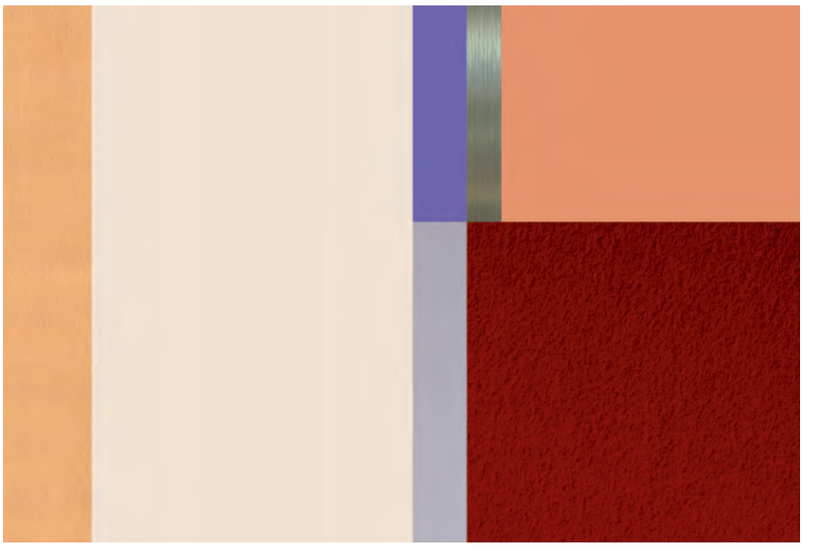
OFFICE WORKPLACES

The office workplace is undergoing major changes. Globalization and worldwide business networking, the transition from an industrial to a knowledge society, pose new challenges for managers and employees. Creativity, information, knowledge, and close cooperation are required to be successful. Employee creativity is an important element of this success. Based on the realization that creativity is best enhanced in an environment that is free of suppression (i.e. one that allows self-determination and independence, and creates important sociopsychological, atmospheric, and material conditions), special areas called interactive creativity landscapes have been introduced to the workplace. These areas reflect the latest findings in creativity research and place special emphasis on an atmosphere that stimulates the senses.

Employees have to meet extremely high productivity demands. Given the fact that health and performance are closely linked, it is important to respect the "work-life balance." There is a growing realization that spatial comfort factors play a key role in our well-being, and thus have a major influence on motivation and productivity. Office workplaces are being transformed from fixed locations equipped with IT infrastructures to places where people talk with each other and create new ideas in appealing surroundings.

In 2002 the Fraunhofer Institute (IAO) in Stuttgart conducted an empirical office performance study called Office 21, which focused on "soft success factors." The results of this study clearly indicate, from an office worker's point of view, which factors play a decisive role in optimizing spatial surroundings, and the extent to which these factors determine well-being and performance (Spath & Kern 2003). Performance and the well-being of office workers are clearly closely linked.

Two main aspects must be taken into consideration when determining the soft factors that contribute to an individual's subjective assessment of his or her well-being in an office en-



Chill-out room

vironment. First, well-being stems from employee satisfaction as well as working together with others and being part of a team. Second, well-being is influenced by perceptions and key stimuli that result from the design and conditions of the spatial working environment. The main factor that enhances well-being is expressed by what the study calls the "office attractiveness index." This is a holistic yardstick of the appeal of office surroundings. Designing an attractive office environment is crucial to achieving a high degree of well-being. "Materialism" also plays a decisive role, i.e. the quality, neatness, attractiveness, and status of the workplace. It is important to create an atmosphere that reflects an intentional design and thus makes an inspiring and orderly impression.

One of the more surprising results of the study is that decorating the workplace with personal objects has no significant effect on well-being. The Office 21 study found that the highest degree of well-being is achieved in combi-offices. Mixed office forms and individual offices also received high ratings.

In addition to the actual work and office areas, office buildings have the following spaces: entrance areas, reception desks, contact areas, break rooms, cafeterias, and conference rooms. These functional zones are connected to work and office areas. There are a number of traditional office types, including open-plan offices, partitioned offices (single and multi-person cellular offices), group offices, and combi-offices. Newly coined terms like action offices, lean offices, nomadic offices, and non-territorial offices are not new forms of office, but merely indicate the tendency towards a flexible division of space or alternative uses of workplaces and work environments. Open-plan offices, individual offices, and combi-offices are currently the most popular forms.

OPEN-PLAN OFFICES

A few years ago, the adherents of open-plan offices attributed a wide range of economic and organizational advantages to this type of workplace. Today, however, the results of numerous evaluation studies have cast doubt on such claims. Open-plan offices have failed in many respects to deliver the expected positive effects on work habits, communication, cooperation, and social climate. Employees who work in open-plan offices often complain that the working environment has a negative influence on satisfaction, performance, and health. Their level of concentration and the quality of their work is impaired by losses in architectural and social

Strasser & Strasser Management Consultants, Munich
Architecture: Löffler and Weber

private space, by endless interruptions and distractions, and by constant background noise and movement. Additional disturbances arise from unclear orientation within the office, for example, when office circulation routes are ambiguous, and workplace territories are not respected. Poor lighting conditions (mixed light from daylight and artificial lighting, irritating shadow effects), incorrect color design, and problematic climate conditions often lead to somatic and psychosomatic dysfunctions and can even cause serious health problems. Two basic issues have emerged from studies on open-plan offices: there is a lack of private space and a corresponding lack of self-determination and freedom of action. There is no question that the spatial and material design of the work environment becomes increasingly important if employees increasingly lose control over their work. In addition to offices, there are special facilities such as cafeterias, and break rooms, as well as communication areas such as meeting rooms and reading rooms that are required for work processes. All these areas gain significant importance when designing humane workplaces in open-plan offices. In order to individualize work zones, partitions should be installed. Color design should have a synesthetic influence on acoustics and climate.

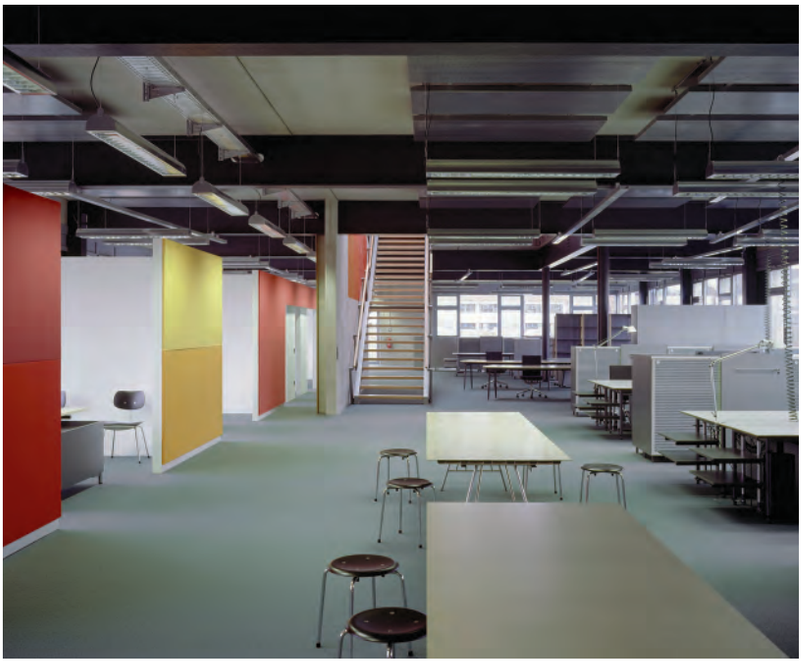
INDIVIDUAL AND COMBI-OFFICES

In comparison to open-plan offices, individual and combi-offices have the inherent advantage of reduced spatial dimensions and lower worker density, thereby avoiding virtually all the problems that plague open-plan situations. Although sources of disturbance can be a problem here as well, their scope is much more limited than in open-plan offices. There is more private space and greater opportunity for individual adjustment, provided these are not controlled by organizational measures.

Individual offices are the easiest to adapt to meet personal needs in the workplace. In general, allocation of individual offices depends on the employee's status in the company hierarchy. Nevertheless, there is no doubt that this type of office is the ideal spatial solution for enhanced concentration at work and confidential meetings.

IMPRESSION AND VISUALIZATION, COLOR AND MATERIAL DESIGN

If we define the office world as a habitat, and rely on humane design as a means of reaching out to people, we have to address their visions, desires, and emotional needs. Contrary to fundamental physiological and psychological principles, far



Open-plan office, Bauwens Forum, Castrop-Rauxel
Architecture: Thomas Kesseler

Facade, Braun AG,
Melsungen

Cellular office,
Braun AG, Melsungen

Conference room,
Braun AG, Melsungen
Architecture: Sterling,
Wilford, Schupp

too little attention is still given to color as a design element, and especially its effective ergonomic use and appropriate integration into the office environment. It is also important to issue an urgent warning against making sweeping statements and claims on the effects of colors. Such generalizations are usually associated with dubious quick-fix solutions that supposedly enhance performance and creativity. Color designs that are patched together based on these suggestions produce results that are every bit as misguided as the color abstinence that has characterized the office design of the past few years, and still enjoys significant influence. This is totally unacceptable for the people who work in these environments and are exposed to these conditions over extended periods of time.

Responsible color design requires a professional, qualified approach to the effects of colors in an architectural and spatial context, with due consideration given to ergonomic and functional demands. An ergonomic color design should meet the following fundamental physiological and psychological requirements: light conditions and color schemes should aim to avoid visual disturbances, concentration difficulties, and fatigue from glare, reflections, low contrast, harsh dark-light contrasts, intensive color stimuli, and irritating patterns in a direct line of vision. The balance of surface brightness plays a key role in creating conditions for good vision at the workplace. Accordingly, the brightness of all large surfaces and objects in the field of vision should be as similar as possible. We should avoid light-dark contrasts, such as black tables in front of white walls and windows, or light office machinery on extremely dark work surfaces. Spaces outside the direct line of vision and the direct working environment may feature starker contrasts. The lighting criteria listed in Chapter 6 should be respected.

The objective of ergonomically correct office design is to create subtle color stimulations in the spatial environment, which prevent both under- and overstimulation.

COMPUTER WORKSTATIONS

Workstations with computers are a significant source of physiological stress in offices. Their integration into the work environment requires adherence to standards for lighting and ergonomics. EU guidelines for workstations make the following recommendations for color design:

For floors, walls and ceilings:

_ Color design and reflectivity of ceilings, 70–85%

_ Color design and reflectivity of walls, 50–65%

_ The floor in work areas, 20–40%

Work surfaces, furnishings, and machines:

_ Reflectivity in the area, 20–50%

_ Degree of gloss: matt to silk matt.

Working on computer screens makes considerable demands on users. They should be informed of the possibilities and the stress factors of their work instrument. Strenuous visual perception leads to increased stress for the eyes and an unnatural posture that causes cramped muscles. Unconsciously, workers at computer screens adopt a posture to avoid reflections in the center of their field of vision. The advice below shows how workstation users can help improve their ergonomic situation.

When positioning the screen, it is essential to ensure that there is no direct or reflected glare, and a balanced luminous density distribution:

_ The screen should not be positioned so the user is facing a window or a light wall
_ Lateral light entry is desirable
_ Reflections from rear light walls, light, and windows should be avoided.

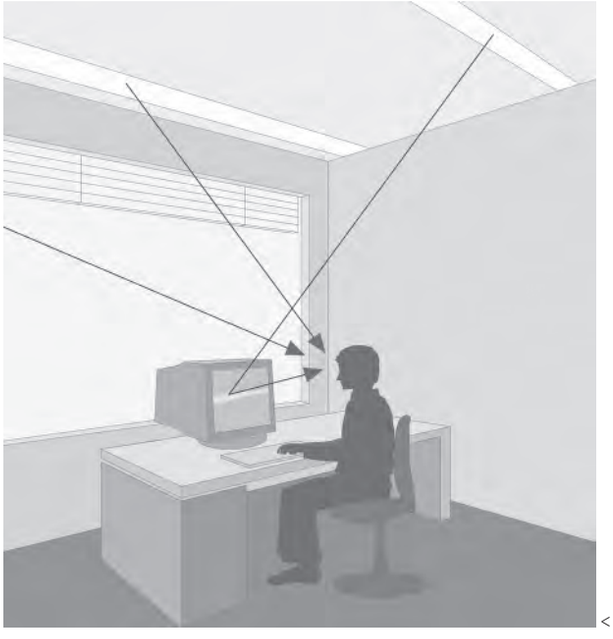
Even white clothing or garments with harsh contrasts can cause disturbing glare on computer screens.

Continuously changing the line of vision between the copyholder and the screen forces the eye to adjust to different distances (accommodation), leading to fatigue. This problem is aggravated when the eye has to adjust to different light densities at the same time (adaptation). The distance to the screen should therefore be the same as the distance to the printed copy. The copyholder (if used) should have the same inclination as the screen. The light density of the copy and the screen should be as closely matched as possible.

A colorful background on the screen increases stress levels during visual work. The characters on the screen should preferably be white, green, or greenish-yellow. Normally, only light in greenish-yellow wavelengths is sharply reproduced on the retina. The eye is farsighted for light in red wavelengths, but shortsighted for light in blue wavelengths. Finally, it should be noted that tinted and multi-focal glasses are generally unsuitable for working at a computer screen.

COMMERCIAL WORKPLACES

A number of criteria mentioned above for the design of open-plan offices (structuring, partitioning spaces) can also be applied to commercial workplaces. In addition to introducing the right lighting, the objective is to create an effective color design for workplaces, spaces, machines, and the work environment. Colors can counteract fatigue, reduce stress, boost motivation, and diminish errors. Colors also provide orientation and create a safe environment. They improve our perception, reduce eyestrain, and generally enhance our sense of well-being. Having the right color design helps clarify work



< Common glare factors at the workplace

processes and reduces harmful effects in the work environment. The ability to recognize objects is an important part of the work process. Forms have to stand out from the background. Objects should be easily recognizable and should not be placed against an irritating backdrop of distracting shapes and patterns. Colors help in these situations by creating contrasts and moving important objects to the foreground.

IMPRESSION AND VISUALIZATION IN THE WORKPLACE

Workplaces should create a spatial experience and have an appropriate quality of impression. This impression must be determined analytically, and the established values, which consist of perceptual and psychological requirements and mood-related work atmospheric applications, are then visualized, i.e. they are rendered visible and discernable.

Workplaces need to meet a wide range of requirements, for example, they should:

_ Create a peaceful atmosphere that is conducive to concentration
_ Allow employees to use their imagination during automatic, rigid, or repetitive work processes
_ Counteract unavoidable sources of stress, e.g. by compensating for heat, noise, and dirt.

The spatial impression and work atmosphere subsequently promote good working habits.

Compensation and Consonance

The most important sources of stress at the workplace can be subjectively counteracted to a certain extent through the psychological influence of color. Some of them, however, are unavoidable. The following chart shows the amplifying and counteracting influences of ambient colors on specific sources of burdensome work conditions.

This list of course does not even come close to covering the wide range of potential strain or work burden factors. Depending on the results of the analysis of the current situation, color tests are conducted with the people who use the surroundings (see Chapter 10, semantic differential) in order to define the counterparts to stresses or work burdens and visual impressions (noise, rattling, poisonous fumes, dust, repetitive work processes, etc.).

The specific type of stress is one of the most important criteria for the selection of a dominant color. For example, the right color selection for cold workspaces (warm color nuances) can heighten the subjective sensation of warmth. It is also interesting to note that sensations of noise can be reduced to a limited extent through color selection. Certain

Spielvogel Machines,
Kulmbach

long-term sources of stress such as unpleasant odors should at the very least be reduced directly at the source.

Color as a Source of Information

Colors can be both signaling and stimulating in nature. Although humans are not as severely programmed to react to colors as many other species in the animal kingdom, repeated experiences can produce reliable associations. As a result, colors in particular situations can automatically lead to immediate, precise reactions. There are specific psychological reasons for this, as shown below.

Yellow (RAL 1004) warning color

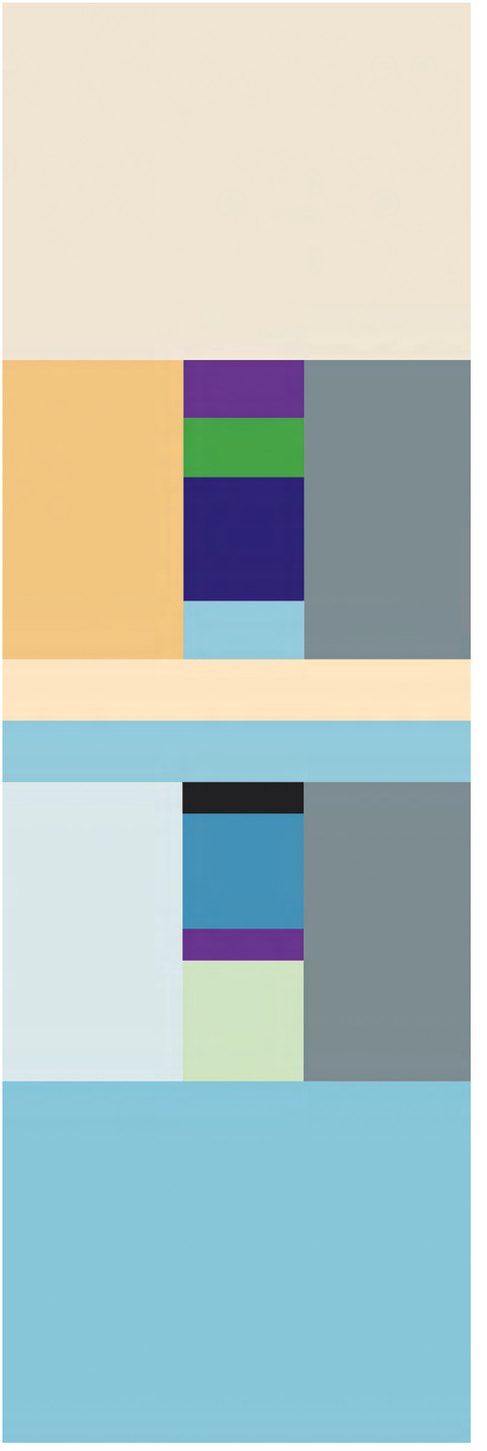
attracts attention, like a source of light. In combination with black it sends a warning. It has primarily an emotional appeal.

EXAMPLES OF COMPENSATION AND AMPLIFICATION

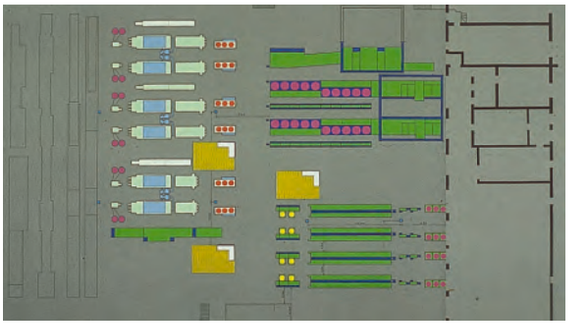
Sense	Stress/burden	Compensation	Amplification
Sense of Touch	Humidity	Sand yellow	Greenish blue
	Dryness	Blue green	Sand yellow, ochre
Sense of Comfort	Monotony	Colorful, lively,	Gray, monotonous color combinations
	smoggy	Clear colors, orange	Gray-blue
Sense of Motion (muscular effort and speed)	Exhausting, rapidly changing work	Calming, relaxing colors	Exciting colors, harsh contrasts
Sense of Smell	Musty	Light blue, clear colors	Blackish green, greenish brown
	Intoxicating, narcotic, heavy	Yellowish-green, blue-green, green	Violet, purple
	Roast, roasted odor	Bright green	Dark brown
Sense of Taste	Sweet/Sweetish	Green-blue	Red, pink
	Sour	Yellow-orange, orange	Yellow-green, green-blue.
	Bitter	Orange, pink	Yellow-brown, blue-violett
Sense of Temperature	Heat	Blue, blue-green	Orange, red
	Cold	Orange-red, brown	Green-blue, white
Sense of Hearing	Shrill	Olive, blue	Yellow, yellow-green
	Muffled	fresh green-yellow	Olive, green-brown

Assessment	Current situation
Dust, fumes	Clean
Temperature conditions: heat, cold	Summer: high temperatures Winter: normal conditions
Sound, acoustics	82 db (A)
Noise	Continuous ambient noise
Climate (dry, humid)	Normal climate, 40–60% relative humidity
Associations – tastes, smells	Artificial, synthetic
Over-/understimulation	Monotony
Required identifying colors present	For gas, air, water, paint
Required signs	Exits, fire extinguishers
Safety requirements	Warning signs for danger of explosion
Daylight	None (insufficient in any case)
Artificial light	(Almost) exclusively, "lux value" is questionable
Activity description	Rapidly changing tasks, shifts, frequent new assignments at various locations
Age structure	Male, 25–50 years old
Break room	Outside the production area (remote)

Checklist for initial planning. Project example Alcatel cable factory



Alcatel cable factory, Bramsche, color diagram
Color design: Gerhard Meerwein



Floor plan
of a factory

Production

Production

Red (RAL 300) alarm color
has the highest stimulating effect, acts as an alarm signal, and has primarily an emotional character. Red is a highly stimulating color.

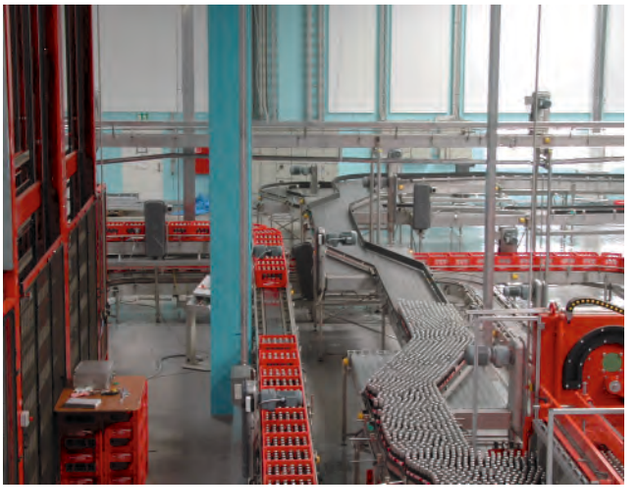
Blue (RAL 5010) organizational color, rules & regulations
raises awareness, allows us to reflect and make decisions, rationalizes our actions and has primarily a rational character. Blue increases and enhances concentration.

Green (RAL 6001) safety color, signs
conveys a feeling of security and indicates a relaxed situation, in contrast to bluey green. Green stimulates emotionally and rationally.

Color engineering is the science of using color to make operational functions visible and readily understandable. This approach thus represents neither a purely architectural nor a purely aesthetic design of spaces and machinery. It focuses primarily on facilities, machines, and all types of equipment. Today, storage systems, conveyor systems, and production facilities are rarely made by the same manufacturer. Most plant equipment is custom-designed and contains different components from an extremely wide range of suppliers. Color engineering involves coordinating different manufacturers and, if necessary, ordering specially painted individual parts to create satisfying results that meet the demands of color design and visual ergonomics.

Safety and Organizational Colors
Many safety and organizational colors are determined by standards and help indicate immediate dangers and important rules and regulations. Only highly saturated colors are suitable for such purposes, such as the primary colors yellow, red, blue, and green. Color effects can also be intensified through the use of complementary contrasts like black and white (see DIN 4818). Safety and organizational colors have to meet the requirements for object/background contrasts. Easy recognition and visibility of these colors has top priority in the production process. Backgrounds and surroundings should thus be designed to serve this principle. Another group of organizational colors indicates processes and contents, for example, by providing information on the functions of pipes. The following colors are used according to DIN 2403.

Machine Colors
Manufacturers often color-design their machines according to their own marketing strategies, corporate image, and corporate identity. These selections of colors rarely meet the design needs of users. As an integral part of the installations at a commercial workplace, machines must be included in the overall color design of the entire space. At the same time, important functions should be defined and emphasized, for example, by specially marking dangerous and/or moving parts. Machines serve people and are tools. It is thus important to color-design them correctly with respect to visual ergonomics. There should be sufficient color and brightness



Coca-Cola Tapperierne, Fredericia
Color design: Bettina Rodeck

contrasts between the machines and the materials that undergo processing. In addition, the design should avoid creating too many accents with too many different kinds of colors. Warning colors should be used sparingly to maintain their impact.

SUMMARY OF THE MAIN CRITERIA FOR QUALITY WORKPLACE DESIGN

The right color scheme

- **Increases visual perception. Improved differentiation in the work environment reduces stress and strain on the eyes and the organism.**
- **Enhances concentration and diminishes errors. Reducing under- and overstimulation helps avoid fatigue and irritation. This is an area where light always plays an important role.**
- **Improves our understanding of the entire work process thanks to correct visualization and associative cues.**
- **Aids orientation by using color and form as a medium to convey information, by effectively partitioning space into different function-related color areas, and by indicating different functions on machinery.**
- **Contributes to organization. Colors are an important factor for differentiating and organizing workflow, storage, transportation, etc.**
- **Increases safety. Using safety and organizational colors reduces the danger of accidents and mistakes.**
- **Enhances the impact, the overall quality of impression, the atmospheric climate, and employee acceptance of the work atmosphere, which in turn has a positive effect on well-being, motivation, and performance.**

Visual ergonomics seeks a balance between extreme conditions of perceptions – as does also the neuro-psychological aspect of human reaction –, overcomes under- and overstimulation through subtle stimulation, reduces stress and strain on the eyes and the organism, improves precise perception, creates organization, aids orientation, increases concentra-

COLORS ACCORDING TO DIN 2403

Water	Green	RAL 6018
Steam	Red	RAL 3000
Air	Gray	RAL 7001
Flammable gases	Yellow or yellow with the auxiliary color red	RAL 1021 + RAL 3000
Non-flammable gases	Yellow with the auxiliary color black, or black	RAL 1021 + RAL 9005
Acids	Orange	RAL 2003
Salts	Violet	RAL 4001
Flammable liquids	Brown, or brown with the auxiliary color red	RAL 8001 + RAL 3000
Non-flammable liquids	Brown with the auxiliary color black, or black	RAL 8001 RAL 9005
Oxygen	Blue	RAL 5015

International mail distribution center,
Frankfurt Airport
Color design: Gerhard Meerwein,
Bettina Rodeck

Conference and Training Center
Interior architecture and color design:
Gerhard Meerwein

Distribution center, sorting room
Color design: Gerhard Meerwein, Bettina Rodeck

Cafeteria
Interior architecture and color design:
Gerhard Meerwein

tion, diminishes errors, enhances well-being, and boosts motivation.

