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**Light as an Intangible Layer of Architectural
Environment**

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Light as an Intangible Layer of Architectural Environment

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Abstract

People get in contact with the environment through their senses and these senses provide a perception of the surrounding space. The relation between people and the environment is formed with the perception of space. Although vision is the primary sense which creates spatial perception, it cannot be formed without light. Thus light is the most important component that affects spatial perception. Lighting affects the way people perceive the architectural environment in harmony with the architectural geometry, the way people evaluate and determine their responses to the environment. From this point of view, this research aims to define the light's impacts on the spatial perception and how light is transformed to an intangible layer of architectural space. To figure out these issues, visual and spatial perception definitions and different buildings in various typologies around the world are examined with considering interaction between light and architectural spaces.

Keywords: Lighting, Perception, Visual environment.

Introduction

People get in contact with the environment they have been in by their sensation competence. These competences provide them to decode their environment or the space they have been in. Perception, which is created by the environment or space, defines the relation between people and the surrounding space. Besides, vision is one of the most important components of perception, light is also the most significant component of vision. Lighting impacts the way we perceive the environment in harmony with the architectural geometry, the way we evaluate and determine our responses to the environment. Moreover, lighting provides visibility of the surrounding objects, tissues and textures; we are not able to see without light. In this context; this research aims to define the light's impacts on the spatial perception and try to figure out how light is transformed to a component of architectural space by giving visual and spatial perception definitions, and examining different buildings in various typologies around the world from the viewpoint of interaction with light.

Light and Architectural Space

Light creates vision and vision creates perception, thus lighting can extremely change the perception of space. Barr and Broudy state that light is the catalyst that can convert a texture to a finished architectural surface. With the effect of light, atmosphere in the architectural space can change, the desired effects can be enhanced, motion and viability can be created (Barr and Broudy, 1990). Lighting can be examined as the combination of light and architectural environment.

As indicated before; spatial perception mainly occurs with visual perception, and visual perception occurs with the effect of light. Also visual perception is the transformer that converts light to an architectural component. Accordingly, to figure out the relation between light and architectural space, firstly visual perception will be defined within the context of a light-eye-brain relation, then spatial perception will be defined with its fundamental components.

Visual Perception

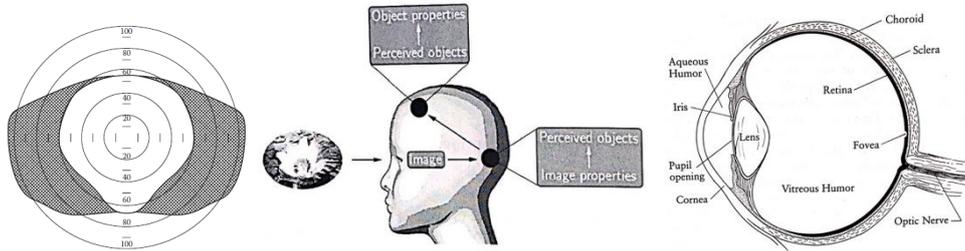
Visual sensation generally takes the first place on the perception of space because it is a distance sense which can provide knowledge from densely distant places in the environment (Fieandt et al., 2016). To comprehend the basis of vision and visual perception, the optical structure of the eye should be explored firstly. Human's two eyes mounted frontally provide a considerable overlap between the two visual fields. Figure 1(a) shows the approximate extent of the visual field of the two eyes in humans and the overlap between them. The binocular visual field is expressed in degrees from the view direction. Areas that are visible to only one eye are shown as shaded. Given the limited field of view imposed by the frontal

mounting of the two eyes, to enhance the visual field it is necessary for two eyes to be able to move. It can be possible in just two ways; by moving the head or by moving the eyes. Although humans have a more limited range of head movements, they have a wide range of eye movements (Boyce, 2003).

Vision creates a bridge between light and spatial perception. Reflected light from the object enters the eye and creates vision. But the process organizes meaningless patches of light on the retina; into the objects we perceive, that is, objects with potentially meaningful properties such as shape and spatial arrangement of parts (Figure 1(b)). In other words, when we look at a scene, the objects we perceive constitute the output of vision – not its input. Light entering the eyes yields a two-dimensional retinal image of a scene. Properties of this image then are extracted to yield a three-dimensional perceptual organization of the scene in terms of objects arranged in space. Properties of these perceived objects and their perceived arrangement in space then determine how we might act upon what we think and see (Helm, 2014). Vision results from the interaction of the eye and the brain; from vision perceptions occur; from perceptions we build our individual worlds, which is extremely affected by the luminous environment (IESNA, 2011). An object's visual image that is illuminated by light enters the eye via the lens (Figure 1(c)). In front of the lens is the iris, which automatically reacts to the amount of light entering the eye. The dark circular aperture in the center of the iris is the pupil. When illumination increases, the iris closes to reduce the amount of light that falls on the retina. Along the same line, when illumination decreases, the iris opens. As a thin membrane in the interior of the eye; the retina covers nearly 200 degrees of the inner surface of the eye, and contains the light sensitive receptor cells. Cones provide to see the color with details of texture and function in daylight and increased brightness of artificial light. Rods function in dim light, operating at night and in darkened rooms that respond to varieties in brightness and provide a black and white view (Michel, 1996). Under different luminance conditions, various types of operating states of the visual system occur. Photopic vision occurs at luminances higher than approximately 10cd/m^2 . For these luminances, the visual response is controlled by the cone photoreceptors so color is perceived and fine detail can be resolved in the fovea. Mesopic vision occurs in luminances below approximately 10cd/m^2 and above 0.001cd/m^2 that both cones and rod receptors are active. As luminance declines through the mesopic region, which contains only cone photoreceptors, it slowly declines in absolute sensitivity without significant change in spectral sensitivity, until foveal vision fails altogether as the scotopic state is reached. In the periphery, the rod photoreceptors slowly come to control the cone photoreceptors, resulting in a slow impairment in color vision and resolution and a shift in spectral sensitivity to shorter wavelengths. Scotopic vision occurs at luminances less than approximately 0.001cd/m^2 which only the large receptive fields consisting of rod photoreceptors react to stimulation. At this state of the visual system there is no perception of color, and the resolution of detail there is minimized (IESNA, 2011). Thus, it can be said that; it is

possible to create different visual perceptions for the same scene by changing the amount of light.

Figure 1. (a) *Visual Field Graphic*; (b) *Visual Perception Process*; (c) *Cross Section of the Human Eye*



Spatial Perception

Perception creates the awareness of the environment, and vision not only provides orientation of people but also it helps them understand the environment and convert it to a useful space (Norberg-Schulz, 1965). Architectural space is a physical reality which has a describable form, texture and color and where different actions take place (Soygeniş, 2006). Additionally, space perception consists with depth perception, form, color and movement. Also, a space can be defined with three dimensions or plane. Height defines the vertical plane, width defines horizontal plane and depth defines sagittal plane (Fieandt et al., 2016). In that case, the primer requirements to perceive a space are; perceiving the form, texture, colors and dimensions of the space. Also, all of these are just possible with the visual sensation and only by this way people can get in contact with the space.

Light is the principal necessity for the visual system's performance. We can see with light but in the absence of light, we cannot (Boyce, 2003). Under weak illumination, the outer edge of an object or the other significant information, like the surface texture etc. may not be visible at all. Nevertheless, as illumination increases, outer contour and surface details become more apparent, hence the object becomes more comprehensible (Michel, 1996). Visual perception occurs on the eye not via light, but via contrast (the difference between light and dark). Thus, visual perception is a sense of contrast or a sense of identification of differentiations (Gordon, 2003).

It is not possible to create a visual perception without light thus it has the majority of the perception of space. It could be said that light makes a space alive by rendering objects/surfaces and creating shadows, remark the forms by creating visual illusions, can define a movement in an environment, can affect and direct human psychology and wellness. Light defines the environment that we have been in by creating visual and psychological perception.

