Today’s Absence Tomorrow’s Presence
Master Thesis explanatory document

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Abstract
Light has fascinated mankind throughout history, and is the single component that makes all things visible, without it, visual perception is mute. Light is more than that, it also provides warmth, separates day from night, work from rest, sowing and reaping, life and death; it is no wonder then, that light is an integral part of culture and society.

Light plays a key role in the visual perception of architectural space, defining size, giving shape, providing colour and highlighting material texture, contributing to the emotional feeling and physical awareness of the space - the atmosphere. However, in contemporary times, there seems to be a growing misconception in society that the perception of light is purely a functional requirement that has little concern with the atmosphere it produces, unless the function is to actually enhance the atmosphere, such as in an art gallery.

The project seeks to determine how the qualities of light – its luminance, contrast, colour, direction and distribution affect the visual perception of space. Further to this understanding, the development of the project is to pursue and explore different innovative techniques to manipulate precessional light, the visual awareness of the trajectory of sunlight as it moves across the sky, which results in altering light compositions and effects in order to modify the visual perception of space. And whether the constantly changing nature of precessional light allows a constantly changing perception of space.
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1. Definitions
Artificial Light
An electrical light source

Daylight
Diffused natural light from the sun, providing ambient light

Precessional Light
Or Ecliptic; is the apparent trajectory of emitted light, from the path of the sun as it moves through the sky.

Sunlight
Direct light from the sun, providing specular light

Colour
Visual sensation caused by a single wavelength of emitted light within the range of the visible spectral composition.

Contrast
The relative difference between luminance levels of different objects that help in providing visual depth.

Direction
Where the light source is pointing.

Distribution
The area of light that will cover a surface.

Height
The relative distance of light source to the surface or object.

Luminance
The relative brightness of perceived light on a surface being reflected from a surface.

Diffused (Reflection)
When a light hits a rough surface it reflects the light in many directions, giving scattered and dim light.

Hard Light
Casting of light that produces sharp and defined shadow edges, resulting in a sharp and dramatic look that tends to accentuate forms and textures.

Soft Light
Casting of light that produces a broad shadow edge, resulting in a gentle and smooth gradient look that tends to smooth forms and textures.

Specular (Reflection)
When a light hits a smooth surface it reflects the light in one direction, giving direct and bright light.

Light Propagation
The direction of light.

Pure Spectral Colours
The seven primary colours that make up every single wavelength of light in the visible spectrum.

Solar Elevation Angle
The elevation angle of the sun.

Oculus
A circular opening in the centre of a dome.
2. Introduction
2.1 Research Question

“Can the precession of light be manipulated to create constantly changing physical and poetic transformations of light, in order to influence people’s visual perception of space?”

2.2 Objectives

Light is a fundamental component in the experience and use of architecture as it plays a crucial role in defining and enhancing the atmosphere of an architectural space. This will be explored by using light as the design driver in the development towards an architectural proposition. In the discovery and advancement of perceptually changing space, the physical and emotional qualities of light will be explored rather than the functional and technical requirements of light for an architectural space.

The intended outcome of this research project is to firstly catalogue experimentations made of light and space into five principle sections. Secondly, apply these principles to an architectural proposition, demonstrating that light can in fact be used in the shaping and enhancing of experience in architectural space.

The following will be the focus in the development of the research:

- Research light in architectural and art installations spaces;
- Investigate different materials and innovative lighting techniques to manipulate precessional light; and
- To create visually stimulating and methods of light manipulation spaces through utilizing precessional light to alter the atmosphere and visual perception of a space, its luminance, contrast, colour, direction and distribution.
2.3 Scope and Constraints/ Limitations

The research will be achieved through design, and the scope of this research project will be divided into two major sections. The initial section will be based on the experimentation of light manipulation in order to alter the visual perception of light composition, resulting in changing the visual perception of space. This will subsequently lead to and help in the development of an architectural proposition and spatial explorations in the second section of the project.

For a successful and resolved project, the research question needs to be defined, and constraints need to be addressed and put in place, to prevent losing focus on what needs to be done. The main areas of concern are:

Research Question

The words of the research question should be addressed, to clarify the meaning of the question.

The term “constantly changing,” can be loosely quantified as either being arrangements of light that are always changing at anytime, or it can be defined as occurring daily. There is no set time frame for the resulting movement of precessional light, and will be dictated by the development of the project.

Further “physical and poetic transformations of light,” means the physical perception of a space, what is seen, and the poetic atmosphere of the space, that is the emotional qualities such as mood and feeling a space produces.

Precedent Research

The direction of the research is to find innovative ways to use precessional light to create a conspicuous change in space, which differs from most contemporary architectural examples that deal primarily with large amounts of static daylight and static artificial lighting. Thus architectural precedents will be limited to examples that exhibit precessional light resulting in change in visual perception of space. For the most part, the precedent research will be about light installations by artists whom freely explore the opportunities and relationships between light and space,
which are not concerned with the functional requirements a particular space might need in terms of its light.

**Design Research**

The research will be broken into two phases:

The first phase deals with the experimentation of light and space. The initial research, the precedent research, will focus on finding similar methods and techniques to manipulate light and categorize them into 5 principle sections. The following chapter seeks to experiment within the knowledge from the five principles, to explore different shaped spaces with different lighting techniques to examine the validity of the research question. These spaces will be free of function, to permit exploration of light to be viewed in its entirety and not scrutinized and tainted by particular building functions and other functional restrictions.

The second phase deals with the application of these explored techniques in the development of an architectural proposition. Providing a synonymous research question, which is free of architectural function, permits the finds of the previous phase to dictate the criteria for a particular building function that would utilize the variety of spaces explored.

**Design**

The explorations of light will focus on direct light and its effects, rather than ambient light. Ambient light will not be ignored, as it is a vital component of light in architecture, but will be implied in all the studies. If a reduction in ambient light is required, it will be discussed.

As the research is purely on precessional light, sunlight, the focus of the design will be on the daytime light rather than on the night-light. If night-light is required, whether it is moonlight or artificial light from the city, it will be discussed later on in the document.
3. Methodology
The research and presentation of the document will be conducted with the following approach:

**Current State of Knowledge**
The literature research will be the focus of this section, defining light, the aesthetic perceptual impacts of light within space, and its unique role within architectural history and culture’s perception and view on its importance within their lives.

**Design Part I: Principles**
An exploration and study of a variety of examples demonstrating the role of manipulated light in a space. Through this section a set of design principles will be established to inform subsequent sections of techniques and materials used to manipulate precessional light with.

**Design Part I: Explorations**
A range of different explorations will be produced that is a result of the findings within the set of principles of the previous chapter. These will be catalogued into the five principles, each exploring the effects of manipulating precessional light into space. These explorations will provide guidelines for light manipulation for the following sections.

**Design Part II: Brief**
This section instigates the application of the preceding principles to an architectural proposition. It will establish a brief that includes a building function along with a site and sun analysis of the site.

**Design Part II: Architectural Development**
Finally, the researched knowledge and explorations from the foregoing sections will work alongside the development of an architectural proposition. This development, from the concept through to its completion, will engage architectural design with lighting design, testing the validity of the research question to see whether precessional light can be adapted in architecture to create perceptually changing spatial arrangements of light to influence the visual perception of space.
4. Current State of Knowledge
4.1 Light

Light is defined as being “something that makes [other] things visible,”¹ and we may think we see light, but in fact we only see “the effects of light.”² This is because light, or electromagnetic radiation, does not require matter, or in this instance air, to travel through and is thus only seen when it interacts with visible matter. This results in light being either refracted, reflected or absorbed; whether light hits a wall surface or dust particles in a space, forming a visible light shaft.

Electromagnetic radiation, part of the electromagnetic spectrum of light, is categorized as seven distinctive portions, of which our eye receptors recognize one portion; the visible spectrum. Within this, it can be divided into the seven ‘pure spectral colours’; the colours of the rainbow. Whilst the other six portions of light cannot be seen and do not influence our visual perception, they can be physically felt. These contribute to the psychological impacts of light, being its warmth and comfort and provide for the acceptance of place around us.

4.2 Role of Light in Space

Without the light around us, it would be impossible to visually perceive and differentiate the space around us. This is why visual perception of space is synonymous to the visual perception of light, implying the inseparable nature of light and space; one could not exist without the other. This visual perception of a space, what is observed, is influenced by the size, shape, colour, material texture and above all, light of a space, which affects the individual psyche, permitting certain moods to be felt and experiences to be had.³ When light alters the four qualities it impacts how space is seen and understood; light alone influences the perception of space.

“Light is an indelible part of our experience of life,”⁴ that has both an aesthetic and technical role in the experience and perception of the spatial world around us. The technical aspect of light is related to the performance of the light, what lighting conditions are required to complete a certain task, where as the aesthetic light is the emotional response to light, “heighten sensitivities”⁵ and enhancing the experience of a space. The ‘technical’ component of light can be described as ‘functional,’ and ‘aesthetic’ as ‘atmospheric.’ Functional light can exist without aesthetic light, but aesthetic light cannot exist without functional light. A space can be lit up for a functional purpose with technical light, or for an atmospheric purpose with both technical and aesthetic light.

Light can range from aiding the way people move through a space to setting up the way a space is seen, how it is experienced - whether it is feeling “very violated by certain types of light; [while] others make you feel very secure.”⁶ The integration of light can transform the atmosphere of a dull and unstimulating space into being mysterious, romantic, spiritual, relaxed, spacious or enticing. It is critical that light is carefully thought out within space as “good lighting, illuminates, clarifies, stimulates. Bad lighting, like bad architecture, dazzles, confuses and produces weariness.”⁷ Herve Descottes says we do not “recall architectural details of a space but what remains with you is a sense of its atmosphere;”⁸ light creates place.

To put it simply, the perception of light and the visual component that makes the atmosphere of a space, could be summarized into the five categories within light: its luminance, contrast, colour, direction and distribution. The different combinations of these five properties have the ability to create visually stimulating or dull atmospheres.

8 Descottes, Hervé. Ultimate lighting design, 12.
Figure 4.1.1: As light moves away from its source, the luminance, the relative brightness of perceived light, reduces. The example shows two quantified areas within the light beam that have different luminance’s.

Figure 4.1.2: The luminance is dependent on the surface it is directed onto. The luminance on the white screen appears brighter than that on the black screen, although there is more contrast on the black screen.

Figure 4.1.3: The depth of any given space is dependent on the luminance contrasts between given surfaces. Being backlit provides a high contrast of different luminance objects in the scene making it appear deep.

Figure 4.1.4: A low contrast scene occurs when the luminance’s of objects appear equally lit.

Figure 4.1.5: Being front-lit provides a medium contrast of different luminance objects in the scene making it appear shallow.
Figure 4.1.6: The colour of a surface is dependent on the colour of the light source. As a white light is shone onto a red background the absorbed light appears white, but when red light is shone onto a red background the absorbed light appears red.

Figure 4.1.7: Subtractive colour mixing (right) and additive colour mixing (left)

Figure 4.1.8: The direction and distribution of light has a great impact on how the space is perceived. When the light is high and covering a large area it makes the space appear large and public.

Figure 4.1.9: When light is low and has a small coverage it makes the space appear small and intimate (right).
4.3 Role of Light in Architectural History

Tadao Ando once said that “works of art from the past show us that each generation has had its way of thinking, its conceptions, and its aesthetics, calling upon the entire range of technical resources of the time to serve as the springboard for its imagination.”9 This same paradigm can be said for the intervention and presentation of light in and through architecture, and architecture in and through light.10 History reveals that each culture, and architectural eras within the culture, has had their own unique way of expressing the aesthetic and functional/technical integration of light “in the configuration of an architectural space.”11 In other words, the importance of light to a culture and the technology and technical knowledge in a particular period dictates the aesthetic/functional relationship; whether consciously or subconsciously, and is presented through the architectural experience.

4.3.1 Antiquity

In the past, the ingenuity of integrated light was seen as “the resolution of the perceived struggle between aesthetic purpose and technical understanding of light.”12 Religious worship was not only important to ancient civilizations, it dictated the way light was treated as an integral part of the design of architecture. Light was seen to be a spiritual and divine presence that was treated as being sacred within the architectural experience; the presence of light was a metaphor, a reflection, a symbol of God or gods.

Light not only had a technical factor in the design of architectural space, it also had the aesthetic and emotional factor that were important in the religious worship of the time. The characteristics of the architecture not only responded to the precession of sunlight for specific technical and functional purposes but promoted a perceptually atmospheric change of space through the change of light qualities.

This was particularly evident in ancient Egypt, where manipulation of sunlight created monumental gestures of light through the day. The architecture was precisely designed by aligning their temples and monuments to astronomically significant times like the precession of sunlight, eclipses, solstices and equinoxes,13 to celebrate and worship their sun god RA. The best example is the area in front of the 'Temple of Amon,' where a large obelisk sat in front of the gateway for the public to come and worship the sun-god. On top of the central obelisk sat a gold plated pyramid14 “to catch the first ray of sun just before dawn, dramatising the illuminating and life-giving power of the creator.”15 The pyramid tip was a symbolic metaphor to Egyptian mythology “in which the first land rising above the primordial waters was touched by the light of the sun.”16

Later on in classical Roman architecture, the pantheon was commissioned by General Marcus Agrippa, as a temple to the twelve most important Roman gods.17 The large space composed of a circular space with an oculus capping the large dome filling the space with light. This enables the space to act as a sundial

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11 Ibid, 112.
“transform(ing) this space in each season, each day of the year, each hour of the
day, each moment.”18 Capturing the constantly changing light qualities of the
precessional sunlight and daylight throughout the day, can perceptually change
the atmosphere within the space, as light is “distilled as it passes from the outside
to the interior.”19

Then in the medievil era, Christianity permeated western culture and cathedrals
became the dominant architectural symbol of this period. The time stamp of
this era marked the start of a search for an “Architecture of Light,” initiated by
Abbot Suger’s Gothic Style. Utilizing the newly invented stained glass windows
and reducing building mass to its structural necessity allowed for greater light
penetration than its predecessors, giving the light filled space a supernatural
feeling.20 The manipulation of light through the windows dramatized the dawn
and dusks rich yellows and the blue colours contrasting mid-day and overcast
occasions within the space. During certain solar angle elevations, light would
draw the attention of the eye upwards towards heaven,21 to the sun, moon and
stars, emphasising the spiritual presence of God. The spaces perceptually change
with the changing quality of sunlight; the external lighting conditions transpire
and articulate into the interiors.

19 Ibid, 112.
4.3.2 Age of Enlightenment / Modernism

From the eighteenth century, the Age of Enlightenment began to change western cultures perspectives of the world around them resulting in aspects of everyday life being questioned, even through to understanding the difference between the aesthetic and technical aspects of light within architecture. This era instigated the beginning of the separation between these aspects of light, into two areas, the “art and science, emotion and quantity, or heavenly and earthly.” Aesthetics of light became an accessory to architecture, rather than being integral part of the design.

The pinnacle of this philosophical thinking came during the modernist movement, which saw the introduction of electricity. The “electric light quickly became a pre-eminent emblem of modernity.” Centuries of precise architectural design concerned with natural lighting was becoming replaced by supposedly idealistic levels of artificial lighting for specific tasks, leading to “uniformly lit spaces that diminished the occupants’ sense of orientation and awareness of space.” It did not help that the solid boundaries between the exterior and interiors of the past were becoming open planned and paper thin allowing transparency and “opening to light and nature through the use of steel framing, the diminishment of mass, and an extensive use of glass.” In removing the mass and breaking the barriers between inside and out, spaces were flooded with natural light during the day and artificial light at night. The new found freedom led to the development of artificial lighting without any restraints and accountability, meaning the art of manipulating and controlling light conditions for aesthetic intervention of light in spaces was diminishing.

Artificial lighting is characterized as being static, in the sources fixed position and unchanging light qualities. Natural lighting was being replaced by mechanical lighting for theatre and night club spaces, mimicking the precession of sunlight, and is often regarded as tacky and unnatural. Religion was replaced by business and individual recreational activities that shifted from day lit spaces to twenty four hour lit spaces. The activities at night that were once celebrated “as a source of danger, romance, confusion and supernatural phenomena,” were taken over by spaces filled with fixed and static artificial lighting. Thus “natural light and responding to the movement of the sun became an irrelevance,” to architects and the culture. Light was “widely seen as a means of curing illness and preventing physical and social ills – notably crime” and became a symbol of health and safety. The adaption of twenty four hour lighting enivitably created cities in which the skies would become filled with light pollution, to remove the unnecessary evils of the world.

Figure 4.2.3: Static light of Frank Lloyd Wright’s Johnson Wax Building

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23 Ibid
25 Ibid
28 Ibid
29 Weston, Richard. *100 Ideas that changed Architecture*, 103.
4.3.3 Contemporary

Environmental sustainability has become a symbol of recent times, which has raised concerns about protecting the natural world and preserving the environment to support human life in the future. These include making responsible decisions such as reducing energy consumption, but increasing productivity and using durable and harmless products for consumption that do not leave a mark on the world.

This strive for efficiency and concern for the natural world has affected the design of architectural light. A hybrid approach is currently emerging in culture, where both natural and artificial light are becoming used for different purposes, whilst natural aesthetic and technical roles are starting to re-engage. For instance, the fluorescent light bulb was introduced as efficient artificial lighting, but it has been polluting buildings and it is only recently that these have started to be designed to bring an aesthetic and comforting feeling to a space with different coloured lights becoming available. This change will only happen when the current perception of light is broken; that light is a technical issue within space, and it is only the sculptural light fittings and materials that enhance the aesthetic qualities of light and experience of the space. The appreciation and design philosophies of natural and precessional light cannot be left behind in the wake of becoming more technologically advanced with more than comprehendable knowledge. If this happens, the understanding of the natural opportunities of light could soon be lost. 32

Although theorists opponents like Henry Plummer suggest otherwise continue saying artificial light is not static but has vitality to it. He discusses how light is no longer used to represent “static and unchanging absolutes” but rather “a more liberating reality in which the only thing believed permanent is change – a reality ideally conveyed by a medium that is the essence of change”. 33 Referring to light of works like Peter Zumthor’s Therme Bathe, which ‘brings spaces to life,’ he refers to the fact that people moving through Zumthor’s spaces are emotionally moving rather than using the change of precessional light.

It was said by Herve Descottes that “today, with electricity, there are myriad forms of artificial lighting used to light buildings and landscapes. Unfortunately, many contemporary lighting schemes are all about the light, not the space or the place, and most fail to evoke any poetic or imaginative affect. Contemporary lighting is often overly bright, too white, and more about fixture and light source than the illuminated object or space.” 34

There is a place for this lighting but also a place for utilizing natural light, and

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5. Design Part I: Principles (techniques)
This chapter looks at establishing foundational principles, techniques to manipulate light, which can be explored and developed in the subsequent sections of the research. This chapter is broken down into two sections:

**Catalogue of Images**

The research will begin by searching and observing the natural environment and numerous projects around the world expressing various dimensionalities of light and space. Each image expresses the aesthetic qualities of light or the effects of different methods of light manipulation.

**Principles: Techniques**

The following principles will be extrapolated from earlier images catalogued, by discovering common characteristics and techniques used to manipulate light in and through to a space, resulting in the ability to change perception of space through changing the perception of light in its physical and atmospheric, emotional, qualities.
5.1.1 Aesthetics of Natural Light
Figures 5.1.1.1 - 5.1.1.9

Crepuscular rays, light shafts and magnificent colours observed in nature, without the need of photo doctoring.

This small selection of examples was chosen to portray the beauty of light and colour. The impact of dramatic colours and light compositions ultimately alters how the environment is visually perceived.
5.1.2 Digital Light

Computer generated light that cannot be observed in our four-dimensional reality.

The examples provide insight into a futuristic and creative perspective of light, light of the intangible, the virtual and the imaginary. These represent different ideas of how light may be produced in the future or inspire people to think of new and innovative ways to use light in our world.
5.1.3 Manipulation of Light
Figures 5.1.3.1 - 5.1.3.12

The effects of light that can be observed in and around the world. These examples are man-made interventions, expressing our current knowledge and understanding of light. The images directly portray how light is manipulated, seen and experienced in and around us.
5.1.4 Architectural Light
Figures 5.1.4.1 - 5.1.4.8

Architectural spaces that are affected by sunlight outside.

This small selection of architectural examples shows the emotional quality of light within a space. Within a space, light can be peaceful and subtle when the contrast of light is low, or it can be bold and provocative when there is a high level of contrast between light and dark or different colours.
5.2.1 Massing

Focus
Light being shaped by mass, where the architectural mass directs and confines the path of light that moves through interior space.

The Pantheon
Is recognized as the largest and oldest unreinforced concrete dome in the world, which caps the main cylinder space. The dome incorporates an oculus, a large aperture, providing the only form of light into the space. This aperture fills the interiors with diffused daylight and allows direct sunlight to provide its famous light shaft as it moves throughout the space.

This famous light shaft is seen when the conditions permit a high contrast level of luminance between the low level of ambient daylight and the high level of direct sunlight. For this to happen, cloud cover needs to be minimal otherwise scattered light from an overcast day brings the level of ambient light up, diminishing the strength of the light shaft. As for the precessional movement of the light, it is the sun’s apparent trajectory movement across the sky in Rome that allows the light to move across the space. This alters depending on the diurnal hours of the sun and in the different seasons, delivering a higher or lower position of light throughout the space.

This is a symbol of perfect light architecture, where people go to see the light as much as to see the architecture.
Cathedral of Christ the Light

The plan of the main space of the contemporary Roman Catholic Cathedral is based on a ‘Vesica Piscis,’ the middle area formed by two intersecting circles. This space is made up of louvred timber walls that rise high above its altar and slope inwards to form a vaulted ceiling that creates “a contemporary design that was still evocative of the Church’s two millennium-old traditions.”1

The spatial experience alters throughout the day because of the strategically inclined louvred walls. These louvres are positioned in such a way that light filters through different portions of the walls only at certain times of the day, to provide a continuously changing spatial quality indoors, as though the light was being filtered through a canopy of tall and varying height trees.2 Although this appears as a simple example of light manipulation it does provide interesting light conditions and effects through the day.

Influence for Design

The success of these lighting strategies comes through the utilization of building mass to aid precessional light manipulation. It is evident that the two forms of natural light, daylight and sunlight, each produce different qualities of light. Daylight provides a diffused, ambient low light within a space while sunlight provides hard and bright light in the space; both can be utilized through different masses to light a space.

Although these examples exhibit precessional light, the movement of this light alone does not change one’s perception of space, it is inclusive of the aesthetic quality and atmosphere created by the sunlight that changes the perception of the space, such as the warm glow of the sunset and the cool blue light of a crisp morning.

2 Ibid

Cathedral of Christ the Light - OMA - Oakland, California, USA [2008]
5.2.2 Optics

Focus

The refraction of white light through transparent materials not only has the potential to create uniquely scattered patterns, but also has the ability to split white light into the pure spectral colours.

Department of Philosophy

As part of a renovation project, the university sought to redevelop its Department of Philosophy Facility. The intention was to organise spaces around light, which focuses around the new central stairwell and skylight joining its six levels together. The stairwell is all white, with windows running down the sides to allow natural light to permeate the entire stairwell. Within the space there are strategically placed prismatic film sheets that are placed over windows and suspended in the middle of the void space, which split the available sunlight into the colours of the rainbow.

These prismatic films are essentially a diffraction grating, which are tiny, irregularly spaced ridges that refracts and splits light into various directions. When sunlight hits this surface, it either reflects the white light or refracts and splits it into the seven colours of the rainbow. The precession of the sunlight and changes of the intensity and quality of the light throughout the day and the season permits this pattern to move through the space.

Figure 5.2.1: The spectral coloured light, rainbow light, within the stairwell

Figure 5.2.2: The spectral coloured light, rainbow light, within the stairwell

Figure 5.2.3: Glass prismatic film attached every few levels, at the centre of the stairwell

New York University: Department of Philosophy - Steven Holl - New York City, USA [2007]
Spectrum
As part of an exhibition, ‘Spectrum,’ was created as a nine-metre window composed of 500 crystal prisms. The large window is made up of rows of prisms, each being orientated in a slightly different way, that are stacked on top of one another. As sunlight enters the prisms, white and spectral colour light is transmitted through the prisms, filling the space with a chaotic pattern of white light balanced by the soft glowing rainbow. The nature of these prisms provides a space that is constantly changing with the slightest change in light direction intensity or colour.

Influence for Design
Light being transmitted through material not only promotes the manipulation of precessional light but also the aesthetic qualities these can provide. Through the refraction of precessional light in prisms, comes the creation of unique patterns of light and the pure spectral colours, both changing with the movement of the light.

However, for a greater result of light vitality and movements, the introduction of additional prisms or other faceted objects could be positioned along the propagation path of the light. Not only does it offer more interaction that generates more scattered light, but also the emitted refracted light displaces faster and further than its source.

Spectrum: Rainbow Church - Tokujin Yoshioka - Seoul, Korea [2010]
5.2.3 Light Defining Space

Focus
With the right conditions of light, space can be altered to reveal and also conceal, and it can create the illusion of vast space and also of small space. Light defines boundaries of space and also dismisses them; light and space are inseparable.

Dhatu
A large walk-in installation, Dhatu, explores the materiality of light, colour and space. Over a half an hour cycle, the installation simulates the gradual sunlight cycle in the atmosphere from dawn to dusk. It is shaped as an extruded round cornered rectangle, creating a continuous surface around the space. The translucent back screen radiates light that uniformly fills the white painted surfaces, creating the illusion of a physically infinite space; this effect is created by absence of defined edges.

As the minimalist form does not attract attention, the ‘volume of light’ does, amplifying the perception of spatial light and colour. The precession of light is not evident in this example; however vitality of light is obvious through the cycle of colours.
Chelsea Art Museum

Composed of a single layer of vertical LED rods each spaced out across the façade of the museum building, this installation seeks to perceptually define the boundary of space with light. Each rod extends beyond the height of the building, has LEDs embedded within it and is made from transparent material, revealing the cityscape behind it.

When sections of the rods are lit, it obstructs the view through the rods creating a boundary, whereas the sections that are not lit up permit views through the rods creating a boundless appearance. This installation works best at night and depicts abstract patterns that morph across the screen, shifting the perception of the enclosed and open boundary of space, concealing and revealing parts of the existing museum structure behind it.

Influence for Design

What can be learnt from these examples is that light defines space and space defines light; light and space are inseparable from one another. There is no question then that “through light, space can be formed without physical material like concrete or steel. We can actually stop vision and the penetration of vision with where light is and where it isn’t. Like the atmosphere, we can’t see through it to the stars that are there during the day. But as soon as that light is dimmed around the self, then this penetration of vision goes out.”

Although these examples do not manipulate the precessional light, the characteristics of light in this use has the ability to transform boundaries of space, between opaque and transparent, making space become infinite or finite. This can visually result in space that appears to physically change in scale and shape with the precession of light.

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Figure 5.2.3.4: Sections of these vertical rods are lit, visually defining the virtual edge of the building

Figure 5.2.3.5: Altering the composition and pattern of light changes the perception of open and enclosed building space
5.2.4 Colours

Focus
Colours have a crucial role in the perception of space, and in aiding the atmosphere and feel of a space.

Your Blind Movement
In this installation, an ordinary space is filled with a fine artificial fog and fitted with overhead fluorescent tubes lighting the space. Each fluorescent tube emits a different coloured light, and with the aid of the fog gently blends each colour into one another creating a visually stimulating space that is soothing and yet confusing. In amongst the space, one would see the smooth blending of colours that would slowly change when moving through the space, demanding ‘Your Blind Movement.’

Removing the spatial component of this installation, like James Turrell’s ‘Dhatu’ piece, intensifies the perception of the spatial quality and beautiful colours of light. As there are no static reference points within the space, it becomes hard to quantify the size of the space and the light.
Slow-Motion Shadow in Colour

‘Slow-Motion Shadow in Colour’ demonstrates coloured shadows being generated when people interfere with the light within the space. The installation is setup with six hydrargyrum medium-arc iodide (HMI) lamps lined up along one side of a space each with either a Red, Orange, Yellow, Green, Blue, and Magenta glass filter. The combination of these lamps produces a white light that is emitted onto a white screen on the other side of the space.

In action, the relative position of a person or object to the lamps and the screen is directly related to the displacement of the coloured shadows. The closer one is to the screen the closer the shadow’s distance is from one another and visa-versa, creating dialogue between light and oneself. The movement of oneself through the space will subsequently manipulate the light in the space.

Influence for Design

What can be taken from these examples is that coloured light, if used appropriately, has an accepting and powerful impact on perception. The appropriate coloured light is one that influences the perception of space that does not conflict the use of the space, such as using dimmed coloured lights in a library that overwhelms and confuses.

These examples are unsuccessful however in the aspect of the manipulation of precessional light, as these both show static light and that people’s movement results in transformations of coloured light. Although people’s interactions transform the light within the space, it would be beneficial to use precessional light as well in the transformation of coloured light.
5.2.5 Reflection

Focus
Reflection ultimately changes the direction of light, although the art of reflection is the enhancement and intensification of light, whether producing specular or diffused light.

Notion Motion
This consists of three exhibitions where the interactive movements of one are intertwined with the effects of reflected light. Each exhibition is composed of two spaces; one side is a pool of water with strong static HMI lamps projecting light from the water onto the large screen that divides the two spaces, the other space is the main space providing a platform to view the screen. Each light source does not directly relate to the movements of the reflected light, as these are a result of the displacement of the waters surface, making the light appear to move.

The first exhibition has intermitted water droplets that land onto the waters surface creating ripples that dissipate. Light is shone onto the water’s surface picking up the water ripples that are then reflected onto the screen.

In the second exhibition, the main space uses intermittently spaced wooden floorboards that are connected to red pads sitting on top of the waters surface in the other space. When people move across the moveable floorboards, it disturbs the water’s surface, which is picked up by the light and then reflected onto the screen.

The third exhibition, like the second, uses wooden floorboards that are connected to pads that disturb the water’s surface. Instead of displaying the entire water’s disturbance, like the other exhibitions, it is displayed as a horizontal line that vibrates with the movements of the floorboards.

Notion Motion- Olafur Eliasson - Berlin, Museum Boijmans Van Beuningen, Rotterdam, Nerthlands [2005]
Fireflies on the Wall

The exhibition consists of a square space, completely lined with mirrors that is lit with a hundred and fifty small light bulbs, hanging at different heights from the ceiling within the space. The parallel mirrors in each of the three directions cause an ‘infinity effect’ where the light bulbs within the space are perceived to stretch over a vast space into infinity. With each light bulb gently transitioning in colour over the cycle of a few minutes, the space creates a soft and dynamic atmosphere of light.

Visually stimulating, the reflected light creates these very strong and intensified light bands that stretch across the horizon line. Appearing as an infinite space, the transition of different colours does not simultaneously change all together but appears to radiate out, letting light slow down so that this transition becomes perceptible.

Influence for Design

When light interacts with a reflective surface, it is reflected off producing either a diffused or a specular light effect. Both the diffused and specular reflected light intensifies the luminance of the original light, changing the perception of the light. Direct precessional light and reflected light could be used to enhance the movement of light.

Light observed in both examples demonstrates the perceived light vitality of an indirect light source from a moving reflective surface even if the origin source is not precessional. When the reflective surface moves like water, this is seen as a moving light source, even though the light is static. This provides the ability for natural precessional light to be amplified by speeding up the movement of light or intensifying the luminance of a light.

6.
Design Part I: Exploration
The focus of this chapter is to initiate the exploration of unique ways of manipulating light within various and somewhat arbitrary shaped spaces to see the opportunities of precessional light and how it interacts with and defines space. The outcome of these explorations will test the techniques of manipulated precessional light in relation to the research question and use the principles of the previous chapter to see what other opportunities and constraints present themselves.
6.1 Massing

*Light being shaped by mass, where the architectural mass directs the confined path of light that moves through interior space*

**Approach for Explorations**

The emphasis of this section is to investigate different spatial configurations whilst provide gaps in between the masses to enhance and make obvious the movement and change of precessional light within space.

The first model [*Figure 6.1.1*] is a simple triangular extruded form, with a vertical slit along one of its sides. The column of images [*Figure 6.1.2*] demonstrates the horizontal precession of light indicative of the sun’s east to west movement, where [*Figure 6.1.3*] shows the vertical displacement of a light equating to the ‘solar elevation angle,’ through different times of the year. Both diagrammatic examples illustrate the linear movement of light through a simple straight slit.
On the other hand [Figure 6.1.4] shows a cylinder form with a gap around the rim, between the curved wall and the circular horizontal plane, to allow for a sufficient amount of light to move into the space. In [Figure 6.1.5] the series of images shows the altering of light arrangements through the horizontal precession of light indicating the sun’s east to west movements, whilst [Figure 6.1.6] reveals the greater exposure of light within the space as the vertical movement of light, transitions from the winter solstice to the summer solstice.
In the series of digital models, [Figure 6.1.7] shows a circular space that is enclosed by the large vertical fins. The arrangement of these fins permits a different amount light to be captured between each fin, marking the right to left, east to west, movements of the light, although this is only suggestive on the ground and is not sufficient enough to define and alter the perception of space.

The box space in [Figure 6.1.8] consists of angled apertures in two walls that explore the principle of the sundial. By creating a dark ambient space and utilizing compartmentalised light, limiting light to certain areas of the space, light that moves within the space creates the appearance of semi-opaque boundary. This boundary shifts in the space throughout the day and the times are marked along the ground in the form of straight lines.

In another box space, a square hole has been made in the top allowing light to move into the space. [Figure 6.1.10 & Figure 6.1.11] shows a comparison of light manipulation between an open space and when a funnel mass intervenes within the space. Light is dramatically altered and suggests the more involvement and distant a secondary mass is within a space, the greater the change in the movement and amount of light within a space.
[Figure 6.1.12] demonstrates a rectangular space incorporating a louvred ceiling. Each louvre is orientated in a slightly different position, permitting differing amounts of light to enter the space along the walls and ground of the space. This system exaggerates light manipulation through the cycle of precessional light in the day.

The final examples [Figure 6.1.13] show a large rectangular space enclosed above with protruding beams and a large ramp on the right side of the space. The images show the transformation of the space as the luminance of each space gradually changes between hard to soft light. Hard light is where there is a strong and defined boundary between light and shadows and soft light is where light gradually transitions to shadow without a defined edge.
6.2 Optics

Refracting of white light through transparent materials not only has the potential to create uniquely scattered patterns but also has the ability to split light into the colours of the rainbow.

Approach for Explorations

The emphasis in this section is on the interactive behaviour and effects of light as it is refracted through transparent mass. The interaction of light with mass, no matter the form and shape of the mass, intensifies the lights luminance and increases the displacement distance of precessional light; which is made more obvious when light moves through more than one mass.

The first exploration [Figure 6.2.2] is of a thin plastic hyperbolic model. When the light source moves horizontally across the hyperbolic model, whilst keeping its 'solar elevation angle' at a constant, the resultant light is both refracted and reflected. In this case [Figure 6.2.1], the series of images demonstrates the light moving across the flat to curved area of the hyperbolic model.
plastic, marked blue. When the light is refracted through the flat surface it results in a single green point, but as it hits the curved surface the light is refracted and reflected resulting in a continuous green curved line.

It is the angle between the direction of the light ray to the angle of the mass flat surface and the refractive index of the mass, which determines the severity of light manipulation as light escapes from the mass. In this case, the escaped light from the prism results in light either converging on itself, becoming brighter, or diverging away from itself, reducing its overall luminance.

When light moves through the three randomly placed prisms [Figure 6.2.3], it results in refracted light generating what seem to be random patterns, which change when light rotates horizontally around these prisms. These examples show that a light source moving a short distance across the prisms can amplify the resulting movement of the refracted light to become more obvious in the change of the spatial composition of light.

[Figure 6.2.4] shows what happens when two light sources move through two different groups of prisms, creating scattered light streaks.
Figure 6.2.5: Precessional light interacting with aligned prisms

Figure 6.2.6: Light moving through a series of slits interacting with the aligned prisms
In this exploration [Figure 6.2.5], a square space includes a single vertical aperture on one of the walls allowing compartmentalized light to fill the space and interact with the blue tinted prisms, arranged in a regular pattern. When light moves through the space, light that is reflected onto the walls is white while the refracted light is blue. The compositions of reflected and refracted light alter with the horizontal movement of the precessional light.

The next two examples are further experimentations of blue prisms arranged in different spatial conditions, seeing the different effects of light manipulation.

In [Figure 6.2.6] the rectangular space has a series of vertical apertures across one side the space, enclosing two rows of triangular prisms. With the large amount of apertures and prisms, the internal space is filled with areas of light that change with the transition of precessional light.

Two perpendicular walls encapsulate the space [Figure 6.2.7], with three precisely angled slits in each wall providing different amounts of light in depending on the position of the source of light. Within the space are two six metre high prisms that capture the direct light, and reflect it or refract it through the space. When precessional light [Figure 6.2.8] moves and interacts with the walls and prisms it not only can be indicative of time but also alters the luminance of the space.

**Figure 6.2.7:** Section of the perpendicular space showing light moving through the the six apertures interacting with the prisms

**Figure 6.2.8:** Perpendicular corner with slits allowing light to interact with the two prisms
6.3 Light Defining Space

Light is important, it can reveal and it can also conceal, it can create the illusion of vast space and also shrink space. Light can create boundaries, it can enclose a space without mass and also open a space; light is a versatile entity.

Approach for Explorations

The focus of this section will be to explore the dimensionality of perceived space that is a direct creation from light. Certain circumstances permit light to visually change the appearance of the size and shape of space.

The first series of images \([\text{Figure 6.3.1} – 6.3.4]\) explores how the absence and presence of lighting visually alters the perception of space. The model is of a rectangular space, divided by a mezzanine floor to split the vertical space. In these examples when a section of the wall space is lit up, the white light reveals the boundaries and edges of the space making appear that it is a finite and confined space of a certain dimension, best seen in \([\text{Figure 6.3.1}]\). However when a section is black, the absence of light conceals the boundaries and edges of the space creating the illusion of infinite, not knowing when the space ends, such as in \([\text{Figure 6.3.4}]\). This is profound in the sense that light restricts, and absence of light expands space, suggesting that light influences the perception of space.
The principle of ‘reflective glare’ can be an instance where light can be used to obstruct and reveal views. This is made possible with the use of a semi-opaque surface, such as a mesh screen. When the screen is backlit [Figure 6.3.5], the luminance of the background is brighter than the foreground, permitting not only light to pass through but also providing a view of the pencil. On the other hand when the screen is front-lit [Figure 6.3.6], by light being reflected off the mesh surface it causes the luminance of the foreground to be brighter than the background, making it virtually impossible to distinguish the pencil behind the screen.

When precessional light interacts with a rectangular space that is enclosed by walls made of mesh [Figure 6.3.7 & 6.3.8], light at different times of the day or differing trajectories can begin to catch and reflect off different screens, creating the illusion of altering space.

Figure 6.3.5: Back-lit mesh providing background view

Figure 6.3.6: Front-lit mesh reducing background view

Figure 6.3.7: Front-lit mesh, on the back wall, reducing background view making it appear opaque

Figure 6.3.8: Front-lit mesh, on the right wall, reducing background view making it appear opaque
In this exploration [Figure 6.3.9 & 6.3.10], the edge boundary is removed by creating an extruded rectangular plane with curved corners, to allow the space to appear infinite. When both spaces are uniformly lit, the perception of the green space is that it is a blank wall or an unfathomable and infinite space. However when the green zone is lit in a certain area, the space begins to accentuate a boundary to the space, defining a dimension of the space. As this light area increases or decreases, so does the appearance of this perceptual wall edge.

Another example is [Figure 6.3.11] composed of transparent vertical rods, which are arranged within a certain area. This works when the background colour does not conflict with the colour of the light. In this case the background is black, so when sections of these rods are not
lit, it stays black but when sections are lit up, it creates a boundary that limits what seems to be infinite space. The different arrangements of light patterns changes the boundary conditions, revealing defined and measurable space.

The next series of explorations look into a light retention strategy, where light leaves a trail of its presence, similar to the effects of light trails in photography. This is achieved through applying an illumination coating, a phosphorus-based chemical, to any surface. For the best results this is best seen in a dark space, and works when exposed to light momentarily [Figure 6.3.12], illuminating the area exposed to light. This illumination fades away, and the retention of light is dependant on the amount and concentration of phosphorus in the coating on the surface, lasting anytime from a minute to twelve hours.

The application of this is limitless, such as creating patterns or the silhouettes of people [Figure 6.3.12 & 6.3.13]. In this exploration [Figure 6.3.14], each transparent panel has half the illumination lifetime to the panel on its right. When a pattern is drawn on the right panel [Figure 6.3.14], the light moves through each subsequent panel and is slightly diffused and less bright. When the light has been removed from the panels [Figure 6.3.15 & 6.3.16], it begins to diminish over the time of an hour, until it reverts back to not retaining or emitting any light.
6.4 Colours

Colours have a crucial role in the perception of space, and in aiding the atmosphere and feel of a space.

Approach for Explorations

Colours are an important component of light and have a great influence in the ability to heighten the perception of light and space. The primary focus of this section is to explore the unique relationship between precessional light and colour; using colour to help enforce the precession and vitality of light.

The first exploration [Figure 6.4.3] looks at translating white light into coloured as the precession of light moves through the space. The rectangular space includes three apertures along the top with a red, green or blue filter within it. The two outside apertures include an inbuilt curved mirrored surface [Figure 6.4.1] and the outside central aperture within the space includes a Plano-convex lens [Figure 6.4.2]. When the precession of light moves from left to right [Figure 6.4.3] the coloured lights appear scattered throughout most of the day blending with one another, creating secondary colours, until midday when all three colours align and merge to produce a white light that fills the space.
In this circumstance where the three colours produce a white light [Figure 6.4.4] because of the distance between the lights, when an object such as a person stands within the zone of the white light, it obstructs the light creating coloured shadows. The shadows move further apart when the distance between the person and the light source increases.

The next explorations look into polarized filters to infer and enhance the colours of precessional light. Polarized filters work by restricting unpolarized light, a circular oscillating wave, to permit only linear oscillating waves, as shown in [Figure 6.4.5]. When a secondary filter is introduced aligning to the first filter it allows light to pass through it, although when one of these filters is rotated by ninety degrees it completely blocks the light. However when one of these filters is flipped over, instead of allowing light through it produces yellow and when rotated ninety degrees produces a blue light.

The applications of these filters are arranged in two 'C' shapes [Figure 6.4.6 & 6.4.7]. The area where the filters overlap, is the area where the images are yellow, blue, clear or blacked out. In each image the colour of the filter is relative to the observer's perspective, so when the perspective changes so too does the area of the polarized effect.

Figure 6.4.5: Circular un-polarized sunlight that moves through the polarized filter producing linear polarized light

Figure 6.4.6: When two or more polarized filters are placed together it can either create a yellow tint or when rotated 90° creates a blue tint

Figure 6.4.7: When one of the two polarized filters are flipped over, it creates a clear filter or when rotated 90° completely blacks out
The polarized effect is further developed [Figures 6.4.8 – 6.4.10] by arranging the filter panels in a triangular manner that permits the colour change of light in respect to the horizontal movement of precessional light. In this instance when light passes through a single panel [Figure 6.4.9] the colour does not change, but as soon as it moves through two panels such as the right and middle panel [Figure 6.4.8] it creates a yellow light or the left and middle panel [Figure 6.4.10] creating a blue light. This could be applied to the end of a space [Figure 6.4.11] displaying the mornings yellow light, the middays white light and afternoons blue light.
The final exploration looks into ultraviolet (UV), sensitive materials that change colour in the presence of ultraviolet light, which is a component of sunlight. When the material is lit, the surface characteristically changes colour like thermal imaging, when the red suggests most and the blue the least amount of exposure to heat, but in this case UV light.

In this example [Figure 6.4.12] each opaque bead begins white, but changes to purple depending on the exposure to UV light; the stronger the purple colour the more exposure to light it has.

Then [Figure 6.4.13 \& 6.4.14] shows a multi-layered structure that is made from a UV sensitive material. When light hits the structure it changes colour, in this instance [Figure 6.4.13] a red indicative of the structure being exposed to a lot of light. The red indicates the greatest intensity of light and the yellow the less intense light. Then [Figure 6.4.14] when the light shifts position and intensity it alters not only the colours but also the patterns of the structure.
6.5 Reflection

Reflection ultimately changes the direction of light, although the art of reflection is the enhancement and intensification of light, whether producing specular or diffused light.

Approach for Explorations

The emphasis of this section will be to experiment with different arrangements of reflective surfaces and different surface conditions, whether smooth or rough, they generating unique patterns and interactions of shadows and light.

The first exploration [Figure 6.5.1] looks at the reflective light from a mirrored cylinder space. When the light hits the outer convex surface, the light diverges from its surface, but when the light hits the inner concave surface, parts of the reflected light converges onto itself, its luminance has a greater intensity than its source, creating bright lines or patterns in the centre of the cylinder space. When light moves horizontally across the cylinder surface, the reflected light moves in a greater distance than its source, making the movement of reflected light more obvious than its source.

The same light conditions are tested in [Figure 6.5.2] with three triangular forms within one another. Like the previous example light that interacts with an acute angle creates light that converges on itself and obtuse angles that produce light that diverge away from itself, resulting in unique and random appearing light patterns. These images correspond to [Figure 6.5.3] which shows internal perspectives of the dramatic changes of light within the triangle forms.

Figure 6.5.1: A mirrored cylinder space with shifting light producing different reflected patterns/compositions

Figure 6.5.2: Precessional light within mirrored triangular space

Figure 6.5.3: Corresponding internal space showing light patterns
Figure 6.5.4: Series of images showing a light source shifting around triangular mirrors casting light and shadow

Figure 6.5.5: Series of images showing a light source shifting around triangular mirrors casting light and shadow
Figure 6.5.6: Vertical orientated mirrors, with triangle cut outs, permitting light to move through the triangle mirrors

In this example [Figure 6.5.6] the model is composed of three mirrored triangles each with triangle cut outs, spaced out across the left edge of the cornered space. The light source in this instance creates three light conditions: shadows, direct and reflected light. As the precession of light moves, so to does the length and severity of the cast light and shadows in between the triangles. Hard light is visible when the light rays are parallel to the triangles creating short light and shadows, whilst soft light is created when the light rays are perpendicular to the triangles creating elongated light and shadows; each creating completely different light and shadow compositions.

The next exploration [Figure 6.5.7] looks at the direct and reflected light that is generated from the mirrored grid layout. In terms of the light within the space, when the light that is situated above the grid moves across this surface, light is either directly or indirectly casted into the space, creating dramatic light patterns within the space. The indirect reflected light diverges from the mirrors making it less intense than the direct light within the space. Due to the characteristics of this mirrored grid, the direct and reflected light is separated from one another but converge together when the rays of the light source moves closer to being perpendicular to the floor level.

Figure 6.5.7: Precessional light moving over the mirrored grid provides direct and reflected light patterns to permeate the space
The final explorations investigate the opportunities of moving water as the medium off which light can be reflected. The attribute of moving water is that it has a rough surface, meaning a richer vitality of reflected light that is constantly changing, enhancing the overall precession and movement of light.

In both instances [Figure 6.5.8 & 6.5.9] the light is being reflected from the water’s surface onto the ceilings of two different surfaces. When the ‘solar elevation angle’ changes, so to does the reflected light, shifting across the surfaces of these spaces.

![Figure 6.5.8: Constantly shifting reflected light resulting from precessional light](image1)

![Figure 6.5.9: Large curved volumes capture the ever-changing reflected precessional light](image2)
6.6 Influence for Design

From the outset, the five principles have provided a suitable framework to work within, permitting the study and exploration of light and space. It has delivered unique techniques to manipulate precessional light and has fostered foundational ideas that came about from the exploration of ideas in the preceding section. It can be concluded thus far that some of the foundational ideas can be explored further, encouraging noticeable precession of light that if used correctly, can result in dramatic transformations of light compositions within a defined space, influencing the visual perception of the scale and shape of a space.

The following are key ideas that were discovered from the development of the five principles:

• When certain techniques are used to manipulate precessional light, by means of reflection, refraction or layering of massing, the resultant light can move and cover more distance than its source. This is important in the development of this project, as it not only speeds up the movement of light, but it makes the movement of light more obvious.

• The absence of light conceals the edge of a space, creating the visual illusion of an infinite space, whereas light reveals the edge of a space, producing the illusion of a restricted space; light visually contains space and its absence expands space. This suggests that light in the right spatial situation can visually influence the perception of spatial dimension and shape.

• The resultant light that is either reflected off or refracted through a material either converges on itself, intensifying the luminance of the light, or diverging away from itself, reducing the light’s overall luminance to the light’s original source. With the introduction of precessional light, as light moves horizontally through the material it can result in converging light to begin with and gradually ends with diverging light, essentially decreasing the light’s luminance from the beginning to end of the horizontal movement of light.

• The explorations have shown that it is achievable and beneficial to create ‘Monumental Light’ gestures. This term means that the visual perception of light, its luminance, contrast, colour, direction and distribution, within a space completely alters for a certain period of time, and then the light reverts back to the way it was before hand. This results in heightening the sensitivity to aesthetic and precessional light. For instance, in a space that is pitch black, a monumental light gesture would be when light would intervene in the space, completely filling the space with light for a period of time, and then reverting back to pitch black.

• And finally, from the above explorations, it seems appropriate, that further development and application of the prior sections techniques used to manipulate precