LAMP

Worktitude for light

Light solutions for cognitive accessibility and sensory integration

Artificial lighting: designing accessible spaces

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EDITORS

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Master's Degree in Accessibility and Design for All from La Salle University. Madrid. She has participated in international cooperation projects with the United Nations. In 2015, she created the Association for Easy Understanding of Environments and Buildings (ACFEE - *Asociación para la comprensión fácil de entornos y edificios*), of which she is the president.

Since 2011, she has developed a design methodology for cognitive accessibility, a model that began to be enriched in 2018 with a focus on neuroscience and architecture. By 2020, she was taking a more holistic approach, by including sensory integration variables. These innovations in design and architecture have opened doors for her as a lecturer at universities –and other centres of learning on topics related to her experiences– in Spain and Latin America: Argentina, Chile, Colombia, Ecuador, Peru. And Central European countries: including Greece and Malta, with the latter taking on board the model with all its consequences by working for a full week according to the model's methodology.

In Chile she had the opportunity to participate in project teams on social housing legislation and cognitive accessibility and sensory integration in official institutions.

She has won prizes, awards and participated in national and international congresses. The books she has published have been translated into English and many of the articles written for CENIE[1] have been translated into English and Portuguese. She collaborates with teams that design spaces for the elderly, people with intellectual disabilities, autism and educational centres to improve the conscious mobility of people who use these facilities and study centres.

A brief overview of the cognitive accessibility projects highlights the intention that natural and artificial light be part of the spirit of the space. However, for various reasons –economic, the pre-existence of the installations, the possibility of using both formal and coloured elements– the projects carried out tended towards the use of a vocabulary of contrasts between volumes, shapes, colours and non-constructive elements: panels, vinyl stickers and human figures as denominators of the space: to act as guides and mobilisers.

By teaching this set of methods and concepts in Technical Schools, many people can change their natural and spontaneous use of space, because they are concepts that accompany them effortlessly and naturally in all their interactions.

[1] CENIE. Centro internacional sobre el envejecimiento (*International Centre on Ageing*) University of Salamanca.

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Lamp S.A.U

Design, development and production of indoor and outdoor technical lighting solutions

SINCE 1972.

LAMP S.A.U. is a company that designs, develops and produces indoor and outdoor technical lighting solutions. **Founded in 1972, the company has its main offices in Terrassa** (Spain). This centre is where it produces its light fittings while it also doubles as the headquarters for Lamp and its **affiliates located in France, Mexico, Colombia, Chile and Dubai, in addition to all the other sales offices**.

For **over 50 years** Lamp has had a strong industrial tradition and its history is a **story of transformation**, running alongside the technological changes that have accompanied the lighting industry, and also the social shifts, as lighting helps to transform spaces and the way in which people live in them.

At Lamp, we embody dedication and attitude; we are Worktitude for Light.

To realise our vision, we are guided by our three strategic pillars or *Working Paths*:

Worktitude for Wellbeing

We see lighting as an essential element to improve people's wellbeing, analysing both the visual and non-visual effects of light.

Worktitude for Innovation

We promote and embrace innovation projects aimed at continual improvement across all areas, with the understanding that innovation is a systemic and systematic process.

Worktitude for Life

We promote projects that have a positive impact on the environment and work to achieve a more sustainable lighting industry.

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Healthy ARCHITECTURE

At the beginning of April 2024, we decided to focus our research, knowledge and experience on two important topics in the field of architecture and design: lighting and universal accessibility. In particular, in the areas of artificial lighting, cognitive accessibility and for sensory integration. Having brought together the initial ideas, it is our intention that the combined effects of these two ways of creating quality, accessible and comprehensible habitats for the wellbeing and integral health of people and for better coexistence will go beyond the projects that follow this common set of assumptions and recommendations. We believe that the enthusiasm of those who have participated can improve the quality of many projects whose authors are looking for innovative rules to incorporate into their work and creations. The examples included are practical, many of them tried and tested. Others have been developed by combining light and the model's approach to designing accessible spaces, always justifying them without being confined to the closed circle of a single author. Rather, they are intended as a way of creating new visions and solutions and, in the future, new knowledge for those who come after the initial pairing of ideas. The document sets out the basic principles of both subjects, which, developed together, create a new approach that can be improved when new authors turn it, as we have done, into a vocational game that leads to healthy architecture.
For this reason, it is impossible to say which part was authored by which participant, as the text is so densely packed with agreements that the result of the experience can be seen as a new and interesting starting point for those who want to design with cognitive accessibility and sensory integration and with light.
With the best companion for this experience: a lighting company that knows what it is doing and what it can offer to its customers, who can feel at ease thanks to the sustainable environments and spaces that shapes, materials and lighting conditions can create for different ideas and realities.

THE AUTHORS
IN ASSOCIATION WITH LAMP

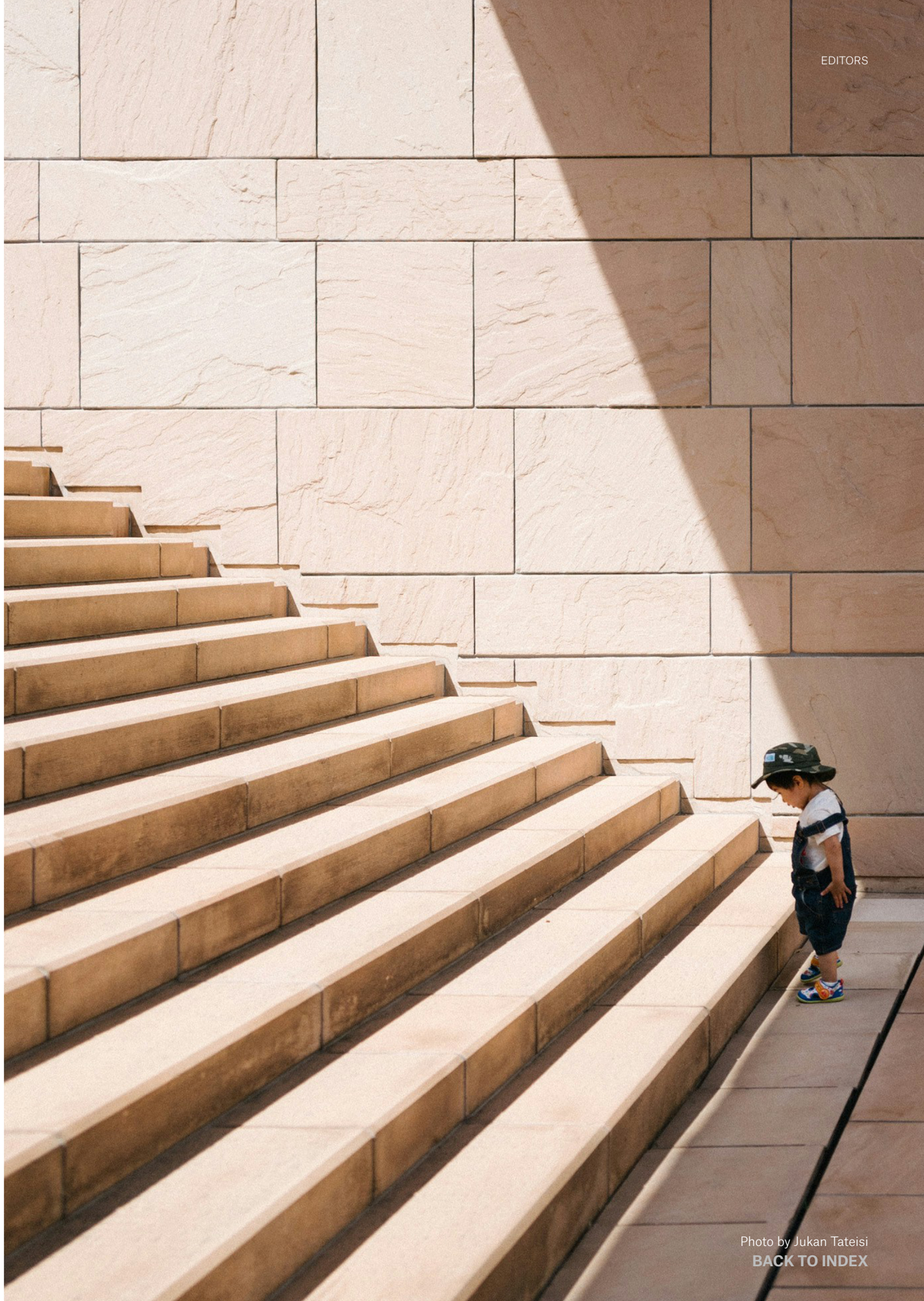

Photo by Jukan Tateisi

Introduction

Artificial light, when used as an architectural language of communication with people, is able to convey the ideas of architecture itself, while maintaining a high level of formal and conceptual coherence with the architectural project.

The notion of simply achieving a level of lighting that complies with standards has been superseded by its use as a justification for certain actions that serve to organise, link and guide proposals with qualities to:

Provide orientation based on the different types, places, colours and shapes.

Influence actions in movement: modifying or reducing the longitudinal dimensions of spaces.

Create actions that influence the different architectural components to serve as sequential connectors.

Incorporate specific design factors including technical components which are not likely to affect human health. On the contrary, they should serve as interlocutors between people, their activities and the space in which they are carried out.

This means incorporating concepts that define components that are modified or reinforced on the basis of their impact, both on the outside and on the inside.

Artificial light as ARCHITECTURE

Functional lighting

Focuses on ensuring the basic lighting conditions necessary to perform the planned activity in the space, in response to quantitative and regulatory compliance criteria, without considering other aspects of a qualitative nature, based on a purely “functionalist” approach.
It is able to provide the right amount of light to perform specific tasks efficiently and safely. This type of lighting is designed to maximise visibility and minimise eye fatigue, ensuring that the space is properly lit for its primary purpose.
It is designed to meet the requirements of each activity, in terms of intensity, distribution and colour temperature.

Emotional lighting

Seeks to create environments that influence people's mood and emotions. Light is used to create atmospheres that can be relaxing, stimulating, cosy or dramatic, depending on the context.
This type of lighting can alter the perception of the space, paying attention to finishes and textures as well as the combination of light and shadow, thus achieving different lighting effects through the appropriate use of optics and light distributions.

KEY ELEMENTS

- **Light levels**
- **Uniformity**
- **Glare criteria**
- **Lighting quality**

KEY ELEMENTS

- **Lighting atmosphere**
- **Colour temperature**
- **Combination of direct and indirect lighting systems**
- **Lighting hierarchies**

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Sensory lighting

Focuses on sensory experiences and the perception of space through light. This type of lighting studies how its qualities –intensity, direction and colour– interact with materials, shapes and volumes in an architectural environment to influence the spatial perception and cognitive performance of users, including the specific criteria and needs of different age and functionally diverse groups.

Expressive lighting

A type of lighting used as a means of artistic expression and communication. These types of effects not only illuminate the space, but also transform it, adding a layer of meaning and emotion that can communicate ideas, tell stories or highlight specific architectural features. It is therefore characterised by its creativity and its ability to generate strong feelings and emotional responses. It allows designers and artists to go beyond basic functionality and harness the power of light to transform and enliven spaces. By combining creativity with technology, any environment can be transformed into a dynamic and interactive work of art.

KEY ELEMENTS

- **Visual experience**
- **Orientation: directing attention to specific details to create a visual path**
- **Stimulation. enhance textures and colours, accentuate architectural forms and materials, encourage physical activity**
- **Interrelation with the user, avoiding negative experiences**

KEY ELEMENTS

- **Dramatism: Using strong contrasts between light and shadow to create dramatic effects and highlight architectural elements**
- **Use of colour: employing coloured lights to alter the perception of the space and elicit different emotions**
- **Plasticity: creating light patterns using projectors and filters to add visual interest and dynamism**
- **Interactivity: it can sometimes be interactive, responding to the presence or actions of people in the room.**
- **This lighting needs to be calibrated before it is used in neurodiverse environments.**

Aesthetic and functional considerations

Balancing aesthetics and functionality: it must be visually pleasing, while also fulfilling practical functions, by facilitating orientation and mobility without sensory overload.

Clear lighting vocabulary

Design that is understandable and accessible to everyone, regardless of their condition, helps to create an inclusive and functional environment.

Photo by Lamp: Masia Freixa, Terrassa

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Integrative approach to LIGHTING

In 2019 the International Commission on Lighting (*CIE: Commission Internationale de l'Éclairage*) introduced the term Integrative lighting as an official term in its ILV: *International Lighting Vocabulary, 2nd edition*, to refer to "lighting integrating both visual and non-visual effects, and producing physiological and/or psychological benefits upon humans".

The International Commission on Lighting (CIE) article entitled "*Position Statement on Non-Visual Effects of Light: Recommending Proper Light at the Proper Time*" addresses the non-visual effects of light on human physiology, mood and behaviour, highlighting the following points:

Non-visual effects

It not only influences vision, but also other aspects of human health, including the regulation of circadian rhythms in relation to the endocrine system, the production of melatonin and general wellbeing. These non-visual effects are mediated by specific photoreceptors in the eye called intrinsically photosensitive retinal ganglion cells (ipRGCs), which are particularly sensitive to emissions at wavelengths around 480nm.

Recommendations for interior lighting

Settings that imitate natural patterns are recommended. In general terms, and according to the characteristics of the users and the space in which the work is performed, it is advisable to increase the intensity during the day so as to promote alertness, and to reduce the blue emissions at night, favouring sources with higher levels of warm tones. This stimulates the biological mechanisms that help prepare the body for adequate rest, a necessary condition for the regenerative mechanisms of the parasympathetic nervous system to take effect.

Importance of exposure to natural light

Exposure during the day is crucial for maintaining the right biological synchronisation. Spending time outdoors is associated with better health and wellness outcomes. Natural light helps to synchronise the internal biological clock with the day/night cycle, as it naturally activates the secretion of cortisol, a hormone necessary to trigger the activation mechanisms of the sympathetic nervous system.

Risks of improper use

Inappropriate use of artificial light, especially from sources with high emissions in the wavelengths between 380 and 450 nm, which correspond to the blue tones of the visible spectrum, can disrupt circadian rhythms and have adverse effects on health.

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Space, spatial behaviour and design

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DESIGN model

The model, originally written more than a decade ago, has been recreated with a more complex and analytical approach based on neuroscience. The initial content included an experimental view based on user experience: both sensory and perceptual, which initially played a predominant role. Delving into the intricacies of the HNS and its complex processes related to spatial behaviour has made it possible to systematically explain each of the model's concepts beyond the initial moments. It also reaches broader age groups than those initially included: people with intellectual or developmental disabilities.

Some of these have been worked on in depth:

- **Older populations that are interesting because of their diversity and the changes they have undergone throughout this century.**
- **People with very different characteristics forming part of the autism environment.**
- **Children and young people with non-specific or rare diseases.**

This enrichment has been possible thanks to an approach that is inclusive of nervous system processes involved in spatial behaviour and deambulation. Cultural changes at the end of the 20th and beginning of the 21st century and the concept of inclusion have played a fundamental role in this process, allowing us to understand how person-environment relationships influence the attitudes and values that determine how individuals view, perceive, enjoy and simply live in their environment.
These investigations were triggered by the following question:
Can a building made of inert matter make us feel anxious or happy, bored or stimulated, engaged or indifferent? Secure or insecure? Oriented? Lost?

KEY CONCEPTS

Understanding how the human brain works in terms of sensory afference, perception and efference of cognition, emotion and motor action during deambulation and spatial behaviour has made it possible to incorporate more appropriate, appropriate and imaginative design strategies. Principles and components are anchored in the nervous system: perceptual and cognitive functions and processes that trigger spatial motor actions. And they affect the health of the nervous system, reducing the negative impact on human autonomy.

Photo by freepik

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COGNITIVE **accessibility and for** SENSORY **integration**

Neuroscience explains why people respond to environments and architecture with visions that were previously misunderstood or subjectively justified. From this approach, certain spatial solutions can work together to solve or improve natural deambulation that is blocked for reasons that can be resolved through appropriate designs.

According to this approach, the model is understood:

01 As a set of characteristics that an urban environment, building or complex must develop.

02 Defined by components integrated into an accessible vocabulary, taking into account the cognitive spectrum and for sensory integration.

Cognitively accessible

This refers to a vocabulary of design components that is understandable and accessible from an ease of use perspective, as it does not present barriers or difficulties to people's orientation and spatial autonomy.
Set of unbroken sequential relationships for spatial orientation.

For sensory integration

A set of spatial vocabulary components that, through their properties and relationships to design components, mitigate the difficulties of people with high sensory integration sensitivity. This is the process by which the central nervous system receives, recognises and interprets (perceptual processes) all the information it receives through the senses, and organises it to produce adaptive, cognitive and motor responses.

BENEFITS PEOPLE WITH

- **Difficulties in the perception of objects in relation to themselves, not for individual or collective use.**
- **Disorientation in terms of direction.**
- **Disorientation when taking surrounding points as a reference.**
- **Topographic amnesia: Disorientation, which relates to the inability to learn and remember topographical connections between reference points. Self-autonomy difficulties.**

BENEFITS PEOPLE WITH

- **Autistic spectrum disorder.**
- **Dementia.**
- **Epilepsy and other seizure disorders, including Dravet syndrome.**
- **People who are sensitive to design components with pronounced sensory effects.**

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Support system

Based on a language of spatial components and their relationships:

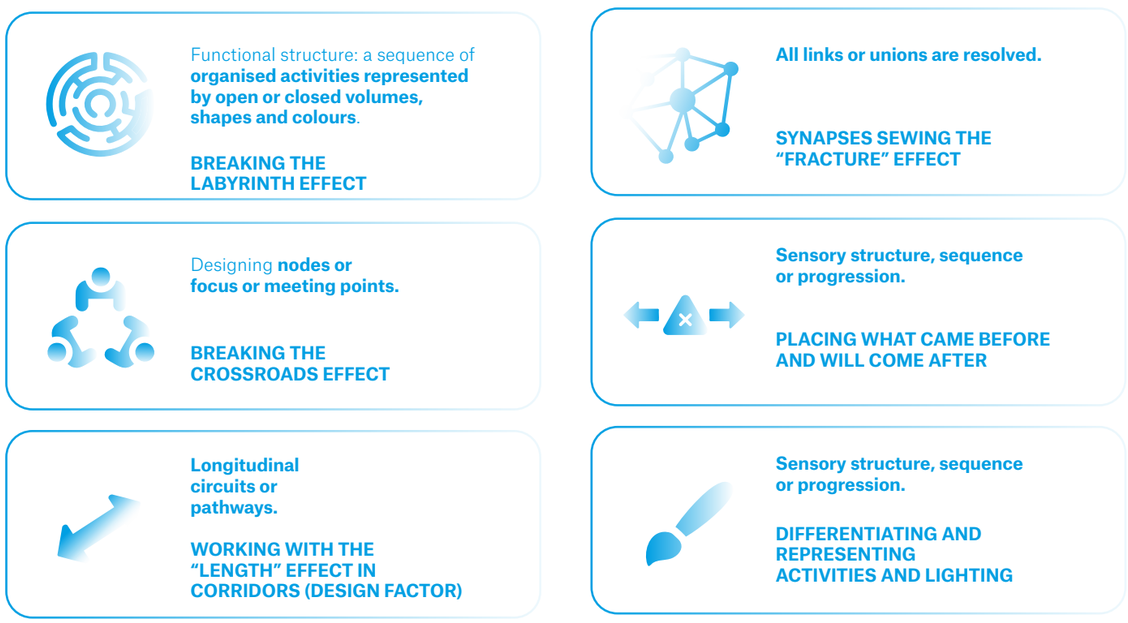

FIG 1. THE MODEL DESIGN COMPONENTS.

- **Design components**: vocabulary that develops the model: these are **individual and related concepts** that are understood beyond the dominant traditional values. Because neuroscience provides innovative values based on improving the functioning of the human nervous system in its **spatial behaviour**.

- This can be equated to a set of spatial coordinates materialised in related structures: using natural, processed or artificial materials, introducing technical and aesthetic aspects.

- Architecture offers a response that consolidates the global notion of "habitat for cognitive spatial security and sensory integration".

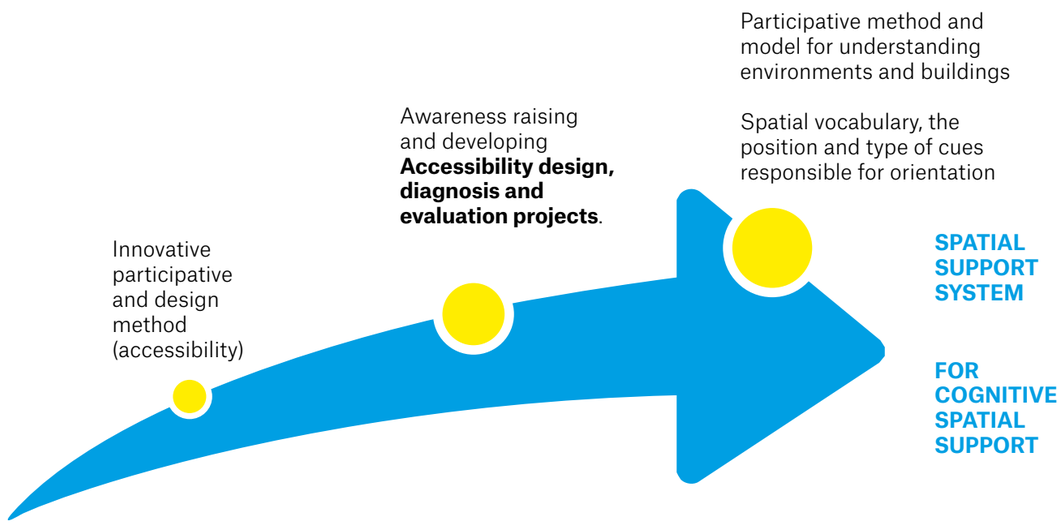

FIG 2. THE MODEL. SEQUENTIAL DIAGRAM OF THE SUPPORT SYSTEM.

The function of architecture

Intervening in improving or rebalancing people's responses in their spatial development: based on a system of supports or spatial scenarios that have the effect of unblocking nerve impulses that might limit motor actions.

Because it represents the veil surrounding everything and allows us to discover reality — improving it many times over!

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FUNCTIONAL **profiles and** SPATIAL **scenarios**

FIG 3. FUNCTIONAL PROFILES

Understanding how the nervous system works: processes and functions related to motor actions has led research and experience to create or synthesise an interactive set of “functional profiles” based on sensation, perception, cognition, emotion and motor behaviour.
In parallel and at the end of the process of identifying, studying and defining each functional profile, answers are provided for the prefiguration of “patterns of spatial scenarios” adapted to each set of needs or situations that present difficulties in deambulation and for carrying out activities in complex environments. These criteria are open and can be multiplied[2]. Prefiguration that each designer or expert can specify and adapt to their project.

[2] Referring to Christopher Alexander's “patterns” for the design of urban spaces.

Each of these profiles represents a “specific activation pattern” that can generate behaviour for performing actions, preferably spatially.

WHAT DO FUNCTIONAL PROFILES REPRESENT?

A selective organisation of HNS functions and processes involved in spatial development: sensory, perceptual, cognitive, motor, attention, memory and emotional aspects.
They represent processes in which the transmission of nerve impulses can become blocked.
On the basis of these profiles, “spatial patterns or scenarios” are proposed which, in the author's opinion, are most likely to overcome the blockage or act as a support system between the environment and human functioning.

EXPLANATORY
In terms of normality.

PREDICTIVE
In terms of what is going to happen: injury case.

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Lighting and spatial BEHAVIOUR

Lighting design based on a deep understanding of integration with these mechanisms can improve the quality of life, creating an environment that is conducive to physical and mental health by creating spaces that are not just functional. They are also healthy and stimulating from an inclusive perspective. To do this, it is important to take into account the following considerations and to understand the specific needs of the population that will be using a particular space.

A lighting design based on an in-depth understanding of how it integrates with the above mechanisms and the specific needs of the different 'functional profiles' will enable the creation of tailor-made scenarios that improve people's quality of life by promoting an environment that is conducive to both physical and mental health.

In short, the creation of spaces that are not only functional but also healthy and stimulating from an inclusive perspective.

Cognitive accessibility

Lighting as a guide: if it is appropriate, it can help with spatial orientation, reducing barriers and difficulties: it allows people to better perceive objects, their relationship to them and to the environment as a whole.
Unfractured sequences: it should create a continuous and comprehensible environment, avoiding poorly lit areas that can cause disorientation or confusion, thus promoting transitions between sequences without fractures.

Sensory integration

Sensory adaptation: minimise sensory overload; soft, uniform lighting can help reduce overwhelming visual stimuli.
Controlled visual stimuli: excessively bright or flickering lights, which can trigger negative reactions in sensitive people, should be avoided.

Photo by Nicole Baster

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Lighting adapted to different FUNCTIONAL PROFILES

Photo by Leon Seibert

This type of design needs to address the functional diversity of users, taking into account different sensory and cognitive characteristics, thus improving people's interaction with their environment.
This section focuses on the specific requirements of different functional profiles to achieve inclusive lighting that improves the quality of life of these users by promoting their physical, cognitive and emotional well-being.

Older adults

VISUAL SAFETY AND COMFORT

Over time, especially after the age of 45, people tend to experience a progressive reduction in their ability to adjust their vision and greater difficulty focusing on objects up close. In addition, progressive lens opacity increases the dispersion of light rays, leading to increased sensitivity to glare and loss of contrast sensitivity.

In addition, older adults need more time to recover from exposure to bright light and more time to adapt to darkness.
For these reasons, it is advisable to increase lighting levels, up to three times those recommended for a young person, and to increase the contrast of adjacent surfaces to facilitate spatial perception: depth, textures, contours and edges.

The Unified Glare Rating (UGR) is the criterion used to assess the glare caused by a light source in a space. However, it does not take into account increased glare sensitivity due to increased scattering in the eye with age. The borderline between comfort and discomfort (BCD) on the other hand, does take into account the ageing factor, although it is harder to apply to lighting projects. For this reason, the UGR is recommended as the standard glare index, lowering the maximum permissible index requirement, i.e. if a maximum UGR of 19 is set for a work task, the recommendation for a space intended for older adults is a maximum of 16.

High luminance levels, direct-emitting light sources in the field of vision and reflective surfaces should be avoided in favour of luminaires with high levels of shielding to reduce glare.

In terms of light quality, the use of warm light sources produces less disturbing glare than sources with short (cold) wavelengths. Sensitivity to colour also changes with age, so it is important to use sources with high colour rendition.

**Recommendations taken from the CIE 227:2017 report: Lighting for older people and people with visual impairment.*

Childhood

COGNITIVE STIMULATION AND EMOTIONAL WELLBEING

Childhood is a period of accelerated visual and cognitive development when visual stimuli contribute significantly to spatial perception and interaction with the environment.

Ensuring a high level of visual comfort in spaces where users spend long periods of time is vital for ocular and nervous system health. This aspect becomes even more relevant if these users are in a developmental period, as is the case with children. The control of glare, whether direct (from the luminaire) or indirect, is one of the most important aspects of visual comfort, as it can cause fatigue or stress.

Preference should be given to the use of luminaires with adequate glare control, which contribute to the low glare index (UGR) of a room, and to the use of flicker-free luminaires.

In the case of infants and primary school children, it is important to consider this comfort and its relationship to the environment and its scale. Due to the height of children's eyes and their greater sensitivity to “blue” emissions, they are more susceptible to direct glare. In these cases, it is recommended to use luminaires classified as RG0 with no photobiological risk according to UNE 62471, a standard that assesses the risk of ocular or dermatological damage caused by a lamp or luminaire. Priority should also be given to indirect lighting, especially in spaces intended for babies, since eye development is intensive up to two years of age, and the first two or three months of life are critical.

Photo by Lamp: Escola Sant Nicolau

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Neurodiversity

SENSORY CONTROL AND STRESS REDUCTION

Lighting must provide a safe and comfortable visual environment, adapted to the individual conditions and needs of each user. People with autism spectrum disorder (ASD) often experience hypersensitivity or hyposensitivity to sensory stimuli, including light, so poorly designed lighting can cause sensory overload and increase anxiety. For this user profile, it is essential to design controlled environments that avoid excessive visual stimulation.

Some of the key strategies for lighting for people with ASD include:
Use of indirect lighting: soft and diffuse light, without direct reflections and pronounced shadows, provides a lighting experience that continues to allow a better spatial understanding, helping to avoid a fragmented perception of space. In this way, the lighting invites you to explore and recognise the space. Avoid flickering sources as much as possible given the greater sensitivity of these users.

Generalised use of warm colour temperatures as they implement simple control and adjustment systems that enable users to interact with the lighting and adapt it to their needs.
Adapting lighting according to sensory zoning, adapting to the different stimuli presented by spaces according to their level of activity and sensory intensity: low stimulation areas, high stimulation areas and safe areas.
Planning spaces with light transitions between different sensory zones or spaces with large differences in lighting levels helps sensory adaptation and allows the user to anticipate.

Neurodiversity

CONTROL OF MOVEMENTS AND COLOURS

Special characteristics that relate to people with epilepsy and other conditions associated with seizures. In addition to the above, changes to moving lights, if they also contain colour, can affect them and cause epileptic seizures.

Mental illness

These cases are complex because there is a relatively large variety of conditions that could be affected by light. In principle, it is important to avoid creating images that distort a reality that may already be altered by the disease.
On the other hand, and this is the function of the designer, the nature of the elements and their distribution should not encourage images that could be attractive in other settings and for other audiences. The distortion of shapes sought through the use of light and shadow is not advisable for these experiences, which are not visual but perceptual; for causes not attributable to visual processing.

Photo by David Werbrouck

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Neuroscience and architecture

The concepts, processes and functions developed and discussed in this section are those that relate to spatial behaviour in general and to light as a medium in particular. With the help of the theoretical materials included, the aim is to evaluate everything that comes from outside the person and that causes changes in their inner self and in their behaviour, even if they seem to be unimportant details when origin of the processes that could be affecting them is not known.

Light is electromagnetic radiation that can be perceived by the human eye –which can only distinguish radiation between 400 and 700 nm– consisting of an oscillating or moving electromagnetic wave that allows objects to be seen. It has components that can influence overall health. To distinguish between them and to encourage the use of the positive range, it is necessary to understand the behaviour of the human nervous system in relation to the environment and light.

This section explores the first one in depth in order to later analyse the positive influence of this energy on the human being.

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Human NERVOUS SYSTEM

The required concepts are introduced in order to move forward with the following points: A description of the HNS[3] with its components, structured by afferences to the CNS[3] and efferences from this centre to the extremities.

Neural Stem Cells (NSCs)

These are the cells that give rise to the human nervous system: they are undifferentiated and divide into neurons and glial cells.

NSCs are known to give rise to the entire nervous system during development. In adults, a small number of NSCs remain and are mostly inactive. However, a large number of studies confirm their role in plasticity, ageing, disease and regeneration of the nervous system.
One of the areas with high stem cell activity is the hippocampus, where certain aspects of learning and storing information take place. It is thought that renewal of pyramidal cells in the hippocampus may be important in replacing old knowledge with new.

The organism's environment "plays a key role in regulating NSCs. The role of the environment in cell production was observed in the study by Gerd Kempermann (2011), where laboratory research showed that physical activity is key to the generation of new neurons in the hippocampus, as well as an enriched environment for these hippocampal-generated neurons to survive"[4].

[3] HNS: human nervous system. CNS: Central nervous system

[4] The nervous system and the neurons. Neuroscience course for teachers Campus TECH 2024.

Neurons and glial cells

Neurons are the basic nerve cells that are responsible for the processing and transmission of information throughout the nervous system. With a body of variable shape and with different extensions, one of which, filiform in appearance and longer than the others, is the axon or neurite. The synapse is the process that enables the connection between neurons, an indispensable requirement for nerve impulses to travel through neural networks: without it, the brain would be "disconnected" from its organisation into complex chains and networks that constitute the different ways in which information is transmitted within the nervous system. They have one thing in common: their activity is of two types: Electrical and Chemical.

Receiving neurons have a chemical structure that is designed to bind only to certain receptors, like keys that fit into a single lock. In this way, they interpret the message they receive and are able to pass it on to the next neuron.

Neurotransmitters

These are chemical messengers whose function is to send signals that cause neurons to generate or not generate an *electrical impulse*. Molecules that are produced, stored and released in nerve cells and at synapses. All of them –more than forty– are excitatory, inhibitory and modulatory, which means that they influence –modulate– the activity of many other nerve cells in the brain. And neurohormones that are produced and secreted into the bloodstream.

They are *released* in response to a stimulus and then act on another post-synaptic neuron or on an organ, such as muscles, i.e. on cells that have the capacity to receive and translate information. Of all the neurotransmitters, dopamine –which is both excitatory and inhibitory– is particularly important for motivation and the pursuit of pleasure, but it also has other functions such as attention, learning or *movement*: people with Parkinson's disease who have problems with stiffness and slow movement have low levels of dopamine. Therefore, their artificial ingestion improves motor symptoms.

Glutamate is the most important neurotransmitter in the central nervous system, and *serotonin* is an antidepressant. The main inhibitory neurotransmitter in the adult brain is *gamma-aminobutyric acid* (GABA): It inhibits involuntary movements. In addition to the above, the following are excitatory: *acetylcholine*, which is secreted by motor neurons; *norepinephrine*, which activates alertness and wakefulness; and *histamine*, which also affects alertness.
All the elements mentioned are influenced by the presence of a physical agent such as light, which, whether natural or artificial, produces different effects in the environment, which are never the same.

- Daylight stimulates the production of serotonin and dopamine, which increase alertness, activity and mobility.
- In the absence of stimulating light, melatonin levels increase, thus inducing sleep.

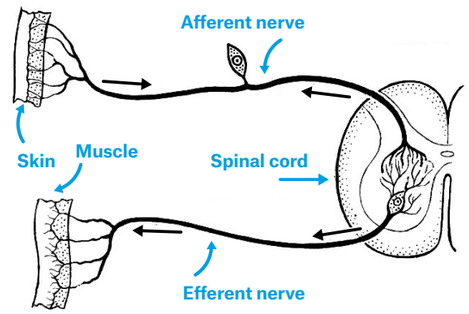


FIG 4. HNS. AFFERENCES AND EFFERENCES.

Brain waves

These are repetitive and oscillating patterns of electrical activity that generate the various structures of the brain. These are very low amplitude oscillations, of the order of microvolts in humans, and do not always follow a regular sinusoid. A predominance of slower ones will cause more fatigue. Higher frequencies will lead to a greater state of alertness or even anxiety.

- Delta waves: with a frequency of 0.2-4 Hz. Theta waves: 4-8 Hz. Alpha waves: 8-12 Hz. Beta waves: 12-30 Hz.
- Gamma waves appear at times of extreme attention and concentration or at times of high stress. These are those with the maximum frequency, above 30 Hz.

Certain techniques have emerged that base their effectiveness on training the brain to learn to increase or inhibit them, thus achieving optimal brain regulation and, consequently, improved functioning and well-being.

It will be possible to see later how the luminous adequacy is influenced in a completely natural way in relation to the amplification of the waves (high or low) according to the space and the desired activity.

HNS

The main components of the nervous system are presented, especially those related to spatial behaviour, which will be used below to justify, explain and develop the concepts of the model and artificial lighting.

The central nervous system is made up of the encephalon and the spinal cord. The brain is a very important part of the encephalon.

- The brain controls thinking, learning, mobility, senses and emotions.

- The spinal cord conveys messages between the brain and the nerves present throughout the body.

The brain and spinal cord are protected by bones: The brain by the bones of the skull, and the spinal cord by a series of ring-shaped, interlocking bones called “vertebrae”. Both are protected by layers of membranes called meninges and by cerebrospinal fluid. This fluid flows through the cavities of the brain, called ventricles, and around the spinal column. It provides nutrients and removes waste, and protects the central nervous system.

NERVOUS SYSTEM

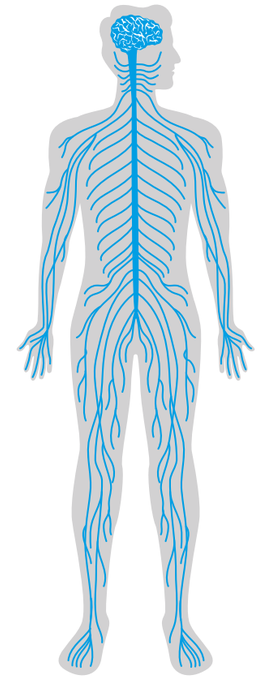
A set of control and information organs and structures of the human body, consisting of highly differentiated cells, known as neurons, which are capable of transmitting electrical impulses through an extensive network of nerve endings. **SENSORY** AFFERENTS AND **PERCEPTUAL, COGNITIVE AND MOTOR** EFFERENTS (nerves or extensions of neurones: axons).

LIMBIC SYSTEM

The hippocampus, the amygdala and the basal ganglia are the nodes that initially or definitively enable the association between the different representations of knowledge established in the cortex (grey) or other brain regions.

PRAXIS SYSTEM

Movements: receiving, giving orders and acting. The execution of praxis involves of two components: a conceptual component, the left parietal lobe, which contains the **concept** stores: knowledge about the **function of objects**; and a production component, the frontal lobe, which **stores** the spatial and temporal information necessary for the **execution of movements**.



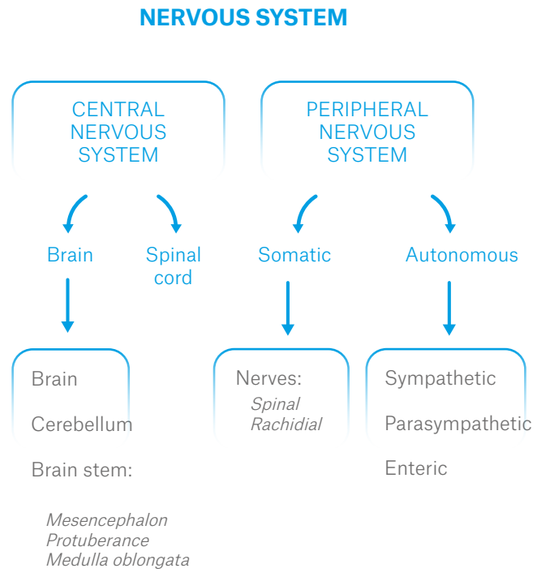


FIG 5. HNS.

The brain is the dominant structure of the nervous system: structurally and functionally, it consists of two parts, or hemispheres, connected by a cord of white matter called the corpus callosum. White matter, or melanin, covers the axons of nerve cells to facilitate synapses and communication in networks. A large part of the brain is the cerebral cortex (also called “grey matter”). The cortex has four areas called “lobes” that work together to form an individual's personality and everything that person knows. **Each lobe** processes a different type of information:

FRONTAL LOBE

It is involved in complex thinking with activities such as planning, imagination, decision making and reasoning. It is located behind the forehead.

PARIETAL LOBE

It processes information about touch, taste and temperature, and is important for spatial orientation. It is located behind the frontal lobe.

TEMPORAL LOBE

It allows us to understand sounds and speech, recognise objects and faces, and create memories. It is located near the ears.

OCCIPITAL LOBE

It is the processing centre for visual information from the eye's cavities and functional components. It is located at the back of the brain, from where a complex pathway of spatial and conceptual identification begins beyond this cortex (ventral-dorsal pathways).

The brain stem connects the brain to the spinal cord. It consists of the brain stem, the medulla and the midbrain. These parts work together to control and coordinate the messages that enter and leave the brain.

Behind the brain is the cerebellum, known as the “little brain”, which controls balance, movement and coordination.

The spinal cord is a complex network of nerve tissue in three parts that runs along the spinal column. The name of each section describes the part of the spine through which the spinal cord passes: cervical, thoracic and sacro-lumbar. From these sections, smaller nerves are sent to nearby parts of the body. The **limbic system** includes important centres such as:

THALAMUS

For perception, as it is the centre through which all sensory afferent fibres pass (except smell), the amygdala for emotions and the hippocampus for short-term memory. Its connection with the praxis structures gives it motivational impulses.

HYPOTHALAMUS

It controls pulse, thirst, appetite, sleep patterns and other processes that occur automatically in the body. It is the body's biological clock that controls most circadian rhythms. Signals from the hypothalamus travel to various light-responsive brain regions, including the pineal gland.

PINEAL GLAND

It is a small structure located on the roof of the interbrain whose main function is to regulate circadian rhythms: sleep/wake.

PITUITARY GLAND

It produces hormones that control growth, metabolism, water and mineral balance, sexual maturation and stress response.

PARAHIPPOCAMPUS

Research in which a subject has to memorise a set of photographs shows that images of places activate the parahippocampus (Prince, Dennis, & Cabeza, 2009). The parahippocampal gyrus, which is responsible for recognising “scenes”, provides a pathway for communication between the hippocampus and all the cortical association areas through which afferent impulses enter the hippocampus. Scenes are always referenced by lighting types, which can affect how they are recognised by the research subject.

EMOTIONS

Due to their importance for deambulation, this point will be examined again later on.

The **praxis system** comprises an active part and a storage component. It is from this storage that it executes the position and movement reaction-response, implying dominance of the body and, for displacement, the lower extremities.

- The components of the praxis functional system include Brodmann areas 39 and 40, parieto-temporooccipital junction –left hemisphere–, which constitute the central nucleus of the praxical processes; this zone allows the transformation of elements of perception or representation into elements of action.

- This is made possible by the availability of a store of acquired motor representations, sensory representations of movements, which are involved in the programming of the motor cortex for the execution of actions. The key areas are the lower parietal lobe of the left hemisphere –the left angular and the supramarginal circumvolution–.

- Through the corresponding fibres of the corpus callosum, the praxis functional system continues to the motor association and primary areas of the right hemisphere. If these connections were to be interrupted[5], movements could be made by reproduction, imitation or direct route. Lighting conditions are essential for more accurate reproduction and movement control.

[5] Callosa disconnection. Note by the authors.

Person-environment interaction

It is carried out through the senses: these are the ways that the HNS has to capture everything that is on the outside, the environment: its physical, informational, cognitive and symbolic characteristics, attitudes or judgements in relation to space are perceived. And while they do not fully determine it, they undoubtedly contribute to explaining behaviour in and towards it.
The senses also capture what is happening inside a person.
This accumulation of external and internal data is then transformed into experience and knowledge for action: these data are crucial for recognising what is real or perceived, and for interpreting what can be changed by light effects.

SENSATIONS

This how nervous stimuli are received through the senses (external and internal): EXT: visual, auditory, tactile, olfactory, taste. INT: vestibular, interoceptive and proprioceptive. This takes place through the body's sensory receptors.

PERCEPTIONS

Integration or transformation of sensory information into experience: giving meaning; being able to take in and organise, integrate, interpret sensations, objects, events to make sense of them, knowing what each is and where it is (thalamus and memory). This is active and complex from a psychological point of view; individuals, as propositional beings, seek and structure their perceptions, involving cognitive, emotional, interpretive and evaluative processes associated with these perceptions, which are individual or shared patterns generated by the actions of society and culture.

MOTOR

Reactions-response of position and movement, implies dominance of the body.

COGNITION

Starting from the previous stages, humans **observe, learn, analyse, remember, decide, carry out and live fully**; the brain lobes and adjacent internal regions intervene: it is necessary to remember, pay attention, carry out actions (executive functions).

EMOTIONS

Psychophysiological reactions to external stimuli.

Multisensory integration

Acting in a particular world that surrounds humans –all living beings and objects that interact with each other– is based on the integration of information from different sensory systems. This interaction of modalities appears to be related to the activation of "multisensory" neurons located in different regions of the brain. This is an indication of the complexity of the operations required for a stable representation of the environment in which an activity takes place.
There are a number of conditions for multisensory integration[6].

The health and balance of the nervous system and the actions that each person can perform in space depend to a large extent on these stimuli, whether they act in isolation or simultaneously, provided that their integration is tolerable. And external stimuli have an important influence.

[6] References taken from the Brain institute led by Dr. Rebeca, creator of ECG-Estimulación Cognitiva Global.

CONDITIONS FOR
MULTISENSORY INTEGRATION

01 That the information that reaches the brain from the different modalities is separate and appropriate to the intensity and duration of the stimulus that causes it.

02 That the intensity and duration of the stimulus is adapted to the capacity of the system (otherwise pain, discomfort and, in the worst case, neuronal damage will occur).

03 That the inhibitory mechanisms at peripheral and central levels work to allow the relevant data to pass to the cerebral cortex (otherwise there will be noise in the system).

04 That the stimuli are processed separately, in parallel, and reintegrated at the upper cortical level.

05 That new connections are made (this is achieved by repetition).

06 That they are meaningful to the subject (this last aspect requires a certain level of awareness).

Photo by Julian Hochgesang

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The areas of association

Generic term for large areas of the cerebral cortex without sensory or motor activity whose primary function appears to be advanced multisensory or sensorimotor integration and advanced processing of sensory information: They are hubs of connectivity.

They are associated with cognitive and affective functions such as speech, thought, emotional behaviour, perception and voluntary movement. These connections can be seen using MRI and DTI image registers or diffusion tensor, where perfectly identified axonal fibres stand out due to processes such as anisotropy[7] and the water content of the axons.

The brain has to work at a high metabolic rate[8] to connect networks and keep them active. Any additional demand can “de-optimise” connections that are urgently needed for the CNS to function optimally according to its structures and functional requirements: connecting the upper areas to each other and to the more remote or peripheral areas.

Attentional systems

The importance of attention for sensory, perceptual and cognitive processing is reflected in the prevalence with which attention disorders are considered serious neurological conditions. If they are visual, they can cause a reduction in the detection of stimuli in the environment, and if they are linguistic, they can cause problems with verbal fluency.

“Attention plays a predominant role in perceptual processing for action in the environment: it is the selection of information for conscious processing and action, and the maintenance of the vigilance required for attentive processing”. (Posner and Bourke, 1999).

This approach to attention was first put forward by Posner (1995), who argued that attention does not belong to a specific area of the brain, nor is it a “global product” of the brain, nor is it a unitary function, as different functions are supported by different areas. These theories have been supplemented and added to by other authors in later years, but the statement has not lost any of its well-deserved importance.

The attention of the systems depends on the attentional demands of the task:

1. ASCENDING RETICULAR SYSTEM

Responsible for tonicity functions, regulating the *waking states and the autonomous operating state*. Its main nuclei are located in the brainstem, although its networks extend up the ascending tracts throughout the brain. They are the main inputs to the areas that make up the posterior attention network that follows.

2. POSTERIOR ATTENTION SYSTEM - ORIENTATION

Related to the control of spatial processing, or visuospatial attention, it has also been called the orientation network. It is carried out in three operations: ***a) Disengagement*** from a previous target to a new one (posterior parietal lobe), ***b) Movement of attention*** to the new target (complemented by an eye movement that 'draws attention'), and ***c) Engagement*** of attention with the new stimulus (located in thalamic areas, specifically the pulvinar nucleus).

3. ANTERIOR OR EXECUTIVE ATTENTIONAL SYSTEM

When attention is engaged with the new stimulus, this new system comes into play, which is associated with detecting objects and recognising their identity. It is conceptualised as an executive type system and has been linked to working memory and consciousness. Its circuit is fed by several brain areas, such as the anterior cingulate, the basal ganglia and the dorsolateral prefrontal cortex.

For some authors, Posner's system implies the ability to assess the state of the system and to detect whether irrelevant information is being inhibited at any given time: whether or not there is resistance to distraction, the chief enemy of spatial recognition tasks for personal autonomy.

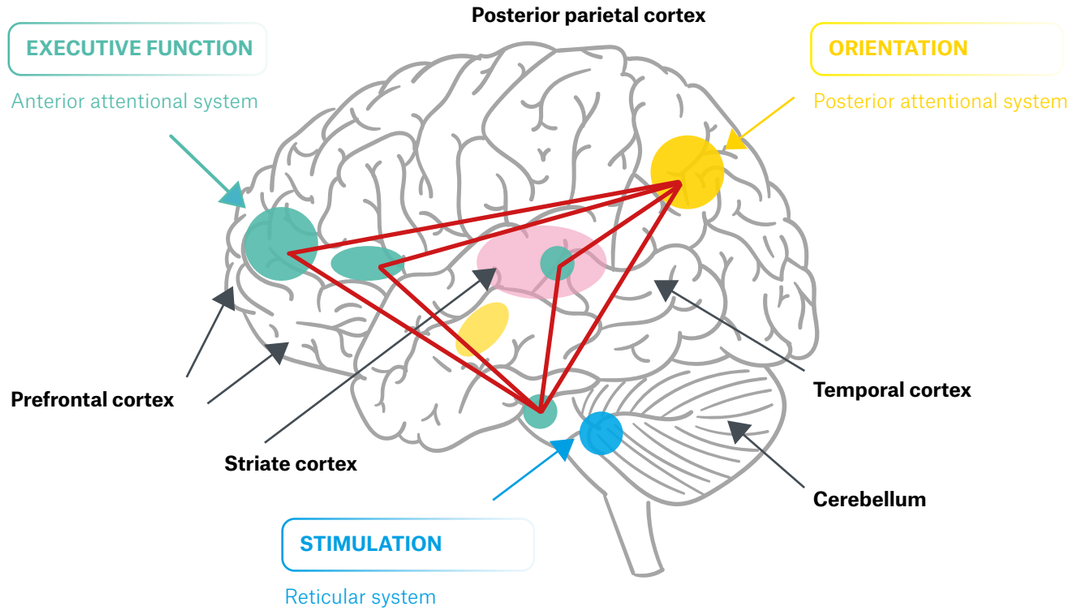

FIG 6. NETWORK OF ATTENTIONAL SYSTEMS.

[7] The water molecules contained within the narrow tubes of axons are confined and diffuse more easily in some directions than in others. This property, known as fractional anisotropy, reflects the connections between brain regions. Neuroscience course. Campus TECH.

[8] A set of biochemical reactions in the brain that mainly use oxygen and glucose and allow the brain to develop its functions. Neuroscience course. Campus TECH.

The case of unilateral motor negligence

An orientation disorder characterised by a variety of symptoms related to a lack of awareness of signals, objects, or parts of objects on the side of space opposite to the injury in one hemisphere of the brain. The role played by attentional mechanisms along with other engines and representations in this condition is extremely important.
Subjects show a motor bias towards the ipsilesional side and a deficit in the generation of voluntary saccades, an excessive orientation of attention towards the ipsilesional side, together with a deteriorated ability to disengage attention from what has automatically captured the attention, and an orientation that shows certain difficulties in orienting towards the counterlesional side.

- Given the important role of attention for sensory and cognitive processing, it is common to find that attentional disorders are very frequent and, above all, have been considered one of the most devastating neurological conditions.

Again, in this and other similar cases, we must point out the need for a very calibrated study of lighting.

Memories

Memory is the storage process: it needs to be used to bring certain information into the present when needed. There are different types, although it is the operational or working type, which is short term –as it stores information for a few seconds– that is of interest here in relation to spatial behaviour. Long-term memory is retained for a longer period of time and often remains unchanged despite certain illnesses and ageing. Memories have been described as complex systems that include components dedicated to the maintenance of verbal and visuospatial information, as well as the selection of information for later processing. Attention systems are important for this, as the retention of a concept or event requires no dispersion of interest or attention. Inattention and distraction occur when the number of elements exceeds the functional capacity to maintain memories simultaneously.

Learning and memory are closely linked. Learning cannot take place without storing it in some kind of memory to be used in the future, either to remember as new knowledge or to improve skills. Neuroscience has shown us that memories are encoded by physical changes in the brain (although there is still debate about what exactly changes, and how). Therefore, the brain physically changes every time you learn something, and so lifelong experience and learning changes and shapes the brain.

SENSORY MEMORY

It retains the sensory stimuli that have already disappeared for a very short time in order to process them and send them to the STM. This is the case with iconic memory (visual) and echoic memory (auditory).

SHORT-TERM MEMORY (STM)

It retains a limited amount of information for a short period of time.

WORKING OR OPERATIONAL MEMORY

It is an active process that allows the information stored in the STM to be manipulated and worked with.

LONG-TERM MEMORY (LTM)

It stores a virtually infinite amount of information, some of it from the STM, for an indefinite period of time.

Visual processing

The ability to walk around is based on the interaction of the visual and motor systems[9], and attentional systems work together to enable the interaction of processes, concentration and message selection.

This point is extremely important because the engine of the sense of sight is either natural or artificial light. The ability of the visual system to recognise a scene –the shape of objects, the brightness of different parts, shadows, etc.– depends on the primary visual cortex, and the most important circadian synchronisers are the light/dark cycles during daily activities. Most importantly, however, is the light information received by a subpopulation of retinal ganglion cells that contain melanopsin, a photosensitive pigment that is normally absent from cones and rods; these neurons transmit the information via the retinohypothalamic tract to the suprachiasmatic nuclei of the hypothalamus.

Light and vision

Light is a physical agent in the form of energy that enters the eye through the cornea and partially through the pupil. The iris, the coloured part of the eye, is responsible for limiting the amount of energy that can penetrate inside. Once inside the lens, it is responsible for focusing objects on the retina. Converted into electrical impulses by the optic nerve, they are sent to the brain's visual areas to carry out the visual process.

Eye movement

These play a very important role in orientation through physical space, hence the interest in analysing their normal or abnormal conditions. They are related to visual exploring and visual spatial skills: “The vestibulo-ocular and optokinetic reflexes are automatic responses to compensate for movements of the head and visual environment and to stabilise the retinal image on a given fixation point. The neural systems involved in gaze, balance and posture act to stabilise the body and, together with vision, provide information about the spatial environment”[10]. Always in the presence of clarity.

The stabilising function of the body carried out by the eye movements is of particular interest because, while a displacement is being carried out, the eyes carry out control and identification, paying attention to the different levels of space, allowing a greater percentage of the scenario to be seen with high visual resolution.

Although they are all part of the functioning of vision, the text refers to those that may be more altered by neurological processes, rather than being of a different nature, that hinder the natural mobility of a person and are therefore included in the group of oculomotor disorders: for example, in pathological conditions that cause dysfunction of the vestibular system or its connections, different types of “nystagmus” or involuntary movements of the eyes may occur, affecting vision, balance and displacement.

The visual tracking of a scene is performed by a series of saccadic movements, i.e. rapid movements of the eyes between two fixation points. Most are used to move the gaze from one point of interest to another outside the central field of vision. Saccadic movements make it possible to scan the environment and mentally develop a three-dimensional map.

[9] If the visual system is affected, components of other pathways would be involved: touch and hearing.

[10] Gila L. et al. 2009) *Fisiopatología y técnicas de registro de los movimientos oculares* (Physiopathology and recording techniques of eye movements). Anales del Sistema Sanitario de Navarra printed version ISSN 1137-6627. Anales Sis San Navarra vol. 32 supl. 3 Pamplona 2009. And Nahum Montagud Rubio. (2019, October 9). *Movimientos sacádicos: definición, características y funciones* (Saccadic movements: Definition, characteristics and functions). Portal Psicología y Mente. https://psicologiaymente.com/neurociencias/movimientos-sacadicos

- Following or slow tracking movements are voluntary and conjugate both eyes to stabilise the foveal image: visual perception or the ability to distinguish fine details and with great sharpness in the central region of the visual field.

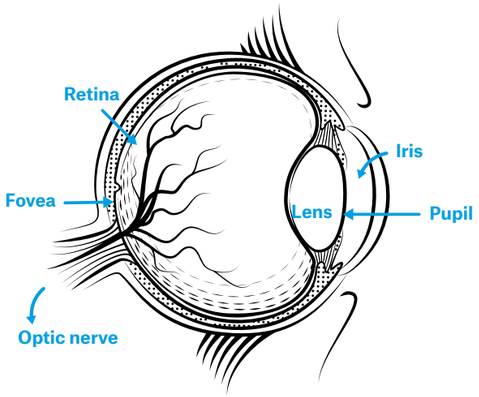

FIG 7. STRUCTURE OF THE EYE

As the cones are activated by changes in light intensity, saccadic movements encode and process information to make a concrete decision.

- If the light received by the eyes did not change, the brain would no longer receive stimuli in certain areas.

Problems that can occur when there are changes: double vision, problems with eye movement or focus, and their effects on mobility:

- Unsteadiness when walking and loss of verticality and balance.
- Tilting or turning the head to try to see more clearly.
- Focusing on one point may make objects appear to move.
- Dizziness if there are rapid changes in the gaze.

Colour

When the white beam hits an object in a straight line, part of the spectrum that makes it up is absorbed by the surface and the rest is re-emitted. The colour we see is determined by the reflected components. If it reflects the whole spectrum, it is white, and if it absorbs everything, it is black: reflection is a property that allows us to see objects that do not emit light. It consists of the change in direction experienced by light rays when they collide with an opaque object. Most objects reflect only part of what reaches them.

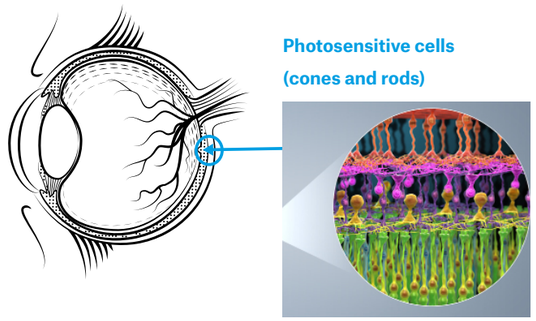

FIG 8. PHOTORECEPTOR CELL
AMERICAN ACADEMY OF OPHTHALMOLOGY.

But colour is “seen” thanks to the presence of photoreceptors: sensitive, specialised nerve cells located in the outer retina. Cones and rods are some of the most specialised and complex cells in the nervous system. There are two types of photoreceptors: rods and cones. Cones are light-sensitive cells and are responsible for colour vision. There are three types of cones:

- **L-type:** sensitive to long wavelengths: red
- **M-type:** sensitive to medium wavelengths: green
- **S-type:** sensitive to short wavelengths: blue

The visual system allows us to distinguish colours by combining the three primary colours: blue, red and green.

The ventral-dorsal pathways

Because of its importance in deambulation, spatial behaviour and its ability to discriminate signals or objects in space, the concepts of this dual system in relation to visual processing are extended.

Visual spatial skills, which are fundamental to spatial orientation processes, require two major cortical subsystems; one responsible for identifying the things sees (the “what”) and the other responsible for locating them (the “where”). They originate in the occipital lobe and have different terminations in the cerebral cortex:

- **Perceptual vision** has a neuroanatomical substrate in the ventral pathway: the vision of the what. Neurons in the lower temporal lobe respond passively to visual stimuli, making it easier to identify the properties of objects. Action vision, associated with the dorsal pathway, has its neuroanatomical reference in the posterior parietal lobe.
- **The two-streams hypothesis** is a widely accepted and influential model of neural processing of vision and hearing. The hypothesis, most prominently described in a 1992 article by Milner and Goodale, argues that humans have two distinct visual systems. More recently, there also seems to be evidence that there are two different hearing systems.

When the visual information leaves the occipital lobe and when the sound leaves the phonological network, it follows two main pathways or “streams”. The ventral stream (also known as the “what pathway”) is involved in identifying and recognizing objects and visual agendas. The dorsal stream (or “where pathway”) is involved in processing the spatial location of the object in relation to the viewer and in the repetition of speech. The arrival of both pathways in the limbic system allows the “where and what” to be brought together as a single event formed by the components that have travelled along both pathways, as well as motor and emotional actions. If the processing is not completed and the indexing is not done in the hippocampus (because there are structural or functional blocks) and the information is retained in the primary areas, everything that looks similar could be confused.

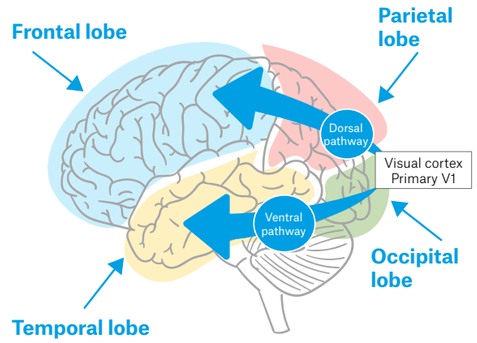

FIG 9. VENTRAL AND DORSAL PROCESSING PATHWAYS

[11] AMERICAN ACADEMY OF OPHTHALMOLOGY

Lighting in relation to THE NERVOUS, VISUAL, AND ENDOCRINE SYSTEM

The central nervous system (CNS) is the main receptor and processor of light stimuli. Light enters the eye through the cornea, passes through the pupil and is focused by the lens on the retina. The retina contains light-sensitive cells: cones and rods, which convert light into electrical signals.

Rods, whose maximum sensitivity is found in emissions around 498 nm, are responsible for scotopic vision, a type of peripheral vision that occurs in dim conditions and allows us to perceive volumes and movement, but does not allow us to perceive colours correctly.

Cones, whose maximum sensitivity is to emissions of 534 nm, are activated in a high-illumination stage, giving rise to photopic vision, which allows the perception of colours.

The visual system and perception

The visual system makes it possible to perceive the environment, influence spatial orientation and identify objects. Visual information is processed in the primary visual cortex, which is located in the occipital lobe. From there, as seen above, it forks into two main routes: The ventral pathway (the “what”) and the dorsal pathway (the “where”).

- **Ventral pathway:** This pathway is responsible for identifying and recognising objects and is projected into the lower temporal lobe. It is essential for tasks such as recognising faces and interpreting visual detail.

- **Dorsal pathway:** Responsible for spatial orientation and motor coordination, this pathway leads to the posterior parietal lobe. It is essential for navigating and interacting with the environment.

Light quality and intensity can significantly influence the effectiveness of these pathways. Appropriate lighting improves detail perception and orientation, while poor lighting can lead to visual fatigue and disorientation.

The endocrine system and hormonal regulation

It can also affect the endocrine system, which regulates various bodily functions through the secretion of hormones. The intrinsically photosensitive retinal ganglion cells in the retina play a crucial role in regulating circadian rhythms.

These ganglion cells send signals through the retinohypothalamic tract to the suprachiasmatic nucleus (SCN) of the hypothalamus. The SCN is the brain's master clock, responsible for regulating the sleep-wake cycle and controlling the pineal gland, which is responsible for the secretion of melatonin, known as the “sleep hormone”. Sleep, wakefulness and other endocrine imbalances can be delayed or accelerated by exposure to blue light.

On the other hand, cortisol, which is produced by the adrenal glands and is known as the “stress hormone”, plays an essential role in the activation of the sympathetic nervous system.

MECHANISMS AND INTERACTION: **visual, motor emotional, cognitive and circadian response**

Motor response

Promotes mobility and spatial orientation by creating milestones to guide navigation and by promoting the visibility of adjacent spaces to enhance the sense of security in interacting with the environment.

Emotional response

Influences emotions, so a certain lighting atmosphere can create a sense of safety and well-being, while inappropriate lighting can cause distress or uncertainty. The correct relationship between colour temperature and lighting level is key. Research[12] shows that higher temperatures (6500K) are associated with increased nerve activity, while low colour temperatures (<3000K) help to relax the nervous system.

Cognitive response

Influences the optimisation of alertness and cognitive performance. Studies have shown how the combination of high illuminances and high colour temperatures optimises alertness and improves performance on complex cognitive tasks.[13]

Exposure to high levels of illuminance (700 lux) has a positive effect on attention and working memory, reducing alpha wave activity in the brain, an indicator of a higher state of cerebral alertness, and increasing heart rate. Poor calibration can lead to states of eye fatigue or stress, as well as sensory processing overload due to intense lighting maintained over time, with the ability to effectively maintain attention.

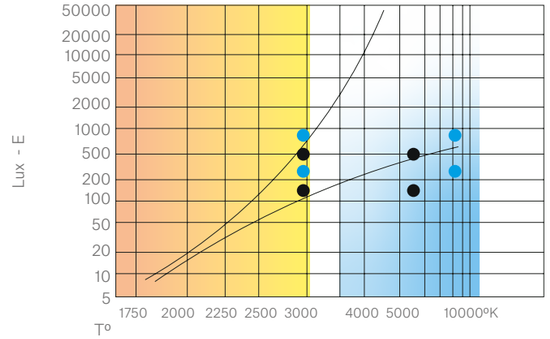

FIG 10. OWN ELABORATION BASED ON THE FOCAL POINTS RELATE INTENSITY AND COLOUR TEMPERATURE IN THE ORIGINAL KRUITHOF CURVE, REFLECTING DATA FROM SEVERAL STUDIES[14]

Circadian response

Exposure, whether natural or artificial, is the main stimulus that regulates circadian rhythms and influences sleep and wake patterns.

This cycle affects both melatonin secretion and cortisol secretion. At night, its absence promotes the production of melatonin, which induces sleep. Exposure, especially to the blue component, at certain times of the day can suppress melatonin production, making sleep difficult and altering circadian rhythms. Exposure to the sun or an artificial substitute, especially in the morning, stimulates the production of cortisol, which promotes alertness and performance during the day. However, excessive exposure to the second during the night can keep cortisol levels elevated, negatively affecting the correct synchronisation of the biological rhythm, contributing to stress and fatigue. It has also been linked to triggering other diseases such as metabolic problems (increased obesity and type 2 diabetes) or reduced cognitive performance (reduced ability to concentrate, memory loss and decision-making difficulties).

Conditions that simulate natural cycles can improve general wellbeing and cognitive function, taking into account the parameters of levels, tones and circadian stimulation.

[12] *Componentes de la luz: factores esenciales en los espacios para modular la actividad cerebral* (Components of light: essential factors in spaces for modulating brain activity) (2021), María Jimena de los Reyes Cruz, Ricardo Gómez Maturano, Luis Guillermo Ayala Torres

[13] Bright illumination reduces parietal EEG alpha activity during a sustained attention task. (2013) Jin Young Park, Byoung Kyong Mi, Young Chul Jung, Hyensou Park, Yeon-Hong Jeong and Eosu Kim

[14] Data from Hiroki Noguchi and Toshihiko Sakaguchi in 1999 and Jin Young Park, Byoung Kyong Min, Young Chul Jung, Hyensou Park, Yeon-Hong Jeong and Eosu Kim in 2013 - Referenced in Components of light essential factors in spaces (2020) María Jimena de los Reyes Cruz, Ricardo Gómez Maturano, Luis Guillermo Ayala Torres.

Design model

The model for the design of accessible spaces for the cognitive spectrum and sensory integration incorporates concepts explained by neuroscience:

01 First, the complex functions of the human nervous system in relation to deambulation or spatial behaviour and habitat.

02 Secondly, how and why they can be treated with artificial light for spatial orientation and inclusion.

It is organised around conditions that must be unequivocally fulfilled:

01 Universal and design principles.

02 Design components: structural, functional, sensory, volumes, shapes and colours.

03 Functional, sensory relationships between design components, especially those that affect spatial deambulation.

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The model approached from NEUROSCIENCE

To successfully deambulate between two points, an organism must first be aware of its position relative to the environment (starting point) before choosing a pathway, because the planned response depends on its initial position. The perception of orientation requires knowledge of two types of information: location and directional course. Starting with the first, and in order to set a direction, the basic quality is functional clarity and relationships between activities. This is the first source of formal and functional security, fundamental to good design.

The consolidation of the model from neuroscience has shaped the concepts that develop it with a more complex and committed definition. Those anchored in sensory aspects and perception, and which has gained solidity through experience, are complemented by the complex contribution of neuroscience, which is reflected in human behaviour.

The expansion of this content is justified by the need to rigorously define the principles and design components that, until a few years ago, were based on afferent processes. When we delve into the functions of the brain, these same units not only acquire greater rigour, coherence and solidity.

Research into the functioning of the human nervous system shows:

- Firstly, the consistency of explanations and definitions.
- To which new justification and design components have been added.

This precision could facilitate their inclusion in codes, such as technical and formal design references with a high impact on the quality of accessible and understandable spaces. Where lighting plays a fundamental role.

Principles or postulates

UNIVERSAL PRINCIPLES

Neutralising the labyrinth effect or internal confusion of the design, the main obstacle to orientation in space: breaking the labyrinth effect:

The parietal and occipital areas receive visual sensory information and use all this data to calculate the coordinates of the visual, auditory and physical environment around them. Sending commands to the spinal cord to perform the desired activity.

Multi-sensory integration is essential for understanding and processing information.

The areas of association integrate the information that comes from the networks or hub of the brain.

The labyrinth effect hinders the passage of clear orders from their functional centres or hubs to other CNS centres or to the periphery, hindering the functioning of brain networks and therefore the planning of cognitive and motor functional sequences.

Perfectly matching encounters at spatial junctions and crossroads to avoid confusion and disorientation: breaking the crossroads.

Excessive pressure (or negative stress) on the limbic system, which is responsible for regulating emotions, can block the natural development of motor actions.

The labyrinth effect is solved by perfectly matching encounters in nodes that have a crossroads effect, in order to avoid disorientation and distress due to excessive pressure on the brain networks capable of managing executive functions: decision-making implies increasing the pressure on a specific activity: one that should concentrate all the functional (attentional) effort of the subject.

Removal of barriers to perception in general and design in particular

Excessive design and surface elements can overwhelm the functioning of memory and attention systems. The three stages of the attention system can be affected by perceptual-environmental overload.

The result is distractibility, which in so many cases leads to insecurity and, more seriously: accidents –slips, falls, blows, cuts– so often attributed to internal factors and caused by environmental excesses that impede the natural flow of information from one system to another.

Creating references with simple text, graphic signals and numerical symbols. Adapted to each location and “type of user”.

Baddeley and Hitch distinguish four components of the aforementioned working memory:

- **Phonological loop:** responsible for maintaining verbal information through continuous repetition of information.
- **Visuo-spatial agenda:** responsible for maintaining non-verbal information.
- **Central executive**: responsible for directing information to co-ordinate two or more tasks and to manipulate or maintain information.
- **Episodic buffer:** stores verbal and visuo-spatial information.

Baddeley's working memory –quoted above– operates through a structure centred on what he calls the “central executive”, the organiser and co-ordinator of the two systems: *the visuo-spatial sketchpad, for visual information, and the phonological loop, for verbal information.*

If there is an excess of information or a disagreement between the visual and phonological parts, the executive may collapse, preventing the flow of connections between the centre and the buffers that capture, store and return the visual and auditory aspects.

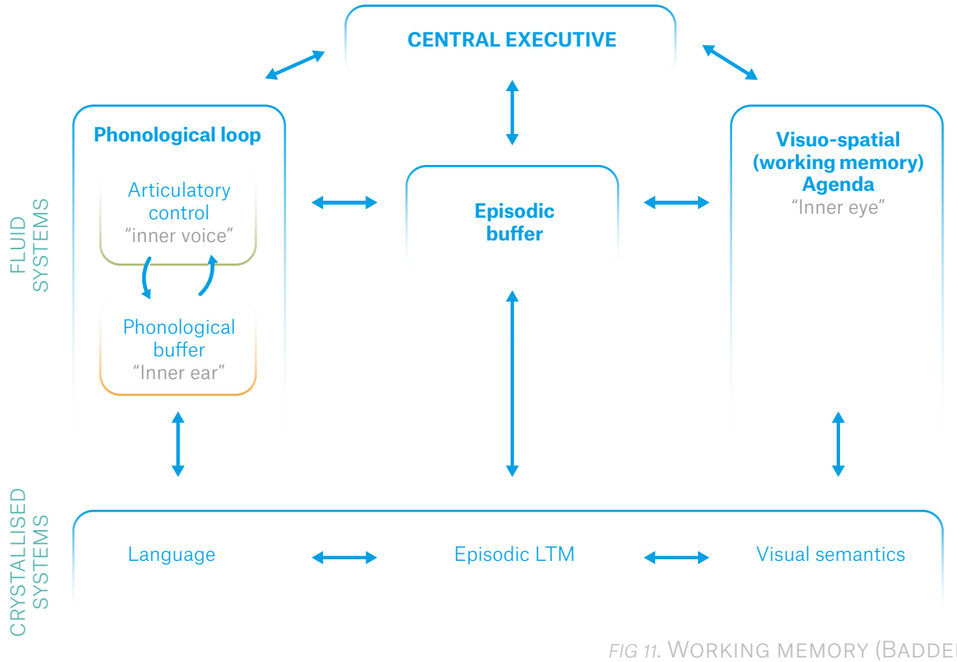


FIG 11. WORKING MEMORY (BADDELEY, 2000)

Organisation into functional, sensory and anticipatory sequences for predictive cognition

Motor behaviour requires the subject to be aware of their surroundings, of the position of their body and extremities in relation to space, under conditions of order –organisation– which must be functional and sensory. In view of the characteristics of the users with whom the model works, sensory and anticipatory aspects for emotional balance are included. Organisation implies:

- **Functional structures** represent the coherence of programmes and projects according to their objectives and desired outcomes. Beyond the scientific approach, there are needs that are resolved by the arrangement of localised and interrelated activities in space.

- **Sensory structures** are based on the sensory compatibility or incompatibility of some neurodivergences: for instance, within the autism spectrum. They define the gradients of activity that must be maintained between activities of different intensities because they are complementary or of different intensities. For example, going up or down from playgrounds to study areas or classrooms.

- **They must be anticipatory.** Following a model of visual information processing known as “predictive coding”, researchers at Duke University have conducted experiments showing that “neurons predict and correct what we see before we actually see it” (Tobias Egner. 2010), a process that takes place unconsciously, in just a few milliseconds, in an area of the brain known as the fusiform cortex, which is known to be involved in face recognition. Each layer of neurons adjusts its perception of the image to eliminate the prediction error and send the correct information back up the neural scale.

Unfractured sequence of design components to break crossroads

The **brain receives** an enormous flow of information from the world around us through the senses, processes it and makes sense of it: **organising and controlling movement**. Other functions of the brain include regulating body temperature, blood circulation, breathing and digestion.

- A group of scientists from the Kavli Institute at the Norwegian University of Science and Technology (NTNU) has discovered a pattern in the human brain that enables the construction of sequences: the process is guided by a fundamental **algorithm** that is intrinsic to the brain and independent of experience (Nature).
- According to the researchers, **the sequences of actions in the brain optimise the mechanical execution of the motor sequence, or “motor chunks”**.
- The cerebellum is the motor through which all the processes involved in the co-ordination of movement take place.
- If any part of the sequence is “skipped”, there may be a **blockage in the processing speed** and related functions: Sensory, cognitive and emotional perception.

DESIGN PRINCIPLES

Threshold effect placing “memories” in longitudinal spaces

To avoid visual and emotional changes and, above all, to keep the **information always present in the operative or working memory.** Multi-sensory integration is essential for understanding and processing information.

- They share similarities due to their short duration: the operative or working memory refers to content that can be manipulated or used in a short time, with an approximate and variable duration of between 25 and 40 seconds, according to the authors.

Markers can be formal, visual, tactile, chromatic, sound, lighting: positioned so as not to interfere with visual activity, fluidity and balance during walking, even in the presence of minor visual problems. Strategies for improving memory skills:

1. Breaking tasks down into small steps.
2. Employ repetition often
3. Strategies: Verbal repetitions, grouping, creating mental images, associations, etc.
4. Practice in a distributed way over time.

Taking into account the difficulties that may be generated by placing guidance or reminder elements:

- The floor: least advisable if they accompany the walk, as they can interfere with the processing of the steps, forcing the eyes to look at the floor. Long distance placement may be advisable provided that they are less than two or three in number and are used only for positioning, marking directions.
- On the sides, at the bottom or in the centre: the most advisable because they do not absorb the attention like the previous ones and do not require the eye to move from one to the other: the person lets themselves be guided or accompanied. They are a support, like the handrail, that can also fulfil this guiding function.

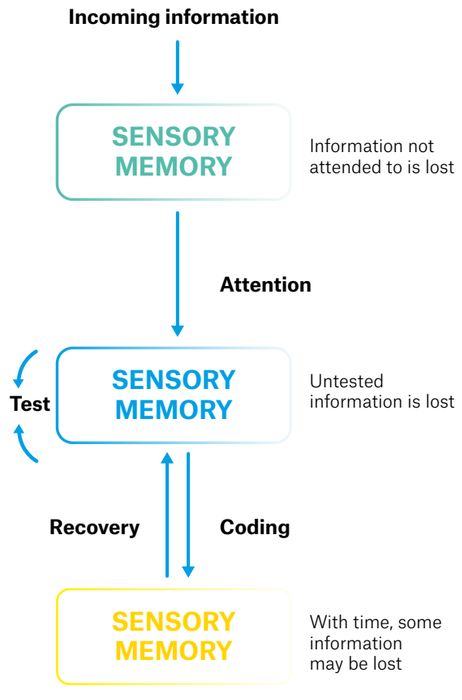


FIG 12. STRUCTURE AND TIMING OF MEMORIES

Design techniques for retaining information[14]

Memory palace (loci method): Technique that involves associating elements of information with familiar places and using emotions to create images. By picturing these places in your mind and associating specific pieces of information with each location, you can mentally tour the “palace” to recall the information when needed.

Chain method: It involves creating a story or logical sequence that connects the elements you want to remember. Each element is linked to the next in a “memorable” way, making it easy to retrieve in sequential order.

Mnemonic method: Uses acronyms, acrostics or mnemonics to help you remember information. For instance, creating a phrase in which the first letter of each word represents a concept that you need to remember.

Mind maps: Organise the information into a diagram or visual coherence that shows relationships between concepts. This can help to visualise the information in a clearer way and make it easier to remember.

Visualisation and association: Associate vivid images or familiar concepts with the information being tried to be remembered. The mind tends to remember images and emotional associations.

The special case of spaced repetition

This technique involves reviewing information at regular intervals rather than repeating it continuously: it is assumed that by spacing out the repetitions over time, the information is consolidated in long-term memory. However, the process of vision via the dual ventral and dorsal pathways is taken into account in this approach and its implementation.

If there are structural or functional blockages and information is held or stopped in the primary areas of vision, any elements that are similar or related could be confused.

Aware of these consequences, the distances between *similar elements*[15] must be very well calibrated so that they are not confused as if they were the same: changes in tonality can exercise a differentiating and calibrating function of the components placed to orient and direct.

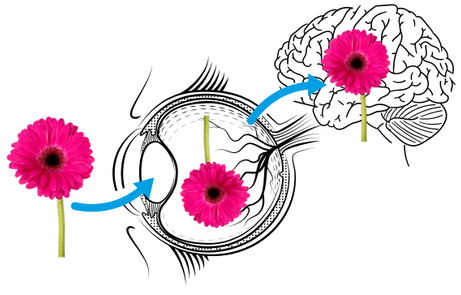


FIG 13. HOW VISION IS PRODUCED. PREPARE BY AUTHOR.

[14] Obtained from various sources, including the Vicent Clinic for Child Psychology, Adult Psychotherapy and Speech Therapy. . And others, as suggested by professionals consulted for this guide.

[15] See text Brusilovsky Berta. (2020) *Seguridad espacial cognitiva arquitectura: cerebro y mente* (Cognitive spatial security architecture: brain and mind). Section “4.1.2.2. *Dónde y cómo de las habilidades visoespaciales* (Where and how of visuo-spatial skills)”.

Clustering-segregation effect and other phenomena of visual perception

As visual organisers that are descriptive but verified by neuroscience.

- **Contrasts:** Clustering-segregation effect, an important regulator of perception.

FIG 14. INTERPRETIVE RECONSTRUCTION BASED ON SHAPES AND COLOURS

Perception relationships

Figure-background law: in an image, we tend to focus our attention on one object (figure), making it stand out from the rest (background).

Law of good figure: when we perceive, we tend to reduce possible ambiguities or distorting effects, looking for the simplest form.

Laws of Prägnanz and grouping of stimuli

- **Law of proximity:** allows different elements that are close to each other to be related and grouped.
- **Law of similarity or alikeness**: relating and grouping different elements if they are similar.

In the first two laws, understood as a phenomenon of perception, they will have consequences that are not always expected, concentrated on the ventral and dorsal visual processing pathways, whose meeting must be in the limbic system, if the function is within the limits of normal visual function.

Law of continuity: perceiving elements that maintain a continuity in their form as part of the same figure.

Agnosia and apraxia

These are disorders related to visual phenomena where alterations occur, resulting in hypersensitivity or hyposensitivity[16]. If the construction of perception fails, the person is unable to identify the shape of objects, cannot tell the difference between similar objects, cannot copy or mentally reconstruct a drawing, and cannot identify boundaries.

"Disorders of learned motor gestural activity, whether movements adapted to a purpose or actual manipulation or mimicry of objects, that cannot be explained by sensory, motor or perceptual injury, nor by altered mental or verbal comprehension, and that occur after brain injury" (Heilman & Rothi, 1997).

Another definition could be:
"Disorder in the execution of movements learned in response to a stimulus that would normally elicit a movement, provided that the necessary afferent and efferent systems are intact and in the absence of attentional *deficits or lack of cooperation"* (Geschwind and Damasio, 1985).

[16] Note by the authors: some cases related to autism or early Alzheimer's.

Typical alterations:

- **Distortion**: this can be a change in the perception of form, space or sound, and can occur in moments of over-excitement or stress. For example, when climbing stairs, the feet are raised above the steps. They occur when a stimulus that exists externally and is accessible to the sensory organs is perceived differently than would be expected given the characteristics of the stimulus itself. Cases that occur in autism spectrum disorder.
- **Metamorphopsia**: distortion can also be the result of any pathology or event that affects the central area of the retina, resulting in a functional distortion of vision.

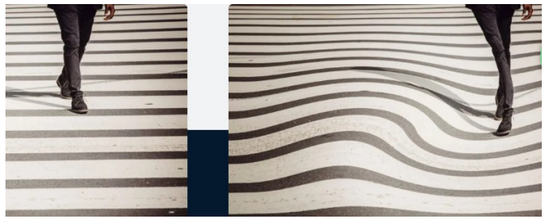


FIG 15. DISTORTED VISION

Perceptive fragmentation or division

A perceptual tendency that tends to fragment space and objects, causing those who experience it to select and focus on the less important aspects of their environment. These are people who get lost easily; they do not recognise people in photographs if there are important changes in them; they hear isolated words rather than complete sentences, etc. Interacting with materials and forms can have a unifying effect, helping to maintain rather than break the perception of the unity of spaces and their contents.

Creating references with the semantics of shapes

Although design is the result of form-function-imagination-creativity, it should seek to define activities, to orient and guide through its meaning, to be understandable and legible.

FIG 16 1 AND 2. LAYOUT OF THE SENSORY ROOM CREATED IN MUNICIPAL DAY CENTRE. CARMEN LAFORET. CITY COUNCIL OF MADRID

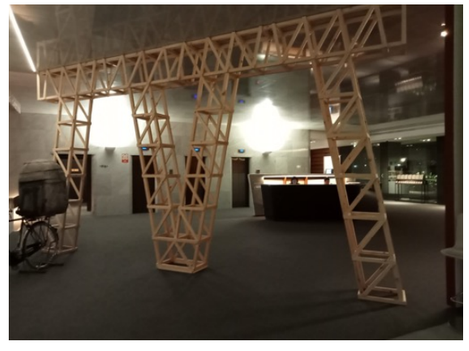


FIG 17. SPATIAL STRUCTURES TO LIMIT, DIRECT AND ORIENT

Components of DESIGN

Photo by Freepik

Components, acting as spatil coordinates for reading space

They are designed to develop an understandable and accessible vocabulary to communicate with people in their complex spatial deambulation.

- Architecture becomes a system of spatial coordinates that guides, directs, protects, informs, anticipates, reassures and speaks to people with its formal, functional and sensory aesthetics.

It is the breakdown of architecture, which, structured in its functional and sensory relationships, leads to cognitively and sensorially accessible spaces and breaks the labyrinth effect. This breakdown incorporates permanent components of the design, the result of which is functional and aesthetic, and with the components of the model, it produces an accessible and understandable vocabulary.

Relationships of real or physical elements

These elements or materials, of a real or physical nature, concretise the functions of each of the preceding components: it is the vocabulary of design according to its purpose, always defined by a programme and a model.

- Volumes, shapes, dimensions, colours, lighting.
- The structure or support that sustains them.
- The installations, which allow for a functional and sensory use.
- The materials that transform a project into a container of real experiences.
- The resulting aesthetics.
- *Relationships: the understandable and accessible language of the model.*

FUNCTIONAL STRUCTURE

This is what the architectural programme indicates: it must be performed with strict submission to the relationships that are to be created: those which are natural and necessary, but which in so many cases are destroyed for reasons of utility, of ignorance. Or because the shape and dimensions of the plot make it impossible to create those that are natural and that should be correlated.

SENSORY STRUCTURE

The sequence of rooms is adapted to the gradients of activity or effort, both physical and mental. They are arranged from the most active, in terms of the function they perform, to the least active, and vice versa. For example, playground activities and the reflective activity in classrooms.

NODES OR FOCAL CENTRES

They are the special parts of the spatial connection: they concentrate elements of orientation and direction. *According to their types: Access, sequence and activity.*

- **Access nodes:** the design parameters are: receiving, orienting and directing.
- **Sequenced nodes**: the design parameters are: defining intermediate meeting and routing spaces. Placed between functional spaces and circuits, they break the crossroads effect.
- **Activity nodes**: concentrate activities with large numbers of people: atriums, courtyards. Corridors can also be included that include several functions: circulation, access and spontaneous activities. Their **design parameters vary according to activities and location.**

CIRCUITS

They are the horizontal and vertical communication structure. In their horizontal redefinition as spaces for relationships and other spontaneous activities, they break the “endless” effect. Experiences in these spaces are related to the laws of **Prägnanz and grouping of stimuli defined above**.

SPATIAL BRIDGES OR UNIONS

They correspond to spatial unions or synapses. They sew together the fracture effect according to type:

- **Specific:** *expressly placed with signs visible from front and back.* They are related to the “predictive coding” visual information processing model.
- **Interfaces or spatial**: *intermediating activities with different sensory gradients.* They are related to the design of the structure for sensory integration.

Placement of guides on the ground

These are linear elements that, centred on a route, can generate difficulties if they are continuous, or if several are placed in parallel.

They can make walking unbalanced by the need to pay attention to one or more signs, which can lead to difficulty concentrating, a shift in vision from short to long distances, and changes in saccadic movements.

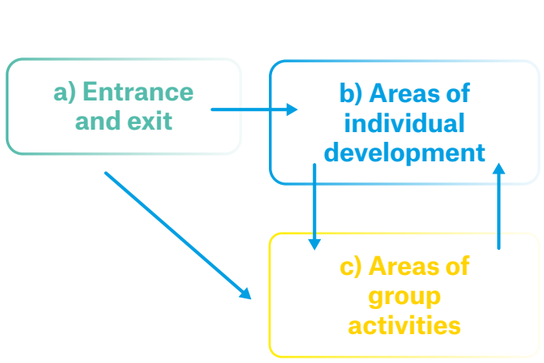
They are useful and harmless when placed at the bottom of walls or parallel planes, enhancing the sense of perspective.

Diagram of flows and sequences

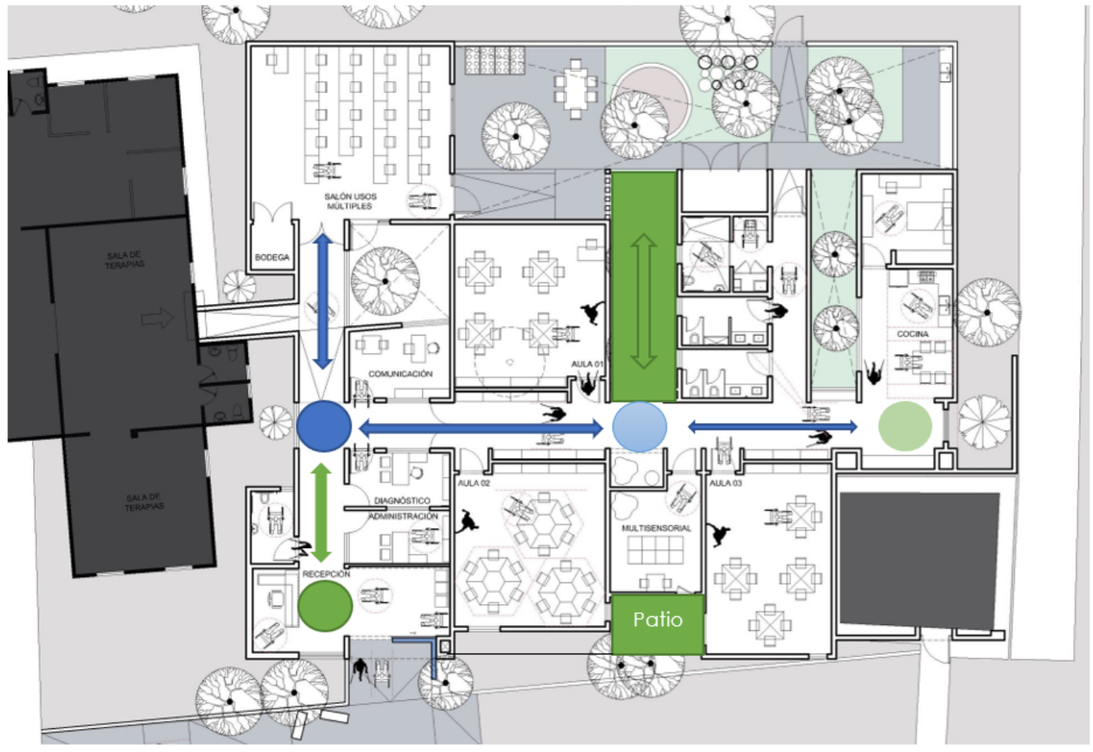
The interest and importance of these general diagrams and of the specific areas of activity is to avoid that the final programme creates relationships that prevent people's autonomy. By incorporating the natural sequence of spatial relationships from the diagram, formal or graphic elements can be introduced that also serve to train working memory.

Simple example of a natural flow diagram: a very common case in the ground floors of collective buildings, where access from individual spaces to those of collective activities crosses the entry and exit areas (entrance hall):

Area a) entrance/exit must be connected to areas b and c. In order to connect areas b and c, area a must not be crossed except by means of circulation elements correctly positioned so as not to obstruct circulation.



From this point, and recognising the implications and benefits of the model and its design components on the human nervous system, the text moves on to consider how artificial light becomes a structural architectural component for cognitive accessibility and sensory integration.



Horizontal circuit: development activities preferably individual.
Vertical circuits: group activities

FIG 18. CRIA TEA CHIHUAHUA-MEXICO. LA SALLE

Lighting planning integrated into the model

To approach the lighting project, the lighting requirements are met and divided into three groups according to the hierarchy of needs and effects:

- Visual ergonomics,
- Psychological and cognitive effects,
- Physiological or endocrine effects.

Thus, as in the model proposed by Abraham Maslow in A Theory of Human Motivation (1943), satisfying the basic needs represented at the base of the pyramid is shown to be a necessary condition for moving on to satisfying the needs classified at the immediately higher level.

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LIGHTING **project and hierarchies of** NEEDS

III Physiological effects

Positively influence the synchronisation of biological processes in humans, especially those related to the sleep-wake cycle and other neural and hormonal processes.

II Psychological/cognitive effects

Improve comfort, experience and spatial usability by incorporating positive stimuli that positively influence cognitive and emotional processes.

I Visual ergonomics

Provide basic and fundamental conditions so that users can live and develop in a healthy and comfortable space.

I Visual ergonomics

This level ensures the basic and fundamental conditions for users to live and develop in a healthy and comfortable environment. Some of the parameters to consider are:

LIGHTING LEVELS

Ensuring adequate lighting levels for different activities and conditions, as there are specific requirements, e.g. older adults may need up to three times more lighting than younger people, as retinal illuminance decreases with age due to reduced pupil size and increased spectral absorption of the lens. In these cases, it is appropriate to apply a multiplication factor to increase the lighting level in the task area, as recommended in CIE 227:2017.

Task area illuminance (lx)	**Illuminance of the task area depending on age, complexity of the visual task and the risk of error. (lx)**
750	1000–1500
500	750–10000
300	500–750
200	300
<150	<150

Context modifiers to increase illuminance maintained
Visualisation in the workplace is critical
Mistakes are expensive to fix
Precision, higher productivity or greater concentration are of vital importance
The object details in the task are unusually small in size or of low contrast
The task is performed for an unusually long time
The task area or activity area has little natural light
The worker's visual capacity is below normal

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CONTRASTS

Good contrast levels must be maintained to improve visual perception of edges and contours. Similarly, in spaces occupied by older adults or users with some degree of visual impairment, it is recommended to increase the contrast between the task area and the immediate and distant surroundings.

Recommended illuminance levels and illuminance ratios between the task area, immediate surroundings and remote surroundings.

		Illuminance of the task area depending on age, complexity of the visual task and risk of failure		Ratio 1: between the average illuminances of the immediate surrounding area and the task area illuminance		Ratio 2: between the mean illuminances of the background area and that of the task area	
E_{av}	U_o	E_{av}	U_o	Rat. 1	U_o	Rat. 2	U_o**
750	0,60	750-1000-1500*	0,60	0,65	0,50	0,20	0,30
500	0,60	500-750-1000*	0,60	0,65	0,50	0,20	0,30
300	0,60	300-500-750*	0,60	0,65	0,50	0,20	0,30
200	0,60	200-300*	0,60	0,75	0,50	0,20	0,30
150	0,50	150	0,50	1,00	0,50	0,20	0,10
100	0,40	100	0,40	1,00	0,40	0,20	0,10
≤ 50	0,40	≤ 50	0,40	1,00	0,40	0,20	0,10

**Range of higher levels depending on factors such as age or risk of falls that will influence the light level.*
*** Illuminance in the peripheral areas of a room tends to be less uniform than in another area. To avoid the use of additional luminaires in the peripheral areas, including corners, a 50 cm strip can be used adjacent to the surrounding walls and can be disregarded in the uniformity calculations.*

VISUAL COMFORT

Lighting conditions must ensure a low glare index (UGR), which is the degree of discomfort caused by light sources in the field of vision. This can be achieved by using luminaires with a high degree of shielding, low luminance and light distributions that combine direct and indirect lighting to ensure a high level of comfort.

Current lighting recommendations according to CIE S 008 and proposed lighting recommendations for the elderly (CIE 227:2017)

Type of area, task or activity	E_m	UGR_L	U_o	R_a	Specific requirements
Filling in, copying, etc.	300	19	0,40	80	
Writing, typing, typing, reading, data processing	500	19	0,60	80	
	750*	16**	0,60	80	Adult person
	1000*	16**	0,60	80	Adult person and high risk of error
Technical drawing	750	16	0,70	80	
	1500*	13**	0,70	80	Adult person and high risk of error

Cells in blue show current recommendations.
** Maximum illuminance level.*
*** Strict UGR.*

QUALITY

Luminaires with good colour rendering and no flicker are recommended to reduce visual fatigue.

II Psychological/ cognitive effects

This level allows for improved comfort, experience and spatial usability by incorporating stimuli that positively influence cognitive and emotional processes by addressing factors such as:

TEMPERATURE AND LIGHTING

Correct relationship between colour temperature and lighting levels: Adjust colour temperature to positively influence cognitive and emotional processes, for example using warm effects for relaxation and cold effects for work areas.

IMPROVING THE SENSORY AND COGNITIVE EXPERIENCE OF THE SPACE

Appropriate lighting improves spatial orientation and contributes to positive stimulation by creating stimuli that enhance the experience and usability of the space. This makes it possible to enhance textures and colours, enriching the space.

FOSTERING RELATIONSHIPS

Creating lighting atmospheres that encourage activity and interaction between users.

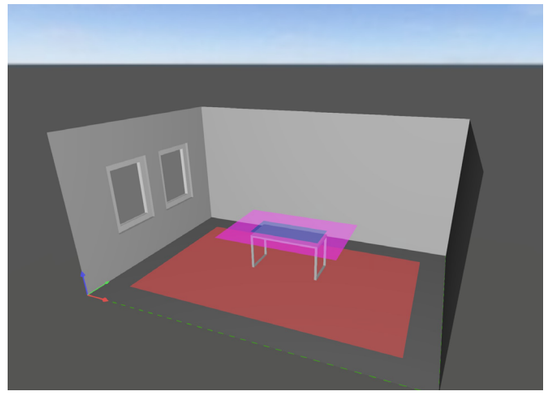

FIG 19. SCHEMATIC REPRESENTATION OF THE TASK AREA (1), THE NEAR OR IMMEDIATE SURROUNDINGS (2) AT LEAST 50 CM AROUND THE TASK AREA, AND THE FAR BACKGROUND AREA OR SURROUNDINGS (3).

III Psychological/ circadian effects

Positively influence the synchronisation of biological processes in humans, especially those related to the sleep-wake cycle and other neural and hormonal processes.

- Synchronisation of circadian cycles: Implementing circadian lighting to help regulate sleep-wake cycles, adjusting intensity and colour temperature during the day, and using technology to provide adequate circadian stimulation in the early hours of the day.

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LIGHTING strategies

UNIVERSAL PRINCIPLES

Neutralising the labyrinth effect or internal confusion of the design, the main obstacle to orientation in space: breaking the labyrinth effect:

The lighting criteria that help to break up this labyrinth effect and thus promote spatial orientation are:

Uniform lighting: use uniform and adequate lighting levels in corridors and transit areas to avoid horizontal shadows, known as the “zebra effect”, which can cause confusion.
Similarly, lighting that follows the flow of navigation, without creating visual breaks that create confusing situations contrary to the 'natural' reading of space, can contribute to the spatial understanding of the transit space.

Contrast balance: good contrast levels must be maintained, especially between task areas, adjacent areas and vertical walls, to improve visual perception of edges and contours. This avoids overly uniform lighting design, which can flatten volumes and lead to spatial disorientation.

Direct and indirect lighting: use a combination of direct and indirect lighting to minimise glare and shadows, create a visually comfortable environment and eliminate the “cave effect”.

Vertical illuminance: Take into account the volumetric illumination of walls and ceilings. To ensure correct facial recognition, include cylindrical lighting calculations.

Lighting key points: place accent lighting on architectural elements and signals that serve as visual references and help with spatial orientation. Lighting levels are increased, especially in areas and elements that need to be highlighted, taking into account vertical lighting plans where appropriate.

Lighting quality: use light sources with high colour rendering levels to improve the perception of colours, and use flicker-free luminaires.

FIG 20. SPACES WITH AND WITHOUT THE “CAVE EFFECT” IMAGE GENERATED WITH AI

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It is advisable to plan the lighting in terms of “layers” of light, taking into account the **background or fill lighting** that will ensure correct circulation and movement throughout the room. The second layer of lighting will be **task or accent lighting**, providing higher levels of illuminance appropriate to the task to be performed and in line with reference standards, and focused on the area of the task to be carried out. Finally, the **atmospheric light** layer will take into account the volumetric lighting, enhancing those elements necessary to improve spatial perception and incorporating selective lighting elements to draw attention to the desired elements.

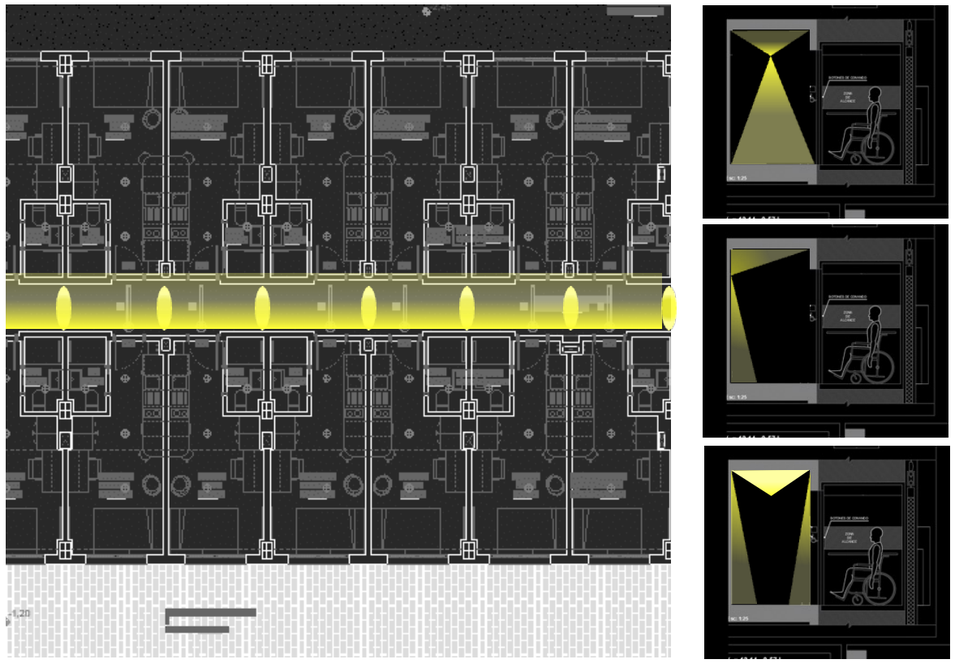

FIG 21. LIGHTING SYSTEM LAYOUTS COMBINING DIRECT/INDIRECT EMISSIONS ON CIRCULATION ROUTES WITH INCREASED INTENSITY AT KEY POINTS

Unfractured sequence of design components to break crossroads

Lighting at junctions and crossroads: Ensure good lighting at all junctions and changes of direction to reduce disorientation. Increase lighting levels with respect to the circulation area.

Lighting semantics: Use lighting systems with their own semantics to help identify the intersection space or node

Transition lighting: Use transition lighting between different areas to help users anticipate changes in space.

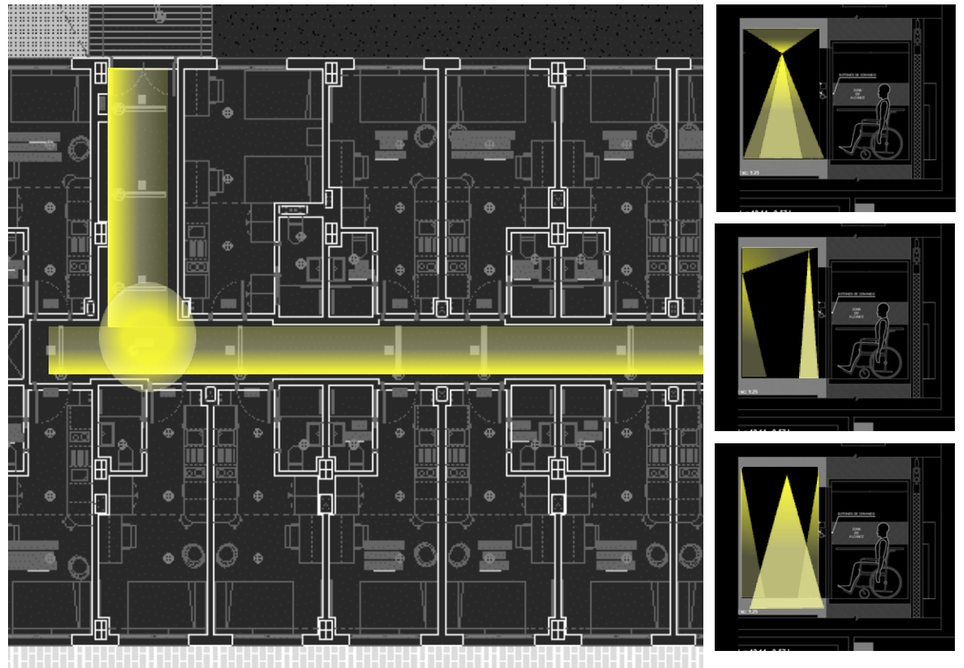

FIG 22 LIGHTING LAYOUTS AT INTERSECTIONS OR NODES

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Removal of barriers to perception in general and design in particular

Avoid excessive contrast: prevent the creation of high-contrast lighting scenarios that create glare.

FIG 23. SPACE WITH EXCESS CONTRAST PREPARED BY THE AUTHORS

Glare and brightness control: use luminaires with high levels of shielding or glare control diffusers, and avoid highly reflective surfaces that can cause distraction or glare.

FIG 23. SPACE WITH EXCESS REFLECTIONS

DESIGN PRINCIPLES

Threshold effect placing “memories” in longitudinal spaces

Reinforce marker lighting: place lights along markers in longitudinal spaces to keep visual information always present, supporting the working memory. Ensure that signs are legible from a reasonable distance and in different lighting conditions.

Colour rendering: use sources with high colour rendering (CRI>90), especially in rooms where colour is used as a design element.

Contrast and visibility: use lighting that improves the contrast of signs to ensure they are visible both day and night. Use high colour rendering to assist in identifying the semantic intent of the colour.

Guide lights: use them on the floor or at eye level to mark distances and directions (low intensity night lighting to guide to and from toilets if they are in bedrooms and in corridors).

FIG 24. EXAMPLE OF A PROTOTYPE NAVIGATION LIGHT ‘DEVELOPING ARCHITECTURAL LIGHTING DESIGNS TO IMPROVE SLEEP IN OLDER ADULTS’ - M.FIGUEIRO, M. S. REA, M. REA (2008). AI-GENERATED IMAGE

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Clustering-segregation effect and other phenomena of visual *perception*

Differentiated lighting: use different types of lighting to group or separate specific areas, facilitating the perception of boundaries and functional zones.

Focused lighting: use focused lighting to highlight key elements and visually organise the space

Creating references with the semantics of shapes

Thematic lighting: Understood as an integrated design element, where the shape of the luminaire can emphasise formal semantics, helping users to identify and understand the function of each space.

Differentiated use of colour: The colour of the source can also be used as an element that reinforces the meaning of each space with its expressive power.

FIG 25. EXAMPLES OF THE USE OF THE SEMANTIC DIFFERENCE OF THE LUMINAIRE (FIL AND MUN DARK MODELS) AS A FORMAL ELEMENT THAT HELPS TO DIFFERENTIATE AND CONTEXTUALISE SPACES.

FIG 26. EXAMPLES OF THE USE OF COLOURED LIGHT TO REINFORCE THE MEANING OF EACH SPACE. IMAGE GENERATED BY IA

DESIGN COMPONENTS

Components, acting as spatial coordinates for reading space

These lighting aspects aim to improve cognitive accessibility and sensory integration of users in different architectural environments through lighting components:

Colour temperature; Use colour temperatures that are comfortable for the eye, such as warm lighting in rest areas and cooler lighting in areas of high activity. Always in relation to the light levels of the tasks to be performed.

Adjustable intensity: Implement lighting systems with intensity levels that can adapt to different needs and times of day.

Sensorial inclusivity: Ensure that lighting is not a source of sensory stress, taking into account different functional profiles, especially for people with increased sensitivity, such as those on the autism spectrum.

Control technology: Use easy-to-use and low-maintenance lighting control technologies, such as motion sensors and natural light controls, to optimise lighting based on actual use of the space. Or accessible controls that allow the lighting atmosphere to be personalised and are accessible to all users.

Lighting itineraries or scenes: Designing dynamic lighting scenes that gradually follow the movement of activity or the change of natural light, helping to connect indoor and outdoor spaces.

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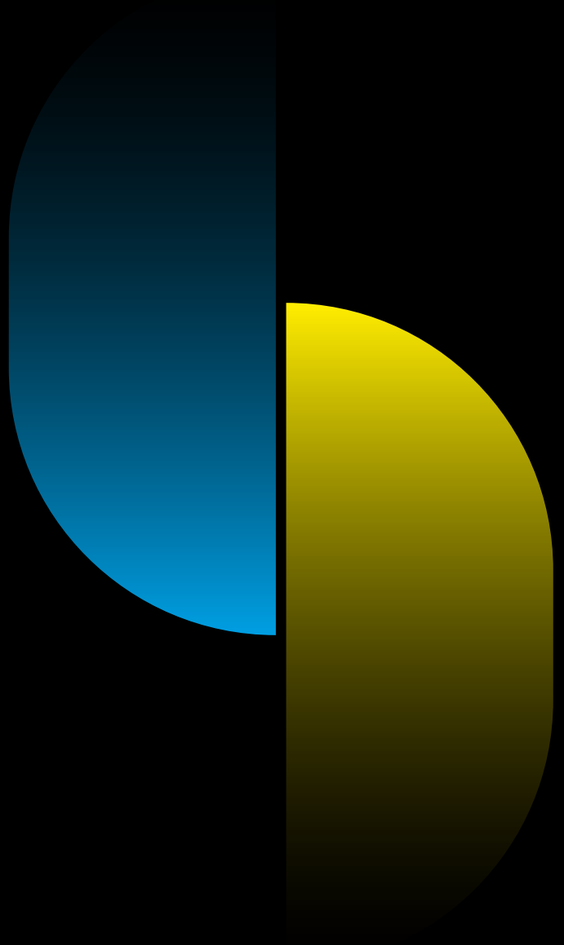

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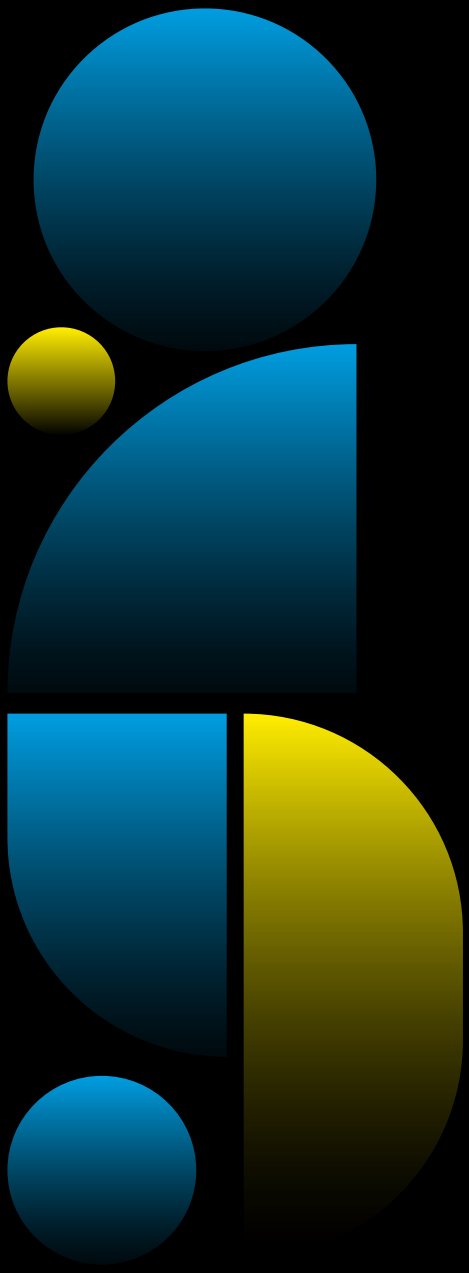

BERTA BRUSILOVSKY &

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Worktitude for light