Lighting Design - Weekly Blog

Week 7

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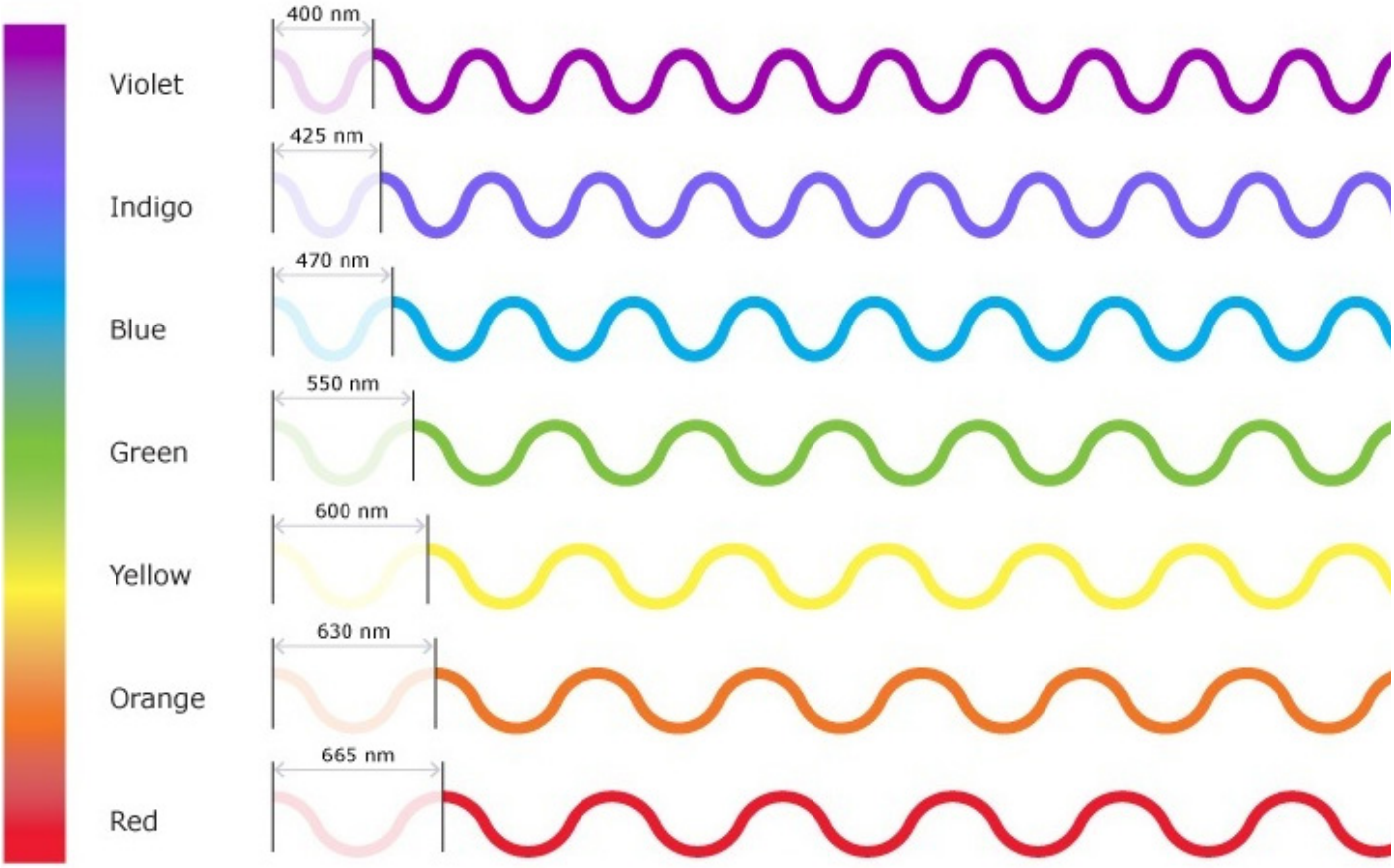
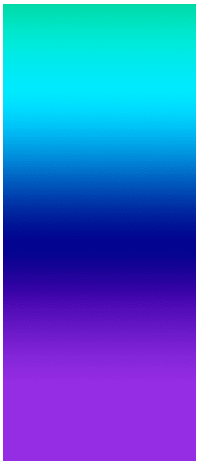
Light and Colour

Behaviour, Perception, Impact

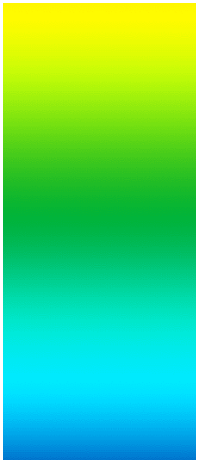
The lecture and workshop this week explored the concepts of light and colour, how they interact, and the impacts on how humans perceive objects. The lecture covered the topics of wavelengths and their impacts, how the light source and colour of an object interact, how to quantitatively and qualitatively measure the quality of light, colour mixing, and shadows. In the workshop, different coloured spotlights were used to study the impacts of colour mixing and behaviour of shadows.



Colour is a wavelength of light on the visible electromagnetic spectrum ranging from 400-700 nm. Colour choice can create the mood and define the program, enhance a space, and influence human behaviour and moods. Exposure to wavelengths releases different hormones and chemicals in the body. Personal memories and cultural influences also influences our perception of different colours.



Short wavelengths are blues/purples and have an energised effect. They release norepinephrine and dopamine as reward transmitters. Cortisol encourages stress and physical activity.



Medium wavelengths are greens and yellows and increased inhibition. They increase GABA, a neutral inhibitory transmitter. This is similar to the wavelength humans receive in the afternoon.

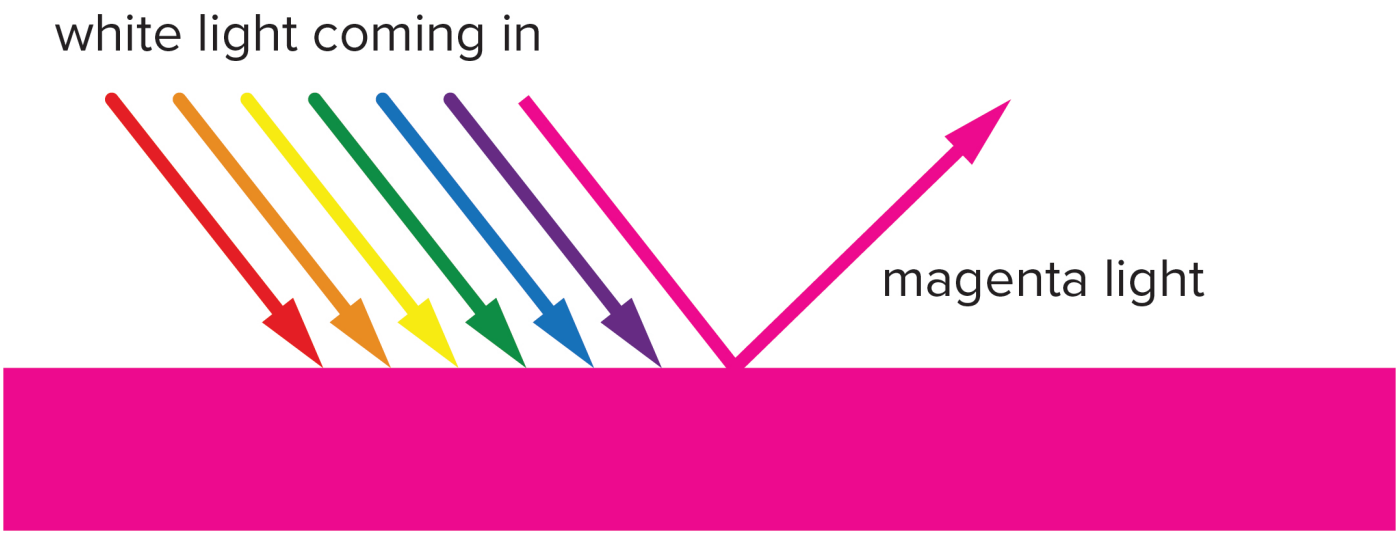
Long wavelengths are reds and oranges and have a calming effect. They suppresses cortisol, and release melatonin and serotonin, resulting in a rebuilding and regenerative state; vital for cognitive and physical health.

Photo Sources:
Science Learning Hub, https://www.sciencelearn.org.nz/resources/47-colours-of-light
ThoughtCo., https://www.thoughtco.com/the-visible-light-spectrum-2699036

How We Perceive Light

Interaction of Light and Object

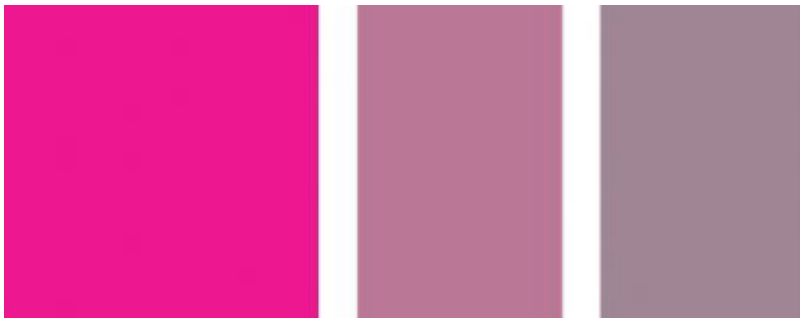
How we perceive colour is dependent on the quality of light. We will only see an object's true colour if the light source contains the same wavelength. The diagram below demonstrates this idea. White light contains all wavelengths (more on this later in the blog). When it hits an object, the object reflects the wavelengths of the colour is composed of, and absorbs all other wavelengths. If it does not contain the proper wavelength, the colour will not appear the same. The quality of a light source can be measured with several metrics.



Wavelengths alone are not sufficient in fully describing colours. Simply saying an object's colour as "510 nm", "green" or even "dark green" does not give a clear picture of the object's appearance. We can qualify colour using terms like hue, saturation, value.

A hue is the most dominant wavelength and is the term we refer to first and most common. Yellow, blue, and green are all example of hue. It can also be defined as the degree on the colour wheel (0-360 degrees), as shown on the left. They have full spectrum saturation and are in their purest form (i.e. no white or black).

Saturation is the level of which white and black are added to the hue's purest form. It defines the brilliance and intensity of a colour. It works on a scale of how much or little other colours are represented. It is interchangeable with the term "chroma". The image on the right shows how magenta decreases saturation moving left to right.



While saturation describes the purity of a colour in terms of how grey it is, brightness (or value) refers to how light or dark a shade is depending on the amount of white and black is added to the colour's purest form. The lighter the colour, the more white it contains, and the higher the value.

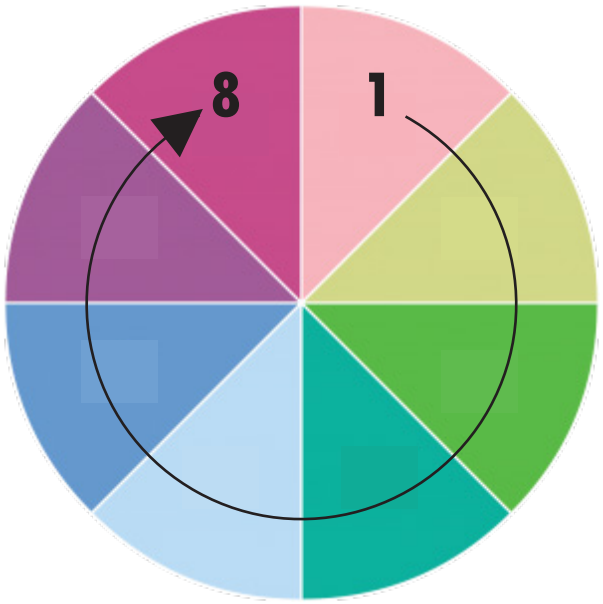
These three terms make up the HSV scale. The combination of these values give a clear definition of the colour, which is important for duplication in all design disciplines.

Photo Sources:
Taylor Hieber Graphics, https://taylorhieber.co/color-terminology-glossary/

Quality of Light

Methods for Quantifying

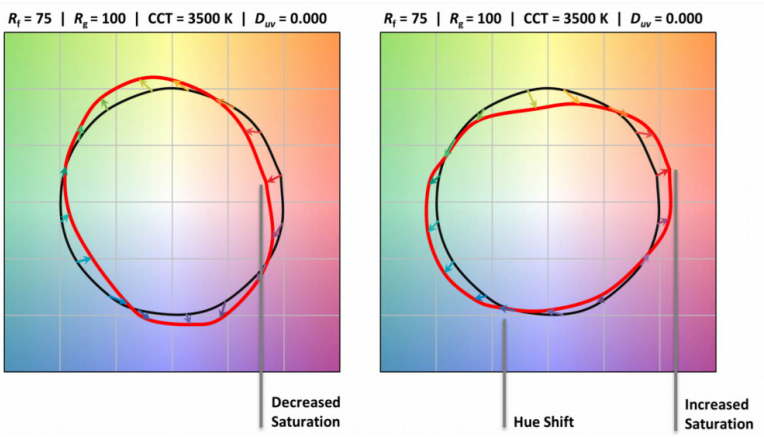
Regardless of the HSV definition of a colour, the way we perceive it depends entirely on the quality of the light source. As mentioned, a colour will only appear in its true form if the light source contains the same wave length. The perfect light source is considered daylight because it contains the full visible electromagnetic spectrum. All colours appear in their truest form when lit by the sun. Designers have developed quantifiable measurements to compare artificial lighting sources to natural light in terms of colour rendering. As lighting technology continues to advance, so do the metrics.



The first and most well-known metric is the colour rendering index (CRI). It measures the ability of an electronic light source to reveal the “true” colours of objects in comparison to the ideal daylight source using 8 standard pastel colours (shown in the image on the left). Values range from 0 to 100, with the average modern LED lighting being between 80-90.

CRI was the primary metric for quantifying the quality of a light source, but the emergence of new LED technology required a new scale to measure the full spectrum of light from LEDs. Some of the limitations include only testing for eight values, ignoring spectral values, and needing to known the CCT of the source when comparing values. Designers often feel like the CRI is becoming less effective at achieving desired results, and a new system was created in 2015.

TM-30 solves many of these problem. While CRI provides a single metric, TM-30 consists of three: fidelity index (how close a source is to the sun), gamut (how intense colours are under a given source), and vector graphic (level of saturation). Moreover, the metrics cover 99 colours (as opposed to CRI’s 8) that are categorised into seven grounds: nature, skin colour, textiles, paints, plastics, printed materials, and colour systems. It makes up for the shortfalls of the CRI system by using a larger colour pallet. In addition, the numerical scores for saturation, vibrancy, and visualisation makes it clear which colours a light source can render well. It gives a holistic story about the light.



The image above alters the vector graphic as a visual representation. The black circles represent the reference light,and the red circles represent possible changes that can be made to change the appearance of a light source.

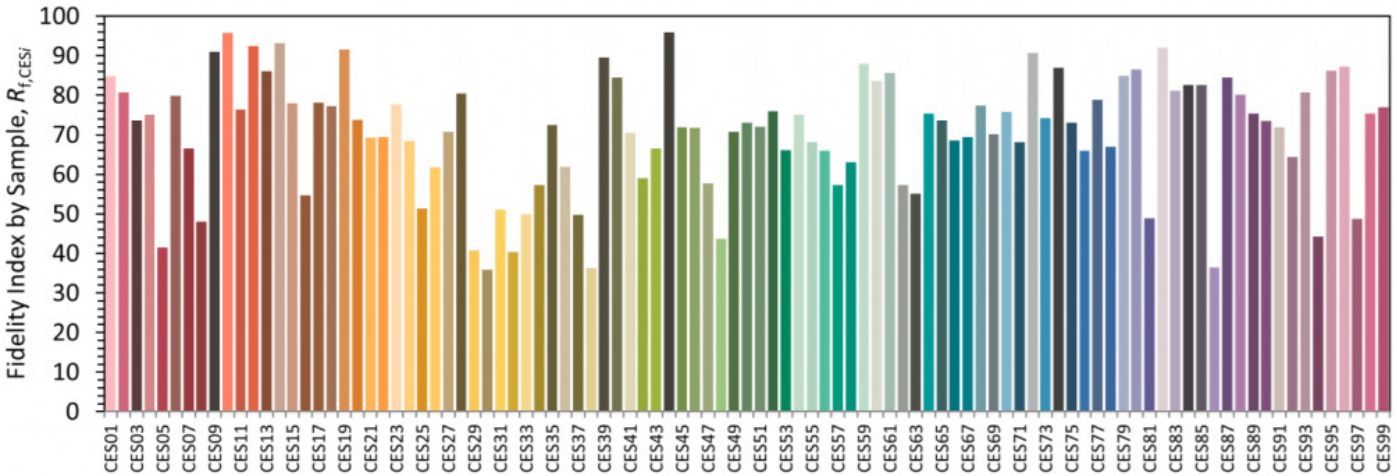
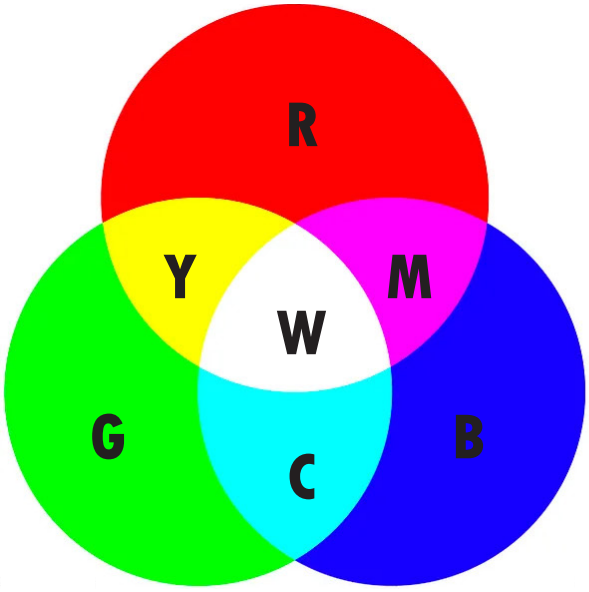


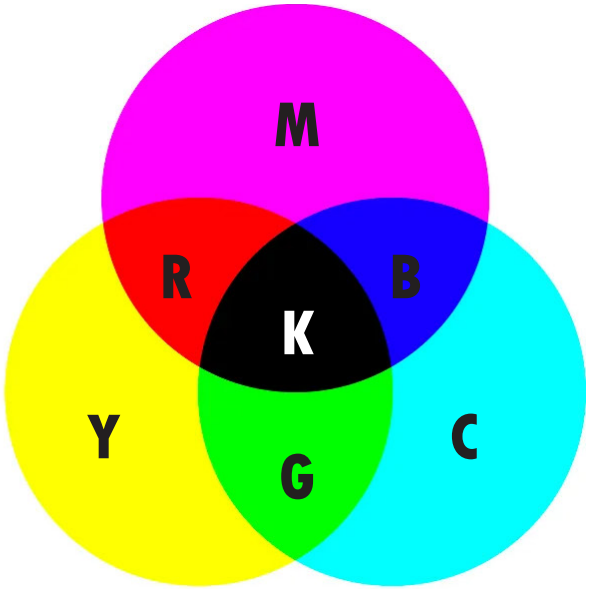
Photo Sources:
AmberLux, https://blog.amerlux.com/cri-vs-tm-30-what-do-these-color-quality-measures-mean/

Colour Mixing

Artistic Medium

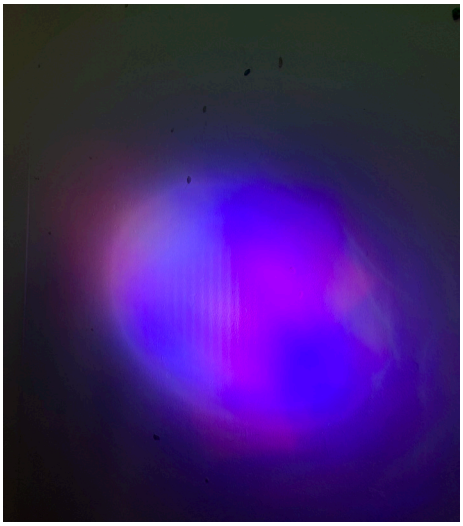
During the workshop, we used different coloured spotlights to explore the concept of colour mixing. This is when one or more primary coloured light sources overlap to create a new colour. There are two types of primary colours; additive (image below on the left) and subtractive (right). The three additive primary colours are red, green, and blue. They are used to create all other colours, and when combined create white light (more on the next page). They are obtained through the light they emit. Alternatively, subtractive colours are associated with the subtraction of light and used for printing. The three subtractive colours are magenta, yellow, and cyan. Mixing the three results in black. Mixing two primary colours creates the secondary colour; the primary additive are the secondary subtractive, and the primary subtractive are the secondary additive.





The image on the left shows the spotlights used in the workshop. The red, green, and blue are distinct. Similar to the diagram above, the areas where they overlap are made clear by the creation of cyan and magenta.

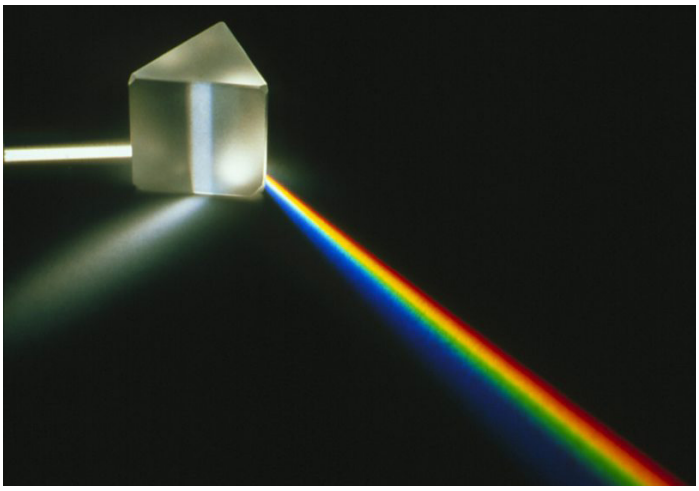
The photo on the bottom left shows how light sources appear when overlapping more closely. The most prominent colours are red and blue, and they combine to create variations of violet and magenta. The green spotlight is appearing less so, which could be due to varying distances or characteristics of the luminare.



The photo on the right shows how the spotlights are interrupted by an object, a hand in this case. As the beams hit the hand at different angles, they are both broken into their separate colours, or fused to create a new one. Compared to the photo on the left, the greens and yellows are much more present. In addition, the different beams create different shadows of the hand, making a unique reflection on the wall.

White Light

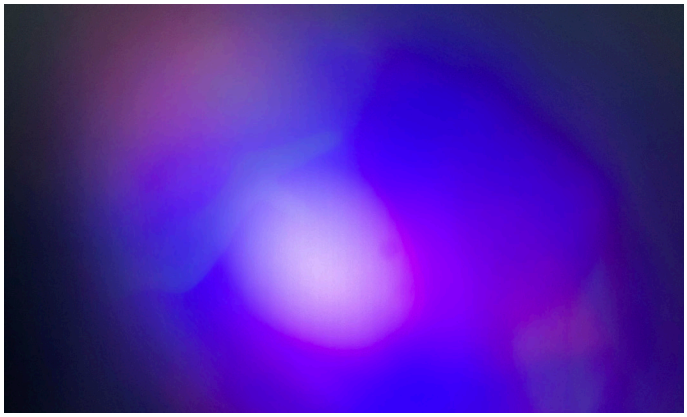
Importance in Our Environment



Mentioned previously, white light contains all wavelengths on the visible spectrum at the same intensity. Put simply, it is transparent daylight. The most common source of white light is the sun. Artificial light sources like LEDs and fluorescent bulbs can produce white light. White light is important for several reasons. It is typically absorbed and emitted by the electrons that shift from energy levels. This reaction triggers human vision and photosynthesis; it's impact on our mood and behaviour are far reaching. This is why many designers emphasis daylight in their design.

White light is important in colour rendering to show an object or surface's true colour. If you have ever bought a piece of clothing or decoration, only to find it appearing completely different when you take it outside, you understand the impact of white light and impact on how we see objects.

The image on the right shows the result when all three primary colour lights are overlapped. The centre where they overlap shows the creation of a white reflection. The spotlights were held in our hands rather than being precisely aimed with equipment. Regardless of the imperfections, it was surprising to see how the coloured lights overlapped and created white.



The photos below are several examples of how coloured lights can be used in architecture to influence the mood of a space.

The image on the upper left is the Sovereign Pop Venue in the Netherlands designed by de Architekten Cie. The violet lights introduce the visitor to the artistic experience they are about to embark on.

The project on the lower left by MIRAG in Spain was part of a remodeling for a cultural institutional centre. The use of green and blue lights aim to provide freshness and luminosity.

The image below shows a town hall in The Netherlands designed by de Architekten Cie and van Dongen-Koschuch. The space is used for commercial space, and the red-orange lights create intensity and focus, contrasting from traditional retail space.

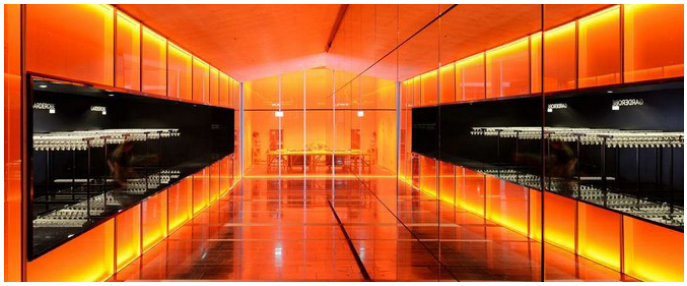


Photo Sources:
Delightful, https://www.delightfull.eu/blog/2014/12/22/top-10-architectural-lighting-projects/

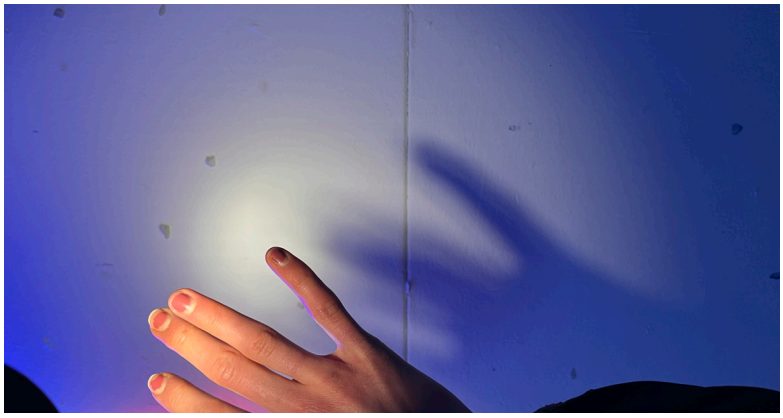
Shadows

Absence of Light

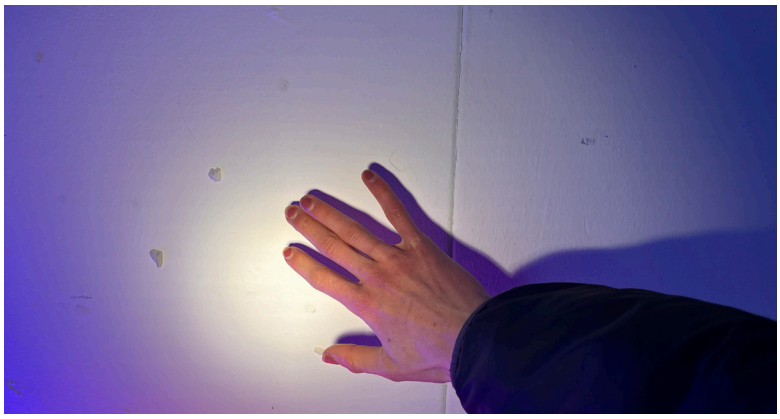
While the lighting of a space is generally prioritised, the resulting shadows are often neglected. Simply put , shadows are the dark areas produced by an object intersection rays of light and a surface. They can be used in to create a mood of a space. Moreover, shadows create layers and dimension to show depth. A darker area may appear farther away and as a background.

Like daylighting, shadows are equally dynamic and change depending on the exterior conditions and sun's position. Designers like Louis Khan celebrate this idea. Khan's Sher-e-Bangla Nagar in Bangladesh (image on the left) uses large circular windows that angle the sun in specific areas to define spaces of light and dark depending on program.

The photos on the right were taken from the workshop and demonstrate how light influences the characteristics and qualities of shadows. In this example, the light source is an LED desk lamp.



The photo on the top shows the shadow of my hand when it is about 20 cm from the wall, and the photo below is when my hand is about 5 cm from the wall. The former results in a much more blurry shadows than the latter's crisp edges.



This demonstrates diffraction, which is the bending of waves around an obstacle. As the waves from the light hit my hand and go through my fingers, they are projected in various angles as they form around the edges. When my hand is farther away from the wall, the waves' angles are more exaggerated since they have farther to travel before reflecting off the surface.

The images on the left and right depict Owen Gildersleeve and Stephen Lenthall's project titled *Shadow Spaces* that studies the relationship between space, form light, and shadow. Using white paper, they use "light as a map to shape each form." They demonstrate how architecture can be done without ornamentation or colour to create decoration and character in a space. Instead, the form is celebrated by using an intense light source to create clean and crisp shadows.

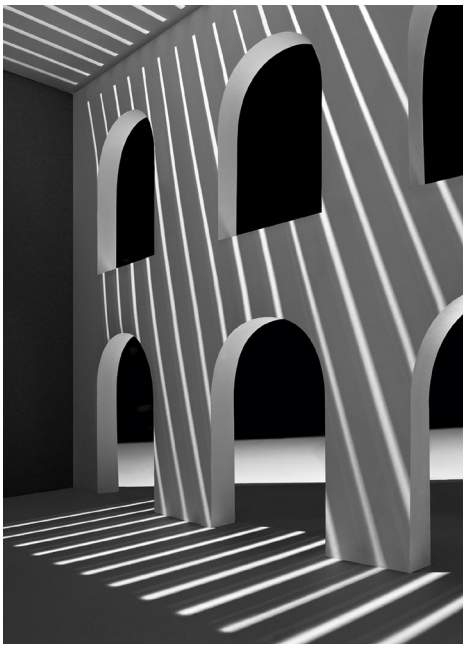


Photo Sources:
Creative Boom, https://www.creativeboom.com/inspiration/shadow-spaces-miniature-architecture-crafted-from-paper-looks-like-real-buildings/