The Role of Light in Architectural Design

Light is the main component of visual and so spatial perception but it is flexible than all of the other components of architectural space and vision. It is movable, changeable in form, colorful and has effects on human emotions. Thus, light can be transformed to another component by its flexible characteristics. In this part; light's flexible characteristics and its transition will be examined as a layer that can remark the form, define the boundary, create pattern, movement, guide and spiritual effects, according to theory that visual sensation generally takes the first place on the perception of space and Schulz's statement that; "Our immediate awareness of the phenomenal world is given through perception. We are highly dependent upon seeing our surroundings in a satisfactory manner" (Fieandt et al., 2016; Norberg-Schulz, 1965).

Light Remarks the Form

The visual perception of the materials and form of buildings can be changed in the day and night time with the effects of daylight or artificial light. The Roca Barcelona Gallery is designed by OAB (Office of Architecture in Barcelona) for the Roca Bathrooms, and built in 2009 in Spain, Barcelona. Even in the first stages of the project, the architectural design was already seen as a tool for spreading the brand and the company. The building is designated as a broadcasting channel for attracting people's interest to the products, projects and preoccupations of the company. The design contains a museum of the brand and a platform of social events that also involve the business world. Thus the aim for the building design is to create a remarkable project, and the façade of the building was one of the main design considerations since it is the point that creates first impression about the building. Although the base material of the façade is glass, it works in various ways. Sometimes it acts as a usual transparent glass material, other times it looks opaque. Besides this, at night with the artificial light it turns into a mark (Figure 2(a)). By this means the building gains a unique character which attracts the attention of visitors or people around it with its varying transparent and opaque properties (ArchDaily, 2012; OAB, 2016). This transformable visual effect of façade material related to the existing luminous conditions - daylight or artificial light - alters the perception and remarks the building mass.

Also at the additional building of The Nelson Atkins Museum of Art in Kansas City, USA has a similar link between light, material and form. The museum was designed by Steven Holl Architects at 2007 and offers an experiential space that is perceived through the visitors' individual movement through space and time. The additional building, named as the Bloch Building has transformed the entire Museum site into the precinct of the visitor's experience by its link between the existing sculpture garden. The additional building can be examined through its light, art, architecture and landscape, with views from one level to another, from inside to outside. Light is gathered, diffused and refracted by the lenses' multiple layers of

translucent glass gather, like blocks of ice. During the day the lenses add varying qualities of light into the galleries, while at night the sculpture garden glows with their internal light. The translucent channel-glass building skin can appear as opaque as stone or may glow brightly from within, depending upon the presence or absence of internal lighting (Figure 2(b), Figure 2(c)). From day to night, translucent building skins can be transformed extremely and they can create alternate changes in the perception of interior and exterior spaces. These façades typically transmit sunlight inwardly by day and artificial light outwardly at night (Murray, 2013). Thus the form of the museum building is seen as an opaque mass during the day time as in a harmony with the old historical building, but at night time it is blowing with the effect of artificial light. It changes the perception of the building within its environment and remarks its form.

Figure 2. (a) *Exterior View of Roca Barcelona Gallery at Night;* (b) *Exterior View of The Nelson Atkins Museum in the Day Time;* (c) *Exterior View of The Nelson Atkins Museum at Night*



Light Defines Boundaries

Light creates brightness and brightness contrast between surfaces and spaces is one of the significant parts of visual perception. This brightness contrast provides to perceive boundaries of forms. Thus the existence or absence and amount of light can maximize or minimize the visual effects of the boundaries of spaces. Sancaklar Mosque is designed on a site overlooking the Büyükçekmece Lake in Istanbul by Emre Arolat Architects and built in 2013. Mosques do not have a predefined form and anywhere could be a prayer's room, thus the project focused on the "essence" of a religious space. The design aimed at representing its purest forms of light and matter, just as a primary inner world, free from all cultural burdens. The mosque is located in a green area that is separated by a busy street from the surrounding suburban gated communities. Placed in the slope of the site the only visible elements of the mosque are the garden surrounded by horizontal courtyard walls and a vertical prismatic mass of stone (minaret). The interior of the mosque is a place where materials are perceived as they are and feels like a cave thus is a dramatic and leading place to feel God. Besides this the slits through the Qiblah wall emphasizes and enhances the directionality of the prayer space and allows daylight to filter into the prayer hall as shown in Figure 3(a) (Emre Arolat Architecture, 2015; ArchDaily, 2014a). With the daylight entering from the ceiling of the mosque and the artificial lights inside of it strengthen boundaries and the levels of the inner

hall are defined. Also a sketch of the designer, which can be seen in Figure 3(b) shows the design consideration related with light and defines its boundaries.

Figure 3. (a) *Sancaklar Mosque, Interior View*; (b) *A Sketch for Sancaklar Mosque*



Light Creates Pattern

The effects in interiors can change with the form of the building and according to the materials used. When combined with form and materials light can create a pattern. Light Walls House by mA-Style Architects can be shown as a sample of this. The Light Walls House was built in Toyokawa, Japan, at 2013. It is located in a shady location as shown in Figure 4(a), where other neighboring buildings possibly create a darkness effect. Thus the architects aimed to create a uniformly illuminated interior and used the roof panels designed to arrange the paths of daylight. Sunlight passes between the roof beams, then it is reflected and diffused by the lightly sloped clapboard, laminated wood and interior walls (Figure 4(b), Figure 4(c)) (ArchDaily, 2013). By this way the material properties, form and the pattern of the roof are felt in the interior via daylight, thus the games of light and shadow create pattern and alter the perception of the flat surfaces. As if a living and moving wall paper or a carpet creates moving patterns occur in the interior so light creates patterns on flat surfaces.

Figure 4. (a) *Light Walls House, Exterior View*; (b) *Light Walls House, Interior View*; (c) *Light Walls House, Interior View*



Light is Movement

Light is movable and changeable in colors so it is possible to create a movement with light. Also this movement can define the life of the space. Hafen City is the largest urban redevelopment project currently under way in Europe which involves the transformation of an underused Port of Hamburg, the inner-city district with mixed residential, work, cultural, recreational and educational uses. To serve these facilities, the city expanded its subway system with the construction of a new station. Munich-based practices Raupach Architekten and Pfarré Lighting Design are the designers of the metro station that looks for creating a link between the existing harbor district and the port. The principal of Raupach Architekten, Christian Raupach indicates that they were inspired from the brick façades of the warehouses changing their appearance due to daylight, and the steel hulls and modules of transport containers changing their colors with the seasons. Above the platform, 12 light boxes were hanged (Figure 5(a)) which were made of shipping-container-size steel and matte-white glass. Pfarré designed the lighting environment by establishing a link with the Port of Hamburg. Therefore he designed it as a transform color in calm, smooth transitions (Figure 5(b)), moving slowly through the boxes like the ships moving through a harbor. The interaction between the light—whether white or colored—and the mottled surface of the steel paneling, which is reflective without creating a glare, makes a brooding yet animated experience. The movement and colors of lighting change according to the season but the transitions between the colors are designed to create a tranquility and deceleration effect. The aim was to transform the waiting situation from the waste of time to a relaxing time with the tranquility and deceleration effect. Pfarré describes interior as a breathtaking atmosphere (Seward, 2013; Gieselmann, 2014). This definition by Pfarré and his design considerations also show that light can make a space alive via its changeable and movable properties. Also inspirations that shape the design of the station are related with the movement and life cycle in the Hafen City district. These characteristics at the exterior of the station is converted to design and transferred to the interior of the station.

Figure 5. (a) *Hafen City Metro Station, Interior View*; (b) *Hafen City Metro Station, Interior View*



Light is a Guide

Light can be used as a guide with its charming effects in architectural spaces. With the brightness properties of light and different brightness levels in architectural spaces, light can create focusing on a specific object and this guides the eye meanwhile the visual perception (Laganier, 2011). The Amsterdam Public Library designed by Jo Coennen & Co Architekten and built in 2007 at The Netherlands, Amsterdam. Architect preferred to design interior and exterior as indissoluble parts of the architecture but the main consideration focused on designing the interior space. With its great dimensions, the form of the library can only be perceived by a sculptor view. The building has its own character with art, interior and light. So experience of library becomes unique with these components. Movements in the structure – materials, details, scale, contrast between light and dark, open to close – are considerable for the way architecture experienced. Additionally, the voids and the openings in the floors, library has great openings on the facade to let in daylight and pass through the heart of the building. Diffused daylight provides natural light where it was not possible used to. Also in the core of the building escalators serve as lighting objects which provide a brightly lit area to orientation where the daylight cannot get in as shown in Figure 6(a) and Figure 6(b) (ArchDaily, 2014b). Lighting design and difference in the brightness levels of the inner surfaces attracts people and creates focusing on the circulation path. Thus it comes through as a guide who directs people to the escalators and different levels of library.

Figure 6. (a) *Amsterdam Public Library, Interior View;* (b) *Amsterdam Public Library, Interior View;* (c) *Istanbul Modern Museum, Interior View of Exhibition Hall*



Especially in exhibition areas orientation is one of the most important design considerations. To guide visitors lighting can be used as a component integrated with design. Galataport Project was a transformation project situated at one of the most significant points of the greatest city of Turkey, Istanbul, 1.5 km coastline of the Galata Pier, Turkish Maritime Operations and the buildings located within this zone. Besides renovation and reinforcement of the historical buildings in this zone, the aim was also to improve the district by adding various social functions to the old buildings correspondingly constitute a modern museum was one of the main objectives of the project. As a part of this urban transformation project the Istanbul Modern Museum transformed from warehouse building#4 by

Tabanlıoğlu Architects at 2004. The design approach was to preserve structural essence of the warehouse therefore simplicity is preferred to reveal the exhibited artwork. The walls of the exhibition halls are white and the rest of the building is colored gray, which creates a stable atmosphere so that the building is not dominating the exhibited works. In parallel with this approach, lighting of the museum is designed as integrated with the interior (Figure 6(c)) (Tabanlıoğlu Architects, 2016; PLD, 2007). The linear lighting fixtures in the exhibition halls provide both a guide for visitors and visual requirements for the exhibition of art objects. Contrast created with the dark grey color of the ceiling and the brightness of the light strengthens the effect.

Light is a Spirit

Light is not just a physical component of architecture, it is also an emotional component. It can create different psychological effects and change the feelings of the visitors. Lighting design is a composition which has bright and dark parts. With this composition of strong contrast and brightness lighting creates a more dramatic scene (Laganier, 2011). Libeskind objectifies the horror and diffractions in the German and Jewish history with the zig-zag form of the Jewish Museum (Neumann and Copans, 2002). The connection between Libeskind's Jewish Museum and the existing museum building is designed underground. Inside of the Baroque Kollegienhaus, a stair downwards passes through the new building. This way ends with three axes which all of them symbolize a different point of German-Jewish history (Studio Liebeskind, 2015). Libeskind designed the museum not as a place just for visit. It is a place for experiencing a hard journey. The language of form, the geometry and shape of the building based on a matrix that the architect Daniel Libeskind plotted the addresses of prominent Jewish and German citizens on a map of pre-war Berlin and joined the points to form an "irrational and invisible matrix". Also the positioning of the narrow slits on the façade, where the light slightly penetrates into the building, are based on to this network of the connections. The first axis in the museum ends with a dead end where visitors meet a black door. There is nothing behind the door just a void and a slit at the top where a weak light enters (Figure 7(a)). In the museum light is intelligible from the sky. Skylights make a dotted line along the roof, cutting through the zig-zag form. The museum route was disturbed several times by black blocks that the architect called voids. There is no way in to the voids and there is nothing in them except the light comes from the skylights. These voids are the incarnation of the final figure in the German Judaism; absence (Neumann and Copans, 2002; Jewish Museum Berlin, 2016). Thus this vision of missing and untouchable light makes us feel the spirit of the space and the German-Jewish history. As the main design consideration of building which comes of different types, at this point the architect again designs and creates an experience with light.

Light is also used to emphasize the godlikeness or as a symbol of miraculously existence of the nature for centuries. Church of the Light by

Tadao Ando is the most recognized and outstanding sample of this. The church is built in the suburban environment of Ibaraki City, Osaka. The church is a building that is a box shaped and penetrated by a 15-degree angle diagonal wall (Figure 7(b)). Completely a freestanding diagonal wall divides the main space into two parts; chapel and vestibule. A passage from vestibule opens to the diagonal wall and, with a 180 degree turning open to the chapel. At the end of the chapel there is a cruciform slit in the wall where light penetrates slightly and creates a cross of light. Even if the light is the theme of this building, creating darkness was important because light becomes staring only against a deep darkness. With the penetrated light, the church offers both representational natural and abstract nature. The light is just cast on the floor so natural materials that appeal to the senses are left in darkness (Figure 7(c)). Furuyama states that “Through light too, we are made to recognize in the most basic sense our relationship to nature” (Furuyama, 2006). As in the Tadao Ando’s church, light can symbolize godlikeness with its naturality, purity and contrast effects. Beginning with design considerations, effects of light in interior spaces can create feelings and emotions on visitors.

Figure 7. (a) *Berlin Jewish Museum, Interior View from a Void*; (b) *Church of the Light, Exterior View*; (c) *Church of the Light, Interior View*



Conclusions

Spatial perception principally occurs under the influence of visual sensation and vision can only occur with light, thus the light can extremely change the visual perception of space. In this context light is embraced as a transformable layer. Lighting and its power on the perception of space and environment are analyzed on the basis of the architectural spaces around the world. The light’s impacts on the spatial perception can occur in different ways at the architectural spaces. To clear it up start with the remark effect of light; with the façade materials’ properties of Roca Barcelona Gallery and The Nelson Atkins Museum, the form of these buildings are remarked by artificial light comes from interiors of the buildings at night, but at the day time both buildings have different perception in the environment. Similar to this effect, in the interior of the Sancaklar Mosque the boundaries of the space are defined via daylight that enters from the slits and artificial light placed on the interior walls and floors. Also the Light Walls House daylight entering from the roof gaps creates a pattern on the interior surfaces but this

is not the only effect of daylight at the Light Walls House. The effects of daylight can also be seen as movement and life in the space, because the pattern is created by the sunlight and it moves sunward. In the meanwhile at the Hafen City Metro Station artificial light creates a movement in the interior, but it is not just the movement that is added to the interior via light. With the color changes of light, the spirit of the station is defined and a link is created between the station and the district which it is located. Also the linear placement of light boxes in the Hafen City Metro Station bears a resemblance to the lighting design of the Istanbul Modern Museum Galleries. The difference between these two designs is; one of them – Hafen City Metro Station – designed to create a staring perception in the space but the other one – Istanbul Modern Museum – designed in harmony with the space. Also at the Amsterdam Public Library light paths which remark the circulation and the levels of the building that are designed in harmony with the interior but the movements and directions of the light path form help to orientate visitors. Finally, the spiritual effect of light may be one of the most interesting ones. At the Libeskind's Berlin Jewish Museum or Church of the Light of Tadao Ando, these spiritual effects can be felt intensely with the contrast effect of penetrated light from slits on the paries. At the Berlin Jewish Museum light refers to the hope and freedom, at the Sancaklar Mosque and the Church of the Light it refers to the nature and the godlikeness.

With these analyses, effects of light on human sensations and spatial perception tried to be examined and revealed. Light can remark a form, define the boundaries, transform to a pattern, create movement in a space, act as a guide and change emotions. Also in consideration of these analyses it can be indicated that light is not only a source that provides us a vision, but also it is an “intangible layer” transformed to a flexible and effective component of the buildings and the architectural design.

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