The effect and acceptance of the color environment is influenced by the amount of chroma, color proportions, dominants, subdominants, and accents as well as the proportions of area and color, form and color, and the location of colored surfaces within the designed space.

Designed corporate culture creates a synthesis of ergonomics, economy, ecology, aesthetics, and quality.
Visual stress factors in the workplace such as
_ Understimulation or overstimulation
_ Monotony or extreme colorfulness
_ Lack of contrasts or harsh contrasts
_ Lack of color variety or lack of color cohesion
_ Indecisive contrasts or lack of continuity
should be avoided.

THERAPEUTIC FACILITIES

Therapeutic facilities include hospitals, rehabilitation clinics, psychiatric clinics, residential care for people with disabilities, nursing homes, etc. Their basic function is to house people with physical, psychological or psycho-physical illnesses, handicaps or disabilities, and to treat and care for them over the short or long term. In therapeutic facilities, it is important to consider both essential user groups: the patients and the employees, in this case with particular focus on the caregiving staff.

When designing therapeutic environments, we must differentiate between facilities for short-term stays, (such as hospitals, rehab clinics) and long-term stays (such as homes for disabled people, nursing homes, and some psychiatric clinics), in order to best cater for the different needs of the user group.

SHORT-TERM THERAPEUTIC FACILITIES

Short-term therapeutic facilities are facilities where patients undergo treatment, cures, and convalescence in order to return to their familiar private and professional lives as soon as possible. Ecological psychology emphasizes that convalescence goes hand in hand with a reduction of harmful effects and stress factors. It stresses the importance of an informed patient, who can exercise influence on and participate in the

events of the facilities in order to counter "learned dependence." Exercising influence on and participating in institutional events can be fostered by:

_ Providing clear information during admissions
_ Explaining diagnostic and therapeutic treatments
_ Providing effective spatial and organizational conditions and orientation in unfamiliar situations
_ Providing privacy in regards to personal territory and social contacts
_ Creating effective architectural, spatial, and organizational structures that cater to individual needs while at the institution.

IMPRESSION AND VISUALIZATION

For many people, especially first-time patients, a hospital stay is like entering an alien world of rules and regulations, and with a language understood only by experts. For patients, whose well-being is limited by illness and who have to leave their familiar environment, a hospital stay can be a threatening or even frightening situation. It is obvious that a hospital should alleviate this strain by providing the most favorable environmental conditions. The notion that hospitals have to be more than functional curing factories is starting to take hold. Architecture can contribute to healing treatments – on a psychological level – by creating a trust-building environment that supports a patient's well-being and by providing a low-stress work environment for the staff. There are many references in medical research to medical success not being purely dependent on the "hard factors" of therapeutic treatments. "Soft factors" also significantly influence the process of convalescence. "The aesthetic dimension of medical science is becoming increasingly recognized." (Rolf Verres, Universitätsklinikum Heidelberg). Karl-Ludwig Resch emphasizes that many patients need an atmosphere of well-being. It contributes to the success of the healthcare process.

Hospitals should thus never impose functional or technical perfection as the design blueprint for their appearance. Neither should patients be treated merely as medical "cases." Most modern hospitals are highly complex facilities, functionally and technically perfect. However, their appearance all too often neglects the needs of the patients. It is essential to create an environment, using color, material, and light, that supports both the patients' psychological and physical well-being and the whole healthcare process. Psychosomatic medical science confirms that a relationship exists between surgical and medical treatment and the patient's mental and emotional attitude. The significance of color as a means of therapeutic support is widely recognized. Professional color design in healthcare facilities should therefore have top priority. People with an illness are in a state of disharmony. Not only their physical harmony is out of balance, but also the harmony between body and mind. For this reason, they should feel that they are being cared for not only medically, but also emotionally. Patients and their relatives expect top-quality care and medical treatment from hospitals, and are therefore often highly concerned and critical of these institutions and their practices. Hospitals should not seem cold, distant, or unapproachable. They should also avoid the other extreme: an environment that randomly presents many highly saturated colors is not only uncomfortable; it can also awaken skepti-

cism with regard to professional expertise. In the areas of hospitals where doctors, nurses, and healthcare staff perform their work (in operating or X-ray rooms, intensive care, therapy wards, or clinical laboratories), an environment should be created to meet every visual ergonomic requirement. The eye should not be overstressed or unduly fatigued. Working conditions should be more visually appealing. We need to consider the well-being of the staff as well as that of the patients. Day-to-day involvement with suffering and illness requires a great deal of strength and patience. Inadequate working conditions overtax the staff and can adversely affect their performance and their relationship to patients.

COLOR AND MATERIAL DESIGN OF THE ESSENTIAL FUNCTIONAL UNITS

Lobby and Admissions Area:
After the building's exterior appearance, the foyer and patient admissions area provide an additional important first impression. The ensemble of design elements should exude a personal and friendly atmosphere. Aspects that convey a sense of warmth, security, and ideal care are perfectly compatible with a homelike yet professional image. The design quality of the foyer should match other functional units, not only in terms of color composition, but also in high-quality design and spatial atmosphere. It would detract from the effectiveness of the foyer's design quality if it failed to harmonize with the spaces devoted to medical treatment, technical procedures, patient care, and visiting.

Corridors and Patient Visiting Areas:
Patient visiting areas provide a space outside the ward, which can be used to meet with other patients or to receive guests. Although they are often extensions of corridors, visiting areas should have a more refined design, providing some sense of privacy by means of color, material, and the choice of furnishings. On the other hand, corridors are seldom used only as passageways, but often serve as spaces where people spend a good deal of time. They comprise a large part of the total area of a hospital and thus contribute significantly to its overall impression. The atmosphere and function of a particular unit should be reflected by its corridors. The color design of an intensive care ward should be different from that of a pediatric ward. Corridors thus also become a navigational aid. If it is not possible to create a differentiated design, architectural elements, such as doors and color accents, can serve as identifying factors for the different wards. Without providing a recipe for color design, here are some possible strategies: In intensive care ward corridors, a not-too-muted light, fresh blue-green or green could be a viable way to convey a sense of peace and quiet; whereas in general corridors, this can generate a friendly, warm atmosphere. It is better to design corridors using complementary colors than using tone-in-tone concepts.

Patient Rooms – General:
General patient rooms are used for short or long-term hospital stays and are occupied by people from different social backgrounds, age, and personal circumstances. The seriousness of their illnesses is also variable. This leads to discrepancies in expectations of the hospital environment. Anxiety,

> Ward 1

> Ward 2

> Cafeteria

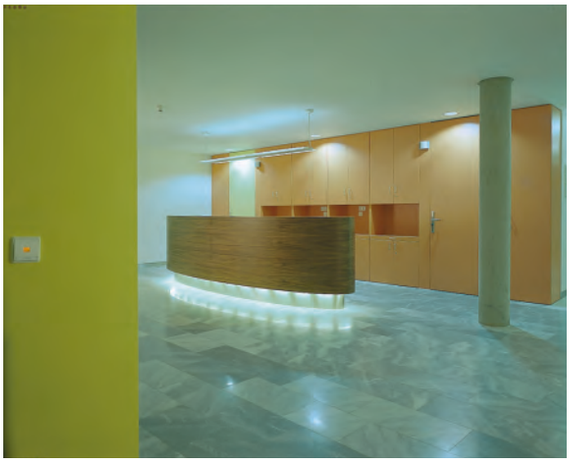
> Patient's room
on the pediatric ward

sleeplessness, and other psychological dysfunctions develop that can however be alleviated by means of design. The architectural space should be harmonized as well as possible to foster therapeutic and healing processes; it should be friendly and comfortable. Bedridden patients often need a focal point on the ceiling; so ceilings should be effectively designed and have some color, but always lighter than the wall color. It is also important to bear in mind that interfering reflections should not alter the color of the patient's skin. Visual diagnoses performed at the patient's bedside should never be affected by ceiling or wall reflections caused by overpowering, saturated colors (simultaneous contrast). Lighting needs to be glare-free and have a high color rendering index.

Intensive Care Wards:
Here, patients are given intensive medical and technical treatment. These patients need comprehensive care and are dependent on assistance in order to carry out even the simplest tasks. They are often restricted to almost complete immobility, severely limiting their sphere of experience, and are often in great pain. Most of them have been admitted to the hospital after experiencing a shock such as a major accident, a stroke, heart attack, or an operation, and for medical reasons or for risk of infection, have to be shielded from outside contact. Loss of sleep and an interruption in circadian rhythms due to the side effects of medicine can temporarily trigger symptoms such as disorientation and hallucinations, which produce strong feelings of insecurity. Subdued lighting conditions are common in intensive care wards. These rooms should convey a feeling of peace and quiet, but should never be monotonous. Aqua and lower chroma greens with small accents in warm tones in incidental areas would be one possible color design strategy (be careful in where to place them so that reflection of the color does not alter the patients' skin tones). In intensive care rooms, clear visual signals need to be provided that convey a feeling of security, thereby also counteracting ICU psychosis. The side effects of drugs, sleep deprivation, and interruption of the circadian rhythms because of the 24-hour lighting may bring on this condition, which is characterized by disorientation and hallucinations.

Operating Theaters:
Surgery presents an unsettling and frightening situation for many patients. They have to place their full trust in the medical and technical equipment and the surgeon's capability. Their fears of the operating room must be eased by effective pre-operative care and medical attention from doctors and nursing staff, if need be, in special preparation rooms. In operating theaters, ergonomic aspects should be taken into account as well as the visual strain that doctors undergo. Green (or, in the United States, blue-green) surgical drapes and gowns with a low degree of brightness have been used for

Facade, St. Georg Hospital, Leipzig
Architecture: HPP Laage & Partner, Stuttgart/Leipzig



Admissions

Hallway

Hallway

Ward

Patient's visitor's area

years to help prevent the eye fatigue that can be caused by too great a difference in luminous density. The reflectivity (8–10%) of the surgical drapes thus has approximately the same degree of luminance as the surgical incision area on the patient. The surrounding green neutralizes the afterimage on the reddish surgical area. Wall colors in operating theaters should not exceed a luminance of 40 percent (the ideal level being 30–35%) and should be similar to the color of the surgical drapes and gowns (green to blue-green).

Medical Laboratories:
Medical laboratories are internal workplaces that are not accessible to patients. Visual ergonomics dictate the prime criteria here. During the planning stages, priority should be given to the color-rendering possibilities of the lighting. This has a significant affect on the choice of color and material. Walls have to be neutral in color – for example, gray – when critical differences in color nuances (colored medicines, etc.) are involved. Monotony can be avoided by the choice of colors used on doors, tables (except for working surfaces, which must remain a neutral gray with approximately 30–35 percent light reflection), chairs, and staff uniforms. Where color discrimination is not critical, tan, pale green, or aqua may be used.

EKG and EEG Measurement Rooms:
In EKG and EEG measuring rooms, a patient's heart and brain activity is monitored. The design of these rooms should be soothing, without becoming monotonous. A monotonous environment affects the heartbeat and brainwaves. In a monotonous environment patients may search for stimulus within themselves, which in turn can affect their physiological reactions. Color is not the only definitive factor; all elements have a significant influence on the space. Hence, a room with a "peaceful" design could have interesting design accents that the patient can explore, such as an interesting wall decoration or abstract painting that invites exploration.

Pediatric Wards:
A hospital stay is a major and potentially traumatic experience for a child. Children often do not understand the reasons for being there. For most children, leaving behind their familiar environment is an interference that needs good personal

Ward, St. Georg Hospital, Leipzig
Architecture: HPP, Stuttgart/Leipzig

Operating theater

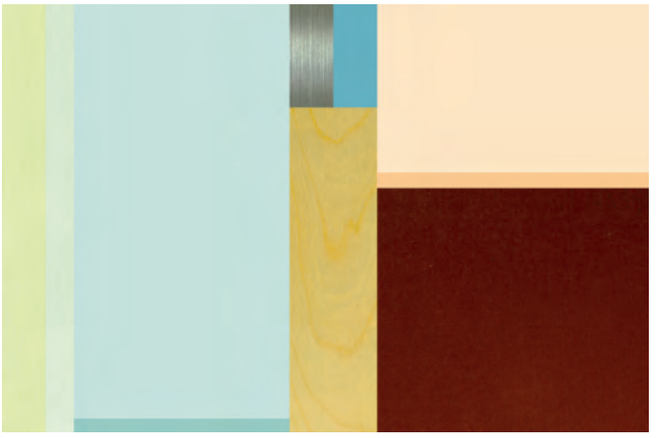
OP wing

preparation and supervision. A pediatric ward's spatial and visual sphere of experience needs to be planned with care to create a loving spatial climate. Choosing mainly bright, warm, friendly, and clear colors can provide a varied atmosphere, without being confusing. The design can be playful, but not naïve or clichéd.

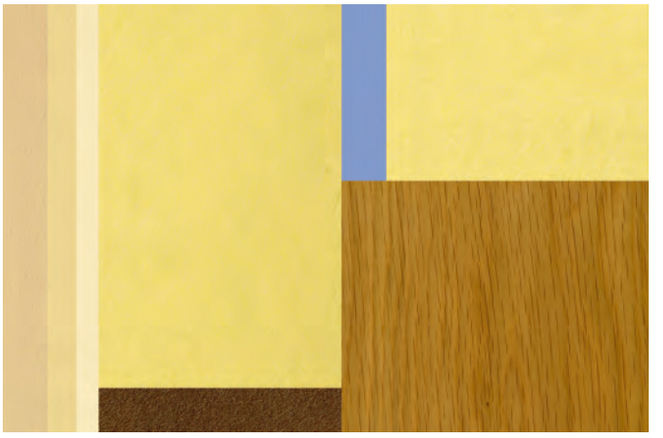
Maternity Wards:
A maternity ward is a special area in a hospital. Its atmosphere should resemble a neat and tidy residential hotel. Intimacy and familiarity are priorities. The antenatal rooms should not be designed with saturated colors that are too warm. The overall impression has to be relaxing and "releasing." The colors in the corridors should be different from colors in other rooms. Here, the "happy event" can well be expressed visually or be associated with color. In the hospital nursery, walls painted pink or pale blue may make parents happy, but they do not help the nurses who care for the newborns. It is a fact that the skin of an infant is highly reflective. Yellow, pink, blue, green, and gray as dominant colors can distort appearances. A yellow wall can simulate jaundice. A blue wall can make a newborn's skin look blue and suggest cyanosis. Light, slightly muted colors like beige or sand are good, as long as the degree of brightness does not exceed a light reflection of more than 75 percent (white is therefore unsuitable). Accents can be added using doors and other elements in the surrounding area.

Nurses' Stations:
Nurses' stations are workplaces for staff, where patients, visitors, and doctors can meet and communicate. It is also, however, an administrative area and therefore criteria for both office and private spaces apply. The nurses' station, the hub of every hospital ward, should differentiate visually from the other rooms and be easily recognized through color.

Waiting Rooms:
Waiting rooms are rooms where patients wait to be examined, receive medical treatment or consultation, and are used by many people. The time spent waiting is often accompanied by feelings of worry and trepidation, but also of hope and expectation. Waiting rooms therefore require a soothing environment that also has visual stimuli and interesting accents, to help direct attention toward the spatial environment and deflect from negative thoughts. If possible, waiting rooms should be naturally lit and provide views to the outside.



Birth room



Mother's and children's room

Cafeteria:

A visit to the cafeteria means a break from routine for hospital staff, for family members on a prolonged visit to a patient, or for patients who are mobile. The cafeteria's design should exude a restaurant atmosphere that is relaxing, inviting, and friendly, and an ambience where the lighting and color concept differs from other functional spaces in the hospital.

Break Rooms:

Break rooms provide a place for the staff to relax. They should also differ in lighting and color from the other work areas. Warm lighting without fluorescent tubes would be best. A homelike atmosphere is required here, with quiet wall coverings over painted surfaces, and wood and textiles combined with comfortable seating arrangements to create a room that regenerates and restores energy.

General Floor Coverings:

The color or colors chosen for floor coverings ought to give a sure-footed, secure impression. There is nothing less appropriate for a patient than having to walk across a bright, polished, shiny floor. The "ice-skating rink" effect is irritating and unsettling. Using textile floor coverings can also satisfy other requirements (e.g. acoustic). Their disadvantages (hygiene) should be evaluated according to the situation at hand.

THERAPEUTIC FACILITIES FOR LONG-TERM STAYS

These are residential facilities for people with long-term illness or permanent disability. These environments must fulfill humane living conditions, and provide the highest possible level of freedom for the patients.

Freedom can be categorized according to four dimensions:

- Freedom of movement: the ability to influence the radius of action in micro and macro areas
- Social freedom: the ability to influence social relationships
- Freedom of activity: the ability to influence the content, breadth, and sequence of activities
- Freedom to decide and control: the ability to influence planning, therapeutic, administrative, and design processes.

The degree of freedom is determined by:

- The architectural situation
- Organizational and administrative conditions
- The attitude and behavior of the people surrounding the patients.

Private rooms and the possibility of privacy foster autonomy. The following passages will provide information on color and material design, using a psychiatric clinic with residential accommodation as an example.

PSYCHIATRIC FACILITIES

For many patients, psychiatric facilities become a residential establishment. The average period of residence is longer here than in medical facilities. For this reason, one priority for psychiatric facilities must be to create an optimistic and encouraging ambience. Many facilities for psychiatric patients are still dull, monotonous, and depressing places. The design should, however, contribute to an atmosphere that reduces fear and mistrust and conveys a feeling of security and good care. The spatial environment and therapeutic processes should complement one another, making the space itself an additional therapeutic agent. Light and color affect body, intellect and spirit, behavior and social interaction. They can therefore serve as a means of healing, or at least contribute to developing and maintaining a sense of well-being.

The balance between under- and overstimulation plays a vital role when designing psychiatric facilities. Psychiatric patients may be subject to hallucinations, which can be provoked by a monotonous, understimulating environment, or one that is overstimulating. The conscious activity of the brain is not stimulated if there is a lack of sensory stimuli in sterile or uninteresting rooms, or a lack of human interaction. A person would then seek other sources of stimulation in his or her fantasy or mental world. This can trigger a process of hallucinating in psychiatric patients and a withdrawal to their inner world, making participation with their surroundings in reality difficult. On the other hand, too much stimulation and information or too many unclear signals can lead to sensory chaos, which the patient cannot process. In particular, patients suffering from manic or schizophrenic disorders have difficulties filtering, selecting, and processing sensory impressions. In the most susceptible phases of their illness, patients can be overwhelmed in rooms that are designed with saturated colors. Sometimes too highly saturated color stimuli can trigger synesthetic effects so strong that the patient can actually feel, taste or hear the color. Another situation that may trigger hallucinations or lead to major irritation and uncertainty are optical illusions, spatial illusions, semi-transparent walls, reflections in glass partitions, glass doors, or shiny surfaces. Patterns, especially lines or checked patterns, can also trigger optical and kinesthetic illusions. These have to be avoided on all surfaces. Information and signals sent by the environment have to be plain and clear and contain no "visual noise." According to Rolf Verres, mentally ill people are "highly dependent on cognitive signals from the external world, which provide order."

USER GROUPS

There are two basic user groups who use the spaces: the residents and the staff.

Residents:

The men and women who reside in homes are a heterogeneous group, with a broad spectrum of disabilities and medical conditions. Many of them have lived there for years. They all need continuous assistance in order to meet the demands of everyday life. It is important to the therapeutic process to provide activating support and assistance in socializing, to foster independent actions in daily life. The patients' various illnesses or disabilities should in no way hinder their existing healthy aspects, their personal potential, hopes, wishes, needs, and possibilities for self-development. We should not assume that sensory perception is adversely affected by cognitive disabilities. The degree of sensitivity to sensory environmental stimulation is often very high. Patients also depend to a certain degree on sensory impressions for their orientation in the environment. It is therefore essential to design a milieu that will allow for differentiated sensory perceptions, as well as transparency, clarity, and orientation. Spatially designing and furnishing a residential facility as a living space, which allows identification and offers a protecting and stimulating environment, is one of the basic external parameters that contribute to feeling at home, and help nurture and motivate the people who live there.

Caregivers:

Several employees are assigned to each residential group. The requirements they have to fulfill are demanding and complex. Their central task is to care for the welfare and progress of the residents and to continuously assist them in everyday situations. Since the residential groups are conceptually oriented toward a family-like structure, one requirement demanded of the staff is to provide their groups with a home and warmth, to convey comfort and security, and to help them build social relationships. The degree to which the caregivers are able to fulfill these requirements and needs is not only dependent on personal attitude and professional competence, but also on the social and architectural climate of their surroundings. In other words, both the staff and the residents require an environment that contributes to their psycho-physical well-being, influences their behavior and action, and supports educational therapeutic goals and procedures. It should also encourage freedom of action and enable this creative capacity to be used to its full capacity.

IMPRESSION AND VISUALIZATION

The view that architectural space contributes considerably to human health, behavior, and actions is of fundamental significance to color concepts and choice of material. On the whole,

living quarters should exude an airy, atmospheric character that conveys warmth, security, and trust, and thus contributes to a sense of stability, home, and contentment. If a warm tone is the main color, it should not induce a sedative effect. This would lead to fatigue and lethargy in both patients and staff in long-term residential facilities. It is therefore important to use warm, cold, and complementary color nuances. This has been proven to stimulate the autonomous nervous system. White should not be the main color for walls and ceilings in residential quarters, but should play a neutralizing, secondary role. Because of its pronounced expanding effect, white makes particularly unstructured surfaces, such as walls, seem intangible, and ceilings blank and empty. It also refuses the residents' need for warmth and comfort. The signalizing effect of pure, fully saturated colors, like yellow, orange, or vermillion – unless used in small amounts as accents – makes these colors equally unsuitable for creating a relaxed atmosphere in long-term residential quarters. The color design should strive to fulfill the following basic objectives and spatial-atmospheric impressions:

_ Warmth, security, trust, stability
_ Comfort, feeling at home
_ Stimulation, differentiation, and sensitization of perception by means of different spatial qualities
_ Communication and contact with the spatial and personal world
_ Activity and creativity
_ Attention, concentration
_ Peace, relaxation
_ The ability to retreat into a personal-private sphere.

The individual and his or her personality should always be a priority of therapeutic, pedagogic and design objectives.

It is also important to consider that the residents' entire daily routine takes place essentially in the same building. This makes a certain differentiation of the design of the rooms absolutely necessary. The residential building as a world of color will satisfy the inhabitants if it is designed with emotionally appropriate colors and materials, and its functionality and atmosphere fulfills the residents' needs.

COLOR AND MATERIAL DESIGN OF ESSENTIAL FUNCTIONAL AREAS

Foyer and Stairways:
The foyer and stairways form connections between the outside and the inside. After the exterior appearance of the build-

ing and its surroundings, the foyer and stairs are the first interior spatial situation that leads to the residential quarters. The color design of a stairway as connecting element should therefore be a friendly transition from outdoors to indoors. Colors corresponding to different floors can be used on walls, the underside of stairs, and/or in foyers to provide differentiation and orientation.

Corridors:

Corridors are areas of circulation, and connect the rooms. They are often also used for a "stroll" and as an area where residents spend time when they want temporary privacy from the group. In some senses, they are like the streets of a restricted world. For this reason, it is vital to design them to be stimulating and exciting areas. Corridors seem long, narrow, high, and spatially constricting because of their dimensions. One way of making them seem optically more spacious would be to apply a darker color to the ceilings than the walls. Replacing the lighting on the ceiling with wall lighting can enhance this optical extension. Architectural elements that divide the corridors in length should be different in color than the walls, in order to make the corridors appear shorter. White should be avoided as much as possible. Despite its brightening and spatially expanding effect, white looks clinically sterile and makes residents feel ill at ease. Bright, warm nuances used intermediately between floor and ceiling are preferable. Doors and wall surfaces, which the residents can design themselves, can become decorative elements that are visually stimulating and contribute to personalizing the entrances to the living and bedrooms.

Common Rooms:

Common rooms fulfill several functions. They provide the residents with a communal area for:

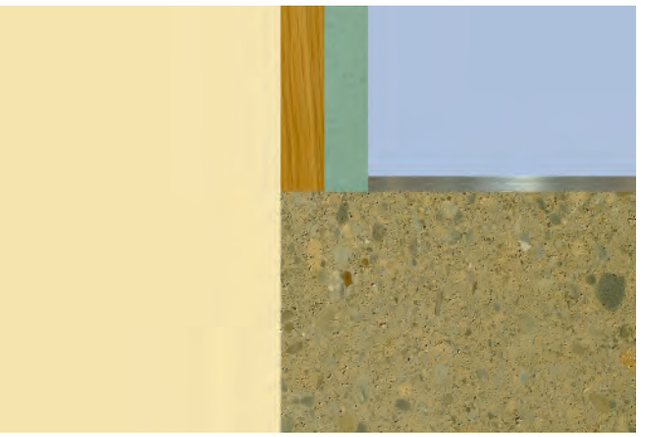
_ Communication
_ Discussion, contemplation, observation
_ Mealtimes
_ Rest and relaxation
_ Activities.

Accordingly, they should be designed in an exciting but homelike, comfortable manner that fosters communication. Some strategies for exciting, contrasting design elements include textiles (such as carpets, upholstery, curtains) and accessories with haptic qualities of material.

Living Spaces and Bedrooms:

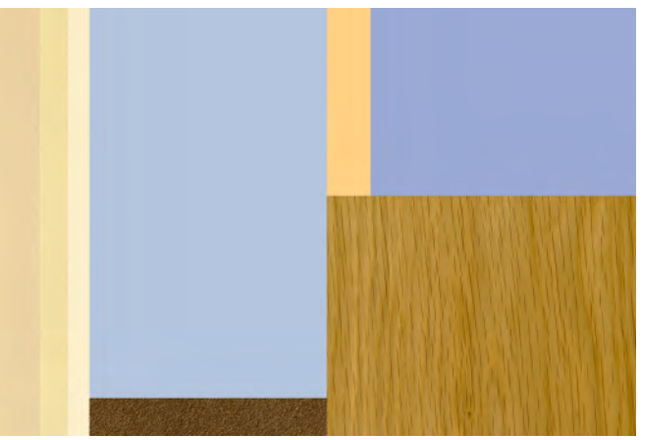
Living spaces and bedrooms are personal areas. To make them pleasant to spend time in, during the day as well, it is important to design them in a friendly and homelike manner. Appropriation of these rooms is influenced by the extent to which in-

> Corridor



> Ward

> Quiet room



> Break room

dividuals can participate in their design. This is also a possibility to stimulate and motivate activity, but has to be carefully coordinated with the conceptual framework of the color concept. Using interior textiles (curtains, upholstery, and carpets) is an excellent approach. A homelike ambiance makes a room feel like "home" to the residents. Single, double, and three-bed rooms should be designed according to the same principles.

Treatment Rooms:
Treatment rooms should also be designed in line with the living areas. Spaces that convey a sense of security and excitement, and foster creativity, are extremely important to the people who live and act in them; they are also highly valuable to the therapeutic process. The atmosphere of the treatment room is equally crucial to the residents' personal growth and development of creative independence because of its varied program of activity combined with personal attention, expert care, and individual support and encouragement from the caregiver.

Quiet Rooms:
Quiet rooms and isolation wards should convey the feeling of refuge, protection, and relaxation. If one patient needs to be isolated from the others, he or she should be guided to a room that is comforting and inviting, as well as minimally and safely furnished. Relaxation can be encouraged by cool colors such as nuances of green or blue-green. The colors must be chosen carefully, so that they seem soft and under no circumstance "institutional."

Bathrooms:
Bathroom designs always run the risk of looking very cold and functional. Warmer, bright colors with fresh accents should provide for an exciting atmosphere and motivate an enhanced awareness of the body.

In conclusion, each specific situation should be weighed up and considered to determine how many standard design measures are needed and how much leeway there is for individual design by group members.

RETIREMENT HOMES

Retirement homes are facilities for elderly people who are no longer able to look after their own households, but do not yet need nursing. Nursing homes provide constant care for elderly people, but not constant medical treatment. Both types of facilities are vital to caring for elderly people. Moving out of one's own home and into a retirement home is a crucial experience that involves feelings of being insecure, uprooted, ostracized, and helpless, especially when the person is confronted with a completely different spatial and social environ-

ment. A move such as this can often trigger serious crises, but also positive developmental processes. Personal disposition, history, whether or not the decision to move has been made independently, and how well the transition has been prepared for, all play a significant role. The affected person's reactions to the change in environment depend on subjective, personality-specific factors, as well as on external, environmental factors such as spatial and architectural characteristics, the social organizational structure, the home's staff and residents, and its social climate (Rudolf H. Moos and Sonne Lemke). Gerontology stresses how environmental control and autonomy are crucially important to the psychological well-being of the residents. Ecological psychology is concerned with the knowledge of designing environments for elderly people. When designing methods to improve the quality of life in homes, Winfried Saup considered the following goals:

_ Creating ways for the residents to exercise control of their environment (for example, having a front door key)
_ Not furnishing private rooms with standardized furniture
_ Creating a stimulating environment that is exciting and activating
_ Enabling residents to regulate their privacy.

Analyses that identified the degree of elderly people's dependence on supportive and restrictive environmental conditions have shown that an environment with a stimulating design can activate the organism's "reserve capacities." This means the organism is more energetic and autonomous than in low-stimulus surroundings. We can therefore assume that older people possess a "reserve capacity" that is often neglected. Environmental conditions in retirement homes that do not stimulate or challenge its residents contribute to stunting their potential, which can fuel apathy, illness, even to feeling tired of life. Older people, according to their individual lifestyle, need peace and quiet in addition to activity and social contact; they need privacy and occasionally to be able to distinctly retreat into their internal, private worlds. All of these differences need to be considered and given the space in which they can be satisfied. The biological fact of aging includes physical degeneration: a reduction of overall fitness and agility, diminishing eyesight, hearing, memory faculties, and sense of orientation. These issues must be addressed when designing environments for elderly people. Sensory deficits lead to changes of perception and a diminished sense of well-being, which often involves strong feelings of insecurity. An effective environmental design should compensate for these deficiencies as much as possible. Changes in sight and hearing are the most common sensory impediments associated with age. The eye's lens thickens and becomes less transparent. Cataracts are also a common ailment associated with age, and cause fragmented and blurred vision. People with cataracts also have a diminished perception of depth, making

it difficult to discern whether objects are in the background or foreground. For this reason, floor coverings with large-patterned designs should not be used on stairs, because they make it difficult to distinguish the height and perimeter of each step. The yellowing and clouding of the optic lens that occurs with age weakens the ability to see color. Violet, blue, and green are perceived increasingly paler; consequently when using these colors it is best to choose more intense nuances. Stronger contrasts (3.5% more than for people between the ages of 20 and 30) have a positive effect on older people's vision. This is particularly important to consider in relation to "figure-ground difference" when looking at an object in its direct surroundings. Objects are easier to see if the contrast between them and their surroundings is clear. Sensitivity to glare also increases with age, and glare also diminishes the perception of contrast. All visible surfaces should therefore be non-shine and glare-free. Floors should have a matt finish and not be polished. Shiny floors look slippery, and make older people afraid that they might fall. The basic needs of elderly people can be attributed to their changed sensitivity to external stimulation and its psychological effects, which often involves certain physical impediments. The sensory organs and central sensory sensations become particularly weakened, which makes external compensation imperative. Memories are also essential to elderly people, and are the basis of their emotions. This creates a need to convey the self to the outer world as well as to stimulate the memory, which can be encouraged by allowing the elderly residents to bring some of their own furniture and other personal items when they move into the retirement home. An older person may well reject new furnishings that someone else has chosen and arranged in his or her private area, and that make him or her feel foreign in the new surroundings. Elderly people's requirements in a retirement home can be summarized as follows: a basic need for a sense of existential well-being and roots, as well as a desire for familiarity, warmth, peace, security, and protection from fear and disturbances in their new environment. It is also important to have human contact, social gatherings, group activities, as well as privacy. Different individual needs for stimulation, participation, activity and intellectual activities, even peace and relaxation, or the space to reflect must also be taken into account.

IMPRESSION AND VISUALIZATION

Retirement homes should convey an atmosphere of warmth, security, peace, and comfort. But they should also provide vitalizing stimulation and diversity, and encourage communication. Retirement homes should never express uniformity or monotony, but project an accommodating, friendly, safe, and lively character, in terms of their external appearance as well.

Friendly, calm but not cool color combinations would be an ideal solution.

The need for visual communication is pronounced in older people, and their environment therefore has to provide something to look at and observe. It is important to note that in older people the sense of touch is often more intact than the other senses. This can be activated and stimulated by consciously choosing materials for their tactile experience.

It is also essential to organize the building in a comprehensible way. Individual functional areas, such as corridors, leisure rooms, dining rooms, living spaces, and treatment rooms must be clearly marked. They need to be located easily and correspond to human dimensions. It is imperative to design an environment in which people can feel at home – an environment that signifies "living" and not merely "housed."

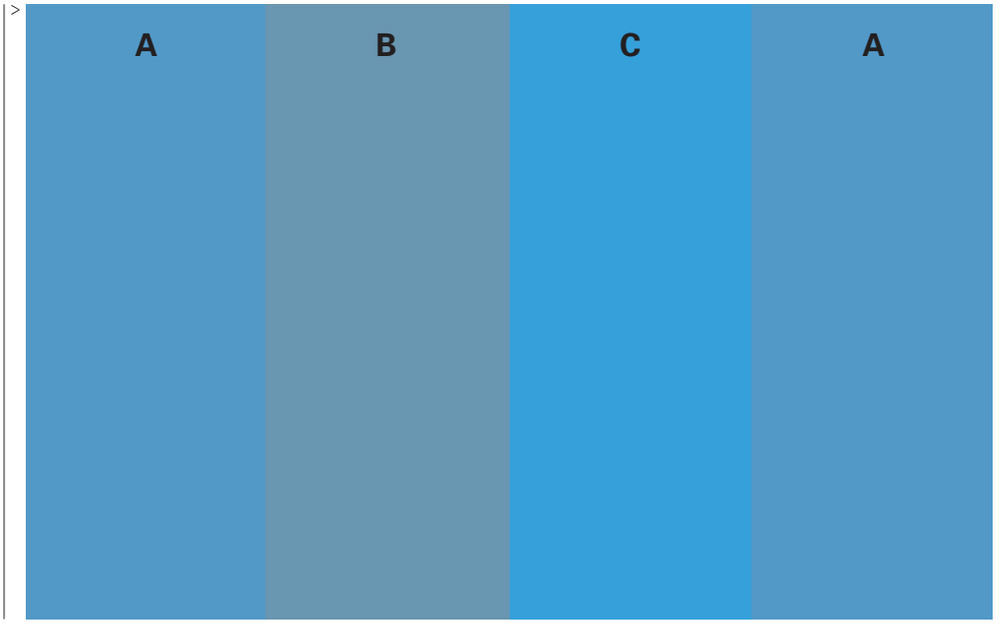
COLOR AND MATERIAL DESIGN OF THE MAIN FUNCTIONAL AREAS

Foyer:
The foyer is the admissions area, but it is also a communicative meeting place. The spatial environment should be designed as such and express an inviting, friendly, and stimulating atmosphere by using mainly warm contrasting nuances with accents of cool color elements.

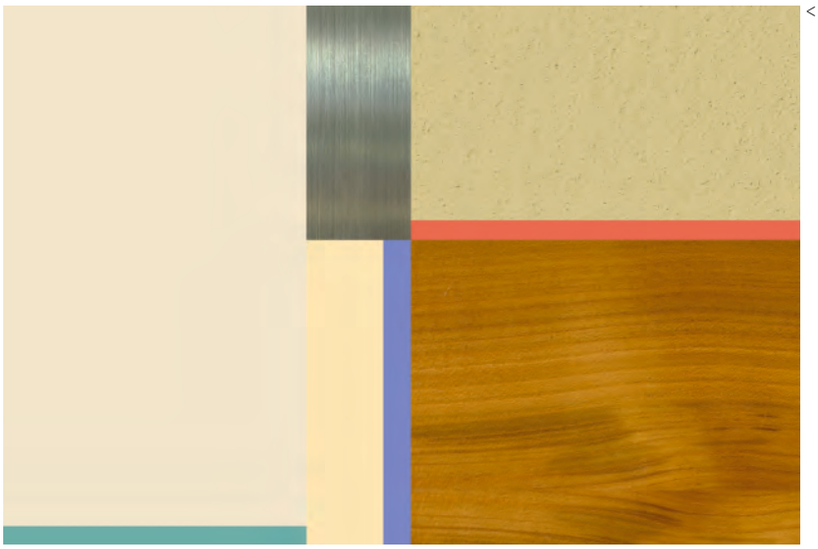
Corridors:
Corridors are places of movement and meeting places for informal communication, discussion, or leisure. They can also become "adventure zones," using windows with a view to the garden outside, seating arrangements, plants, and a differentiated light, material, and color design. Corridors on different floors and functional areas should be clearly marked by different colors, which help orientation.

Living Spaces:
Living spaces are private areas and, as such, should be arranged by the residents with their own furniture and according to their own taste as far as possible. Living spaces in retirement homes should not be uniform in design. They need to allow for individuality, personality, and for a "distinct ambiance," which serves a sense of well-being and a feeling of being at home.

Community Rooms:
Regarding community rooms, there should be a distinction between places to enjoy peace and quiet, and those used for entertainment and activity. They should be designed accordingly with the appropriate color milieu: muted color nuances are recommended for rooms in which to relax, while for activity rooms, a more stimulating and communicative atmos-

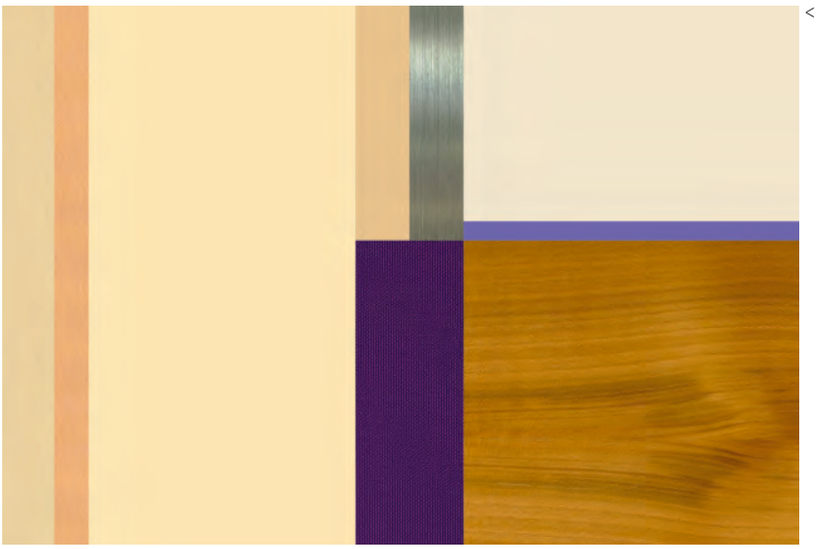


Due to a loss of sight caused by aging, hue A is perceived as grayer, as is illustrated in B. In order to display A more accurately, the chroma has to be increased as in figure C.



Corridor in a retirement home

Treatment room
in a retirement home



Multipurpose and dining room
of a retirement home

phere can be attained by using bright, warm shades or saturated nuances.

Dining Rooms:
Meals are an important daily event for many older people, and they can well be anticipated with joy. The environment of the dining room can resemble a dignified and friendly restaurant, an inviting place where the residents can feel good and be relaxed. It is also recommendable to use primarily warm nuances, and materials and contrasting accents can achieve this ambiance, as well as dividing large spaces to allow small table groups to form.

ALTERNATIVE CONCEPTS

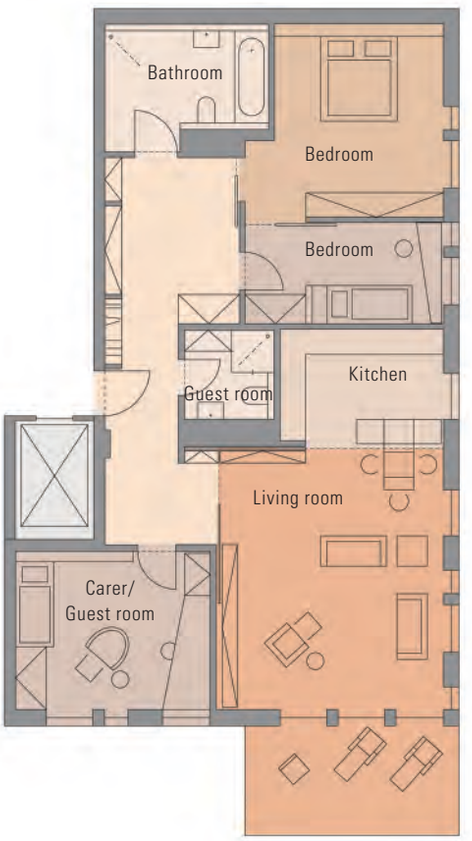
Alternatives to traditional retirement homes are being discussed and developed in many countries. For a large majority, "senior living" means living in one's own four walls. Yet the conditions here are often inadequate. The shortcomings of small-minded investor floor plans or social housing standardization become evident when home care begins. This period of life may last 20, 30, or 40 years, which makes it vital to define an apartment standard that will suit an entire life. "Assisted living," "small units," communal residential homes, and other such models need to be more thoroughly evaluated.

HOME CARE

Home care means having to create a new floor plan. Over the course of a life, flexible areas have to be adapted to the current life conditions at hand. Gerontology studies the increasingly differentiated pattern of disease in older people. The sensitivity needed when designing the domestic and medical environment must increase accordingly. This is our suggestion for taking care of a patient with Alzheimer's disease: first, install only two supply lines in the floor plan. A sequence of rooms should be developed that allow for optimum moveability (an infinite loop would be the ideal). The apartment should be able to accommodate nursing staff and family members, and must be wheelchair-friendly. Studies in day clinics have shown that Alzheimer's patients are tactile and olfactory sensitive. Besides scents and different natural materials, there is a preference for gentle colors, such as dusky pink or apricot, which are not too loud or contrasting.

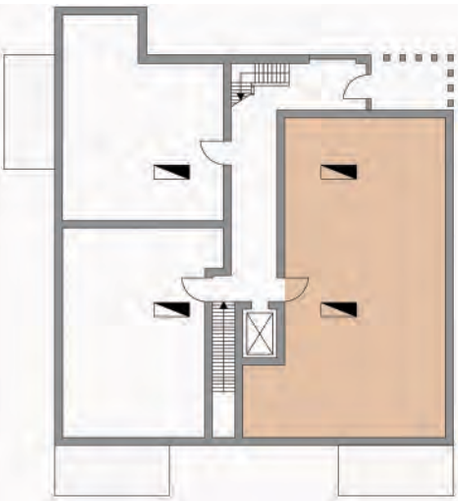
HOSPICES

Hospices existed as early as the Middle Ages; as places of hospitality, they offered refuge to pilgrims and travelers and took in people in need of care. Today, the term hospice denotes a "home" for severely and terminally ill individuals who can no



Home care
Architecture and color design:
Otto Steidle, Gerhard Meerwein

Home care, dementia



Ground plan diagram

longer be cared for adequately in their own homes or in the hospital. Hospices are places where death is understood to be a natural part of life, and patients and their families are provided with psychological and spiritual support in the process of saying goodbye. The main focus of hospice care is quality of life. Here, patients are provided with space for individuality and community, and experience support, companionship, and peace.

IMPRESSION AND VISUALIZATION; COLOR AND MATERIAL DESIGN

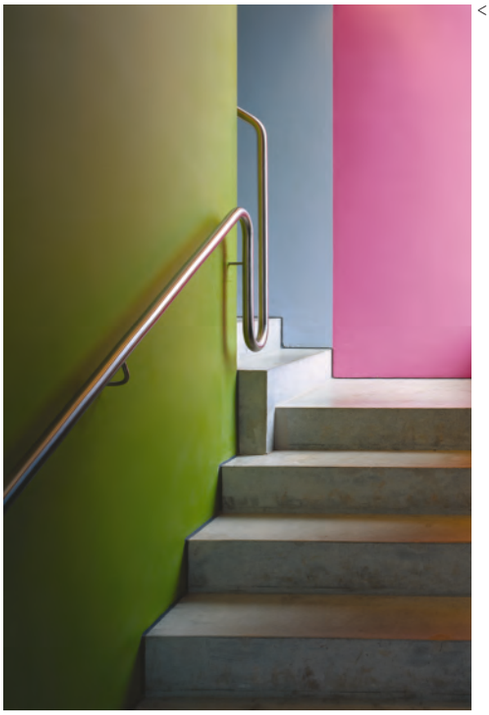
The spatial environment of a hospice must be designed with care and convey a sense of well-being. The different functional areas should all be treated equally. Guests need to feel safe, secure, and in control of their surroundings. Rooms and spaces in the building should reduce anxiety and stress and have a refreshing, vitalizing effect. Moreover, the hospice must provide space for intimacy, peace, and quiet. We recommend using subtly stimulating colors that appeal to the senses, as well as invigorating elements. The building should employ natural materials and facilitate a rapport with nature.

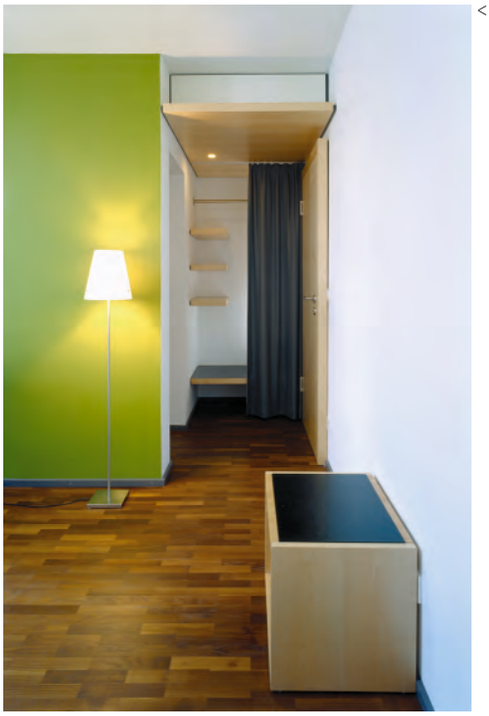
CHILDREN'S HOSPICES

In addition to hospices for adults, there are also hospices designed specifically for children. The first of these were founded some 20 years ago. Great Britain has taken a leading role internationally in the conceptual development and quality criteria of children's hospices. Child hospices care for children with terminal diseases and limited life expectancy, but who do not require intensive medical care. Children can visit a hospice together with their parents and siblings many times during the course of their illness. Their stays can last anywhere from several days to two weeks. Because hospices are regarded as a place to live, only eight to ten children, together with their relatives, are admitted at any one time. The family members live in an area connected to the hospice itself. This allows them to spend time together with their child and also to enjoy some privacy.

Aside from caring for children in their final phase of illness, the most important function of a child hospice is to support, stabilize, and provide relief to relatives. The services offered are geared toward the entire family and include guidance and counseling on home nursing, as well as support in coping with psychological stress and solving intrafamilial problems. The siblings of the sick child are given the chance to process their fears and often ambivalent feelings in a manner appropriate to their age.

The children's illnesses are severe and complex; physical complaints, psychological problems, and mental impairments often appear simultaneously. The children's everyday lives are shaped by fears and painful phases. As their disease progresses, older children may lose skills they once possessed, such as the ability to speak. Indeed, their sensory perceptions can become so impaired that they have difficulty expressing them-





Hotel Haeckenhaus, Ramsen
Architecture and color design: Richter, Naumann, Stuttgart
This illustration of a hotel situated in a peaceful landscape location corresponds to the conditions requested by the hospice.

selves or understanding what they are experiencing. In extreme cases, children remain almost fully cut off from environmental stimuli.

For children, the need for emotional warmth and loving care, to feel accepted, safe, and secure, is of the utmost importance. They react very sensitively to their surroundings and the behavior of their attachment figures. Klaus Wingenfeld points out that the aim of a hospice is to provide children with a space that activates their skills of perception in many diverse ways, fosters existing resources, and promotes social contacts. The ability of a child hospice to address these many needs depends on exceptionally good personnel and material resources, and the high degree of professionalism demanded of a hospice's staff must be reflected in the facility's interior design.

Peter Schmieg from the University of Dresden points to observations made in children's hospices in the United States showing that "disease symptoms are less likely to occur and are easier to control in spatially optimal surroundings. One criterion in this regard is ensuring an environment that supports communication."

IMPRESSION AND VISUALIZATION; COLOR AND MATERIAL DESIGN

The requirements of interior design in child hospices include:

_ Combining functional needs with modern conveniences
_ Taking the needs of children into account
_ Designing the children's rooms with special consideration for their impaired perceptions or mobility
_ Incorporating medical and nursing equipment in an inconspicuous manner
_ Ensuring that the spatial environment and options for play and other activities are appropriate for children
_ Ensure sufficient acoustic, visual, and tactile stimuli
_ Creating a snoezelen room.

Snoezelen can be defined as "a concept for designed, primarily interior environments in which controlled multisensory stimulation generates a sense of well-being. Specially constructed rooms offer a wide variety of sensory stimuli. The user can embark upon a journey of discovery through the realm of his or her senses, experiencing either the individual effects or unique combinations of music, tones, sounds, light effects, tactile stimulation, and fragrances" (Deutsche Snoezelen Stiftung 2000).

The spatial environment of a children's hospice should foster a sense of well-being. A differentiated design should ensure that all sensory organs are stimulated in a subtle manner. In addition to the choice of colors and lighting, the quality of experience facilitated by the materials is very important. In this regard, preference should be given to natural materials. The color composition should create a friendly, overall impression of warm tones. Strong nuances of color may be employed

as accents or within lounge areas. Aside from specifications pertaining to the building as a whole, colors should be used to distinguish between the various functional areas in order to achieve stimulating and invigorating color dynamics, easy orientation, and diversity of architectural space. Here, it is very important that the relationship between the interior and exterior of the building be designed to enable a rapport with nature.

RESTAURANTS

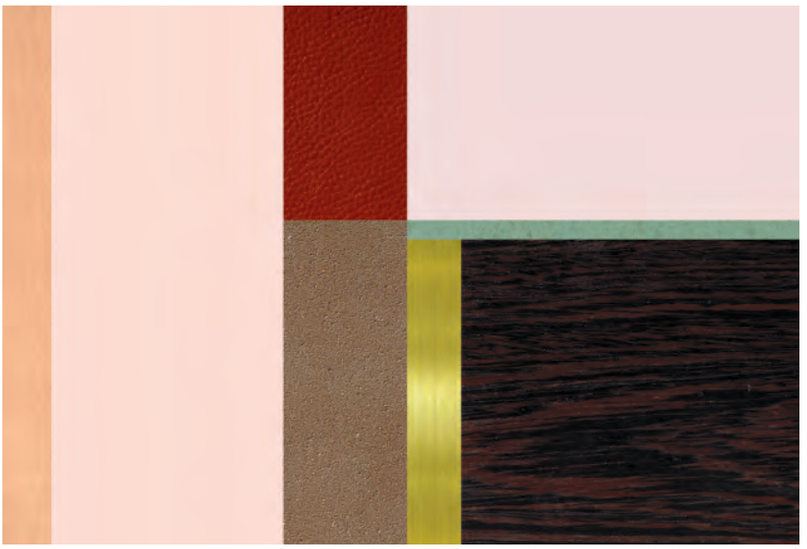
A restaurant's success depends on a combination of many factors, including the quality of the cooking and the service, as well as the price and range of dishes and beverages on offer. As long as the criteria of good food and service are met, an inviting and attractive restaurant will always be a more successful one. Studies in the United States show that in addition to the cuisine, service, price, odor, sounds, and lighting, as well as comfort, interior furnishings, color design, and a suitable amount of privacy are crucial to whether guests will rate the overall atmosphere as positive or negative. Of course, these evaluations depend on individual expectations, attitudes, and experience. As a result, guests display a varying degree of tolerance for each factor.

The stimulating nature of a restaurant encompasses its social and physical ambience. Social ambiance describes how guests experience a restaurant, both in terms of the other guests (crowded, loud, lacking in privacy), and the behavior of the wait staff (friendly/unfriendly, competent/incompetent). Physical ambience in turn describes the atmosphere, the comfort of the seats, and the overall design of the furniture, materials, colors, and other important design elements.

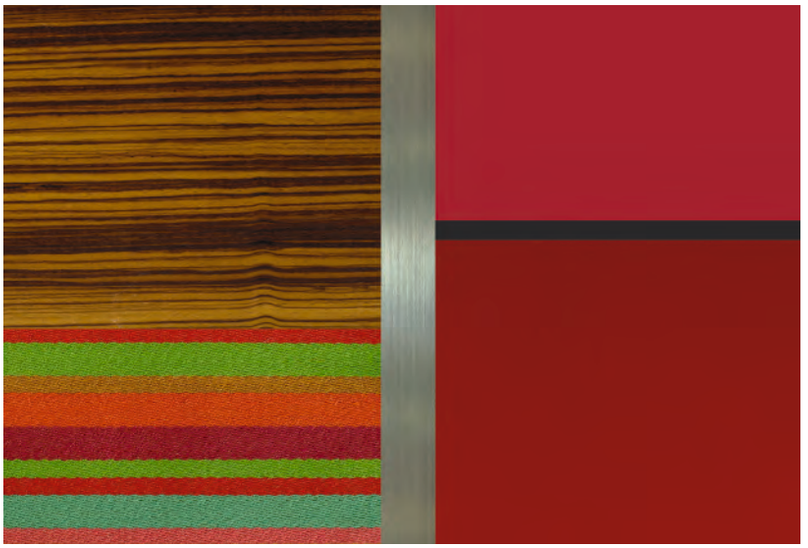
These elements play a key role in determining a guest's overall impression and experience; combined, they must create an appearance that appeals to a majority of customers. Psychological effects determine the feelings and behavior of the guests: satisfaction with the cuisine, comfort, and the length of time spent in the restaurant are all crucial factors that people remember. The following aspects should be considered with regard to design:

- Type of space (fast food stand, bistro/café, pub or wine bar, standard restaurant, first-class restaurant; special types include dinner and dance restaurants, hotel restaurants, bars, and family restaurants)
- Type of cuisine (fast food, home-style cooking, haute cuisine, national and international specialties)
- Type of atmosphere (ethnic, country-style, family restaurant, middle class, cozy, exclusive, elegant, luxurious).

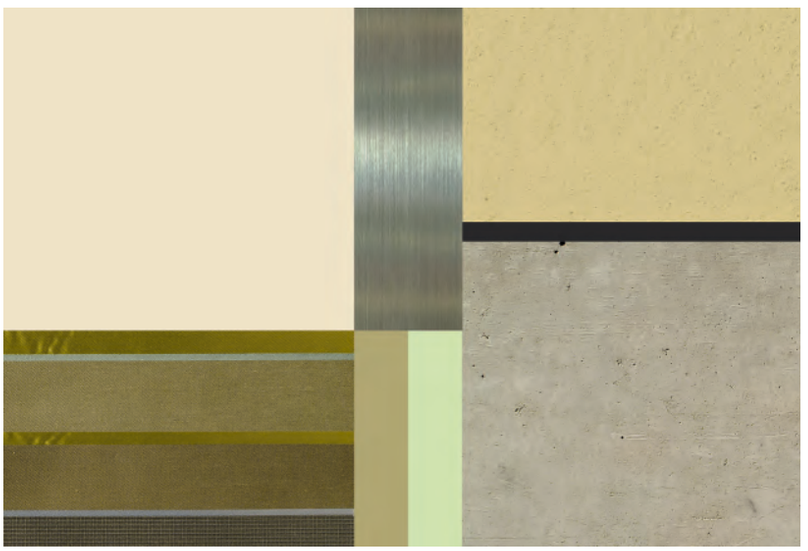
Elegant, classical restaurant >



Exotic, ethnic restaurant >



Purist restaurant >



There is no doubt that various types of restaurants can elicit different feelings and behaviors. A restaurant's atmosphere should emphasize its character; whereas its social and physical ambience defines the harmony of the restaurant's visual atmosphere and cuisine. For example, a seafood restaurant can mirror freshness through nuances associated with the coolness of the sea, sun, or beach. For restaurants with specialty cuisine, it is of course important to establish a connection between milieu and menu by means of design, yet cultural design elements and decorations are too often an over-used, hackneyed design tactic in ethnic restaurants, despite the fact that a few, carefully placed and abstract stylistic features would create a more persuasive link in terms of atmosphere. A Mexican restaurant, for example, can be more convincing and effective when using subtler color combinations, instead of the clichéd, highly chromatic colors, and stuffing it with cacti and sombreros. An attitude towards design such as Luis Barragán's would more credibly symbolize the characteristic features of Mexican cuisine (hot, spicy) outside of the Mexican cultural milieu.

IMPRESSION AND VISUALIZATION; COLOR AND MATERIAL DESIGN

Design solutions are as numerous and diverse as restaurants themselves. In general, the associative effect and symbolic meaning of colors can contribute to achieving the desired spatial environment. If a cheerful, sociable atmosphere is sought, cheerful and somewhat stronger colors may be used, whereas a tranquil, elegant, and subdued atmosphere is best achieved by tranquil, elegant, and subdued materials and nuances of color. The following planning criteria need to be considered:

_ Type of restaurant/cuisine
_ Target group/guests
_ Spatial environment/size/location
_ Image
_ Lighting
_ Material and color design.

Applied color psychology provides advice on effective synesthetic impressions of colors and color groups. It seems in

Neobar, Chemnitz
Architecture: Jan Piechulla

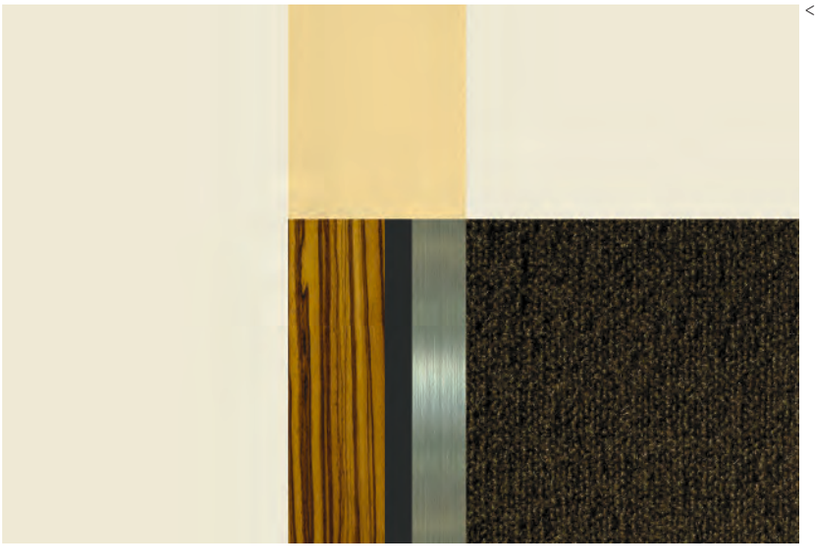
retrospect that the positions outlined in older literature sources reflected more the *zeitgeist* at the time of their publication. Below is a summary of the findings of a number of studies on color impressions (see also Frieling 1990, Birren 1982, Mahnke 1996).

_ Warm red nuances (vermillion, flamingo, coral), oranges (peach, pumpkin), warm yellow, light yellows, and fresh clear greens are thought to stimulate the appetite. Purple, violet, purplish red, yellow-green, mustard, and gray tones hold little food appeal.
_ Blue-greens (aqua, turquoise), although seldom associated with food itself, are well regarded as complimentary accents and can be used to advantage as backgrounds for food displays.

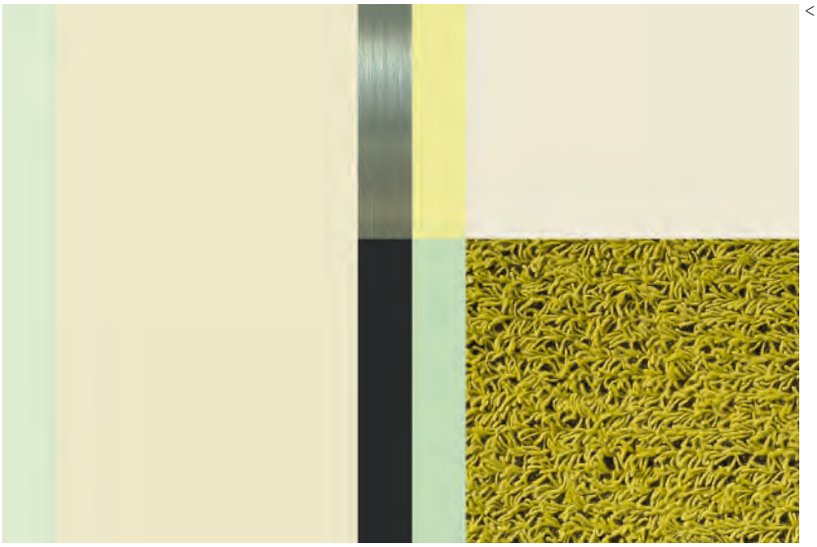
In the field of vision surrounding a dining table, it is essential to use appropriate contrasts to emphasize the quality, freshness, seasoning, and natural flavor of the meals, as well as differences in and relationships between flavors. This is where complementary contrasts are particularly effective: the contrast between the dishware, table, and meals should be stimulating. This is when the quality of light plays a key role: cold or warm light or improperly mixed lighting can determine whether the meals appear fresh and appetizing, as well as influence personal physical appearance. Consequently, it is essential to modulate a room with spots and accentuated lighting. Creating "private islands" and avoiding boring, monotone, or flat lighting is crucial to psychological perception in general. The space has to seem lively and friendly. The quality of the meals and the atmosphere of the interior space should combine to create a congruent overall impression. In addition to the basic function of eating, restaurants fulfill additional needs for the vast majority of people: being a guest, presenting oneself in public, seeing and being seen, prestige, communication, enjoyment, and relaxation. People often see restaurants as an "alternative world" to their own homes. Yet a homelike design approach can still be very well-suited to restaurants.

Restaurant Centre Pompidou, Paris
Architecture: Jakob and MacFarlane
Futuristic image

Side-Hotel, Hamburg
Interior Design: Matteo Thun
The spatial mood can be varied by changing the lighting.



< Residential but severe



< Young and playful

APARTMENTS/HOUSES

IMPRESSION AND VISUALIZATION; COLOR AND MATERIAL DESIGN

There are hardly any universally applicable rules for using colors in living spaces. Nevertheless, it is important to approach certain criteria methodologically. Here, as elsewhere, the laws of harmonious color contrasts hold true and can be judged according to the way they balance dominance, subdominance, and accent. Developing a color design that suits an occupant and the space surrounding him or her requires an intensive analysis of the relationship between people and architectural space.

Interior design is only good if it is geared toward an occupant's mentality and ideas, as well as the architecture of the space and relationships between spaces. In living spaces, in particular, interior design must establish connections between people – between partners, parents, and children – at least if they are not living alone. This means finding the common denominator among a variety of individual needs.

People experience their environment, their house, or their apartment as agreeable only when the relationship with their surroundings is harmonious. This happens, in particular, when people create their environment themselves or in collaboration with responsible advisors, regardless of whether the goal is baroque opulence or Zen-like simplicity. Both are expressions of home furnishing styles and individual needs that can change over the course of personal development. We design our living space differently according to our current state of being. As part of this process, outside advisors can help us implement our own ideas about the functions of certain rooms and their quality of impression.

We can only feel good in our private spaces if they conform to us – in both their usefulness and atmosphere. The design of a living space has to be adapted to its occupants, including their current lifestyle; it has to relate to the personal aspects of their lives, their ideas, wishes, and needs so that a link can be established between individuals and their living environment, together with a synthesis of inner and outer worlds, the integration of people and architectural space.

The more time a person spends at home, the greater the effect of a living space's interior design. The interplay of light, colors, materials, and forms influences a person's well-being and can thus, if applied meaningfully and correctly, contribute to rest, relaxation, and recuperation. However, many people have lost a natural feeling for how to design their living space so that it meets their personal needs, especially when it comes to the use of color. This question is often accompanied by a great deal of uncertainty. Interior design consultants, architects, and interior architects are confronted with these problems on a daily basis.

The numerous optical impressions and an overabundance of stimuli offered by today's civilization, in all areas of the en-

vironment, are hardly suited to refine our sense of or to help us choose colors – not to mention the increasingly short-lived trends in fashion and color that also affect the field of interior design. The key task of competent consulting and design practice – if they are to convey quality of living and, thus, quality of life – is to establish people's wishes with regard to the design of their living environment, to interpret these wishes in a sensitive manner, and only then to develop a design concept that will produce clear ideas of the space at hand and translate these into reality.

Villa Laroche, Paris
Architecture: Le Corbusier 1924
Classical modern image

Living X, Leinfelden-Echterdingen
Architecture: G.A.S. Sahner

CONCLUSION

A person's appreciation of aesthetics and quality continues to develop well into age. Consequently, good color design requires sensitive insight, sound knowledge of color's meaning and effect, professional competence in the use of color in architecture and interior design, plus a holistic conceptual approach, awareness, and creative courage.

It also requires a distinct sense of elegance, culture, design, and material.

In addition to architecture, interior design, materials and light, good color design is an essential factor in the communication between human beings and architectural space, in all areas of life. It is a cultural and social responsibility.

For information on educational opportunities and project consultation please contact:

Prof. Gerhard Meerwein
Augustinerstrasse 32
D-55116 Mainz
Tel.: (+49) 06131-224602
Fax: (+49) 06131-238103
meerwein@gmx.de

Dr. Bettina Rodeck
Taarbaek Strandvej 89 C, 1.
DK-2930 Klampenborg
Tel.: (+45) 39907210
Fax: (+45) 39908210
rodeck@axicon.dk

Frank H. Mahnke
11 Quai Capo d'Istria
CH-1205 Genf
Tel.: (+41) 022-3295836
Fax: (+41) 022-3295836
mahnke_aicce@hotmail.com

AICCE – American Information
Center for Color and Environment
3621 Alexia Place
San Diego, California 92116, USA
Tel.: (+1) 619-2830062
Fax: (+1) 619-6400768
mahnke_aicce@worldnet.att.net

APPENDIX

BIBLIOGRAPHY

Albers, Josef: Interaction of Color, Yale University Press, New Haven and London 1963

Ali, M. R.: Pattern of EEG Recovery under Photic Stimulation by Light of Different Colors. Electroencephalography and Clinical Neurophysiology 33 (1972): 332–35

Beral, Valerie, et al.: Malignant Melanoma and Exposure to Fluorescent Lighting at Work. The Lancet (1982): 200–293

Berlyne, D. E.; McDonnell, P.: Effects of Stimulus Complexity and Incongruity on Duration of EEG Desynchronization. Electroencephalography and Clinical Neurophysiology 18 (1965): 156–61

Bettelheim, Bruno: Der Weg aus dem Labyrinth, Deutsche Verlagsanstalt, Stuttgart 1975 (2nd ed., Deutscher Taschenbuchverlag, Munich 1990)

Birren, Faber: Color and Human Response, Van Nostrand Reinhold, New York 1978

Birren, Faber: Light, Color and Environment, rev. ed. Van Nostrand Reinhold, New York 1982

Bollnow, Otto Friedrich: Mensch und Raum, Kohlhammer, 5th ed., Stuttgart 1984

Dantsig, N. M.; Lazarev, D. N.; Sokolov, M. V.: Ultraviolet Installations of Beneficial Action. International Commission of Illumination, Publication CIE No. 14A, Bureau Central de la Commission (1968): 225–31

Deutsche Snoezelen Stiftung (ed.): Snoezelen. Eine Einführung in die Arbeit der Deutschen Snoezelen-Stiftung, Königslutter 2000

Ewers, Michael; Schaeffer, Doris (eds.): Am Ende des Lebens. Versorgung und Pflege von Menschen in der letzten Lebensphase, Verlag Hans Huber, Bern 2005

Fell, Margret: Bildungsräume der Erwachsenenbildung, Grundlagen der Weiterbildung – Zeitschrift 10 (1999): 176–178

Felten, David, "Wie Gedanken und Gefühle das Immunsystem beeinflussen"– Interview Psychologie Heute 5, Beltz Verlag, Weinheim (1994): 32–40

Frankl, Viktor E.: Logotherapie und Existenzanalyse, Quintessenz, Munich 1994

Frankl, Viktor E.: Ärztliche Seelsorge – Grundlagen der Logotherapie und Existenzanalyse, new ed., Zsolnay-Verlag, Vienna 2005

Frieling, Heinrich: Gesetz der Farbe, Muster-Schmidt Verlag, Göttingen 1990

Frieling, Heinrich; Meerwein, Gerhard; Rodeck, Bettina: Farbe am Arbeitsplatz, Bayerisches Staatsministerium für Arbeit, Familie und Sozialordnung, Munich 1992

Gebessler, Renate: Zeichen einer humanen Arbeitswelt, in: Votteler, Arno: Ideen für eine neue Bürowelt – Catalog for the exhibition "Lebensraum Büro" at the Orgatec in Cologne, 22.10–27.10.1992, Oktagon-Verlag, Munich 1992

Gerard, R.: The Differential Effects of Lights on Physiological Functions. Ph.D. thesis, University of California, Los Angeles 1957

Goldstein, E. B.: Wahrnehmungspsychologie, Spektrum Akademischer Verlag, Heidelberg 1997

Grandjean, Etienne: Physiologische Arbeitsgestaltung – Leitfaden der Ergonomie, 4th ed., Ott-Verlag, Thun 1991

Gregory, R. L.: Seeing in the Light of Experience. Trotter-Paterson Memorial Lecture. Lighting Research and Technology 3 (1971): 247–50

Hentschel, H. J.: Lichtquellen und Lampen, Siemens-Haus-Zeitschrift (3/93)

Hesselgren, Sven: On Architecture: An Architectural Theory Based on Psychological Research. Studentlitteratur, Lund; Chartwell-Bratt Ltd., Bickley 1987

Hodecek, Otto: Seminarräume, Diploma thesis, IACC Academy, Salzburg 2002

Hollwich, F.; Dieckhues, B.; Schrameyer, B.: Die Wirkung des natürlichen und künstlichen Lichtes über das Auge [The effect of natural and artificial light via the eye on the hormonal and metabolic balance of man [author's transl.]. Klinische Monatsblätter für Augenheilkunde und für augenärztliche Fortbildung, 171 (1977): 98–104

Hosak-Knoll, Sanna: Wellness-Spa-Vitarium, AIT – BDIA-Impulse 1 (2001)

Hughes, Philip C: Lighting and the Work Environment. North Bergen N.J. Duro-Test Corporation, 1982

Itten, Johannes: Kunst der Farbe, 5th ed., Otto Maier Verlag, Ravensburg 1961

Jacobs, K. W.; Hustmyer, F. E.: Effects of Four Psychological Primary Colors on GSR, Heart Rate and Respiration Rate. Perceptual and Motor Skills 38 (1974): 763–766

Jung, C. G.: Man and His Symbols, Doubleday 1969

Klee, Paul: Pedagogical sketch book, Nierendorf Gallery, New York 1944

Kruse, L.; Graumann, C. F.; Lantermann, E. D. (eds.): Ökologische Psychologie, Psychologie Verlags-Union, Munich 1990

Kükelhaus, Hugo: Fassen Fühlen Bilden – Organerfahrungen im Umgang mit Phänomenen, Gaia Verlag, Cologne 1978

Kükelhaus, Hugo: Unmenschliche Architektur – von der Tierfabrik zur Lernanstalt, 7th ed., Gaia Verlag, Cologne 1991

Küller, Rikard: Non-Visual Effects of Light and Color, Annotated Bibliography, Document D15: 81, Swedish Council for Building Research, Stockholm 1981

Kunze, Mirko: Architekturpsychologische Untersuchungen zum Krankenhausbau, Dissertation, HAB Weimar 1994

Kurz, Wolfram: Philosophie für helfende Berufe, Verlag Lebenskunst, Tübingen 2005

Lam, W. M. C.: Perception and Lighting as Formgivers for Architecture, Van Nostrand Reinhold, New York 1992

Lempp, R.; Schiefele, H. (eds.): Ärzte sehen die Schule, Beltz Verlag, Weinheim/Basel 1987

Mahnke, Frank; Mahnke, Rudolf: Color and Light in Man-Made Environments, Van Nostrand Reinhold, New York 1987

Mahnke, Frank: Color, Environment & Human Response, Van Nostrand Reinhold, New York 1996

Meisenheimer, Wolfgang: Raumstrukturen, ad 16, FH Düsseldorf 1989

von Meiss, Pierre: Vom Objekt zum Raum zum Ort, Birkhäuser, Basel, Boston, Berlin 1994

Moholy-Nagy, László: The New Vision, from Material to Architecture, New York: Brewster, Warren and Putnam 1930

Moruzzi, G.; Magoun, H. W.: Brain Stem Reticular Formation and Activation of the EEG. Electroencephalography and Clinical Neurophysiology, 1949: U 55–73

Osram Lichtprogramm 2004/2005

Piaget, Jean: Die Entwicklung des räumlichen Denkens beim Kinde, Complete works vol. 6, 3rd ed., Klett, Stuttgart 1999

Pierman, Brian C. (ed.): Color in the Health Care Environment. NBS Special Publication 516. U.S. Department of Commerce/National Bureau of Standards 1978

Resch, Karl-Ludwig: Kontaktanzeige: Medizin sucht Innenarchitektur, AIT – BDIA-Impulse 1 (2001)

Riedel, Ingrid: Farben in Religion, Gesellschaft, Kunst und Psychotherapie, Kreuz Verlag, Stuttgart 1991

Rittelmeyer, Christian: Schulbauten positiv gestalten, Bauverlag, Wiesbaden, Berlin 1994

Rock, I.: Wahrnehmung. Vom visuellen Reiz zum Sehen und Erkennen. Spektrum Akademischer Verlag, Heidelberg, Berlin, Oxford 1985

Rodeck, Bettina; Meerwein, Gerhard; Mahnke, Frank: Mensch-Farbe-Raum, 2nd ed., Alexander Koch, Leinfelden-Echterdingen 1999

Rodeck, Bettina: Raum als sinnesanregendes Milieu, Workshop accompanying materials, Klampenborg 2004

Rüegg, J. C.: Psychosomatik, Psychotherapie und Gehirn, Schattauer, Stuttgart 2003

Saup, Winfried: Altenheim, in: Kruse, et al. 1990

Scheurle, Hans Jürgen: Die Gesamtsinnesorganisation. Überwindung der Subjekt-Objekt-Spaltung in der Sinneslehre, Georg Thieme Verlag, Stuttgart 1984

Schierz, Christoph: Licht und Wahrnehmung, Lecture given at the ETH Zurich 2005

Schmieg, Peter: Gestaltung für ein würdiges Sterben, AIT – BDIA-Impulse 2 (2005)

Schneider, Wulf: Sinn und Un-Sinn – Umwelt sinnlich erlebbar gestalten in Architektur und Design, Konradin Verlag, Leinfelden-Echterdingen 1995

Servan-Schreiber, D.: Die neue Medizin der Emotionen, Goldmann, Munich 2006

Spath, Dieter; Kern, Peter (eds.): Office 21 – Mehr Leistung in innovativen Arbeitswelten, vgs, Stuttgart 2003

Spillmann, Werner: Farbe als Gestaltungselement der Architektur, Textbook for color courses in the Architecture Faculty, Technikum Winterthur 1988

Spivack, Mayer; Tamer, Joanna: Light and Color. A Designer's Guide, American Institute of Architects Service Corporation, AIA Press Division, 1984

Uyttenhove, Pieter: Tendenzen der Farbgestaltung in Frankreich, in: Taverne, Ed; Wagenaar, Cor (eds.): Die Farbigkeit der Stadt, Birkhäuser Verlag, Basel, Berlin, Boston 1992

van der Star, Ada: Schöpferisch pflegen, Verlag Urachhaus, Stuttgart 2001

Verres, Rolf: Heilsame Wirkfaktoren von Räumen, Der Architekt 7–8 (2003)

Verres, Rolf: Was uns gesund macht, Ganzheitliche Heilkunde statt seelenloser Medizin, Herder, Freiburg, Basel, Vienna 2005

Verres, Rolf: Über die Heilkraft von Innenarchitektur im sozialen Kontext, AIT – BDIA-Impulse 2 (2005)

Wingenfeld, Klaus: Hospizversorgung schwerkranker Kinder mit begrenzter Lebenserwartung, in: Ewers and Schaeffer 2005

Wurtman, Richard J.: The Pineal and Endocrine Function. Hospital Practice 4 (1969): 32–37

Wurtman, Richard J.; Neer, Robert M.: Good Light and Bad. New England Journal of Medicine 282 (1979): 394–395

Wyszecki, Günter: Farbsysteme, Muster-Schmidt, Sudheim 1960

Zajonc, A.: Die gemeinsame Geschichte von Licht und Bewusstsein, Rowohlt, Hamburg 1994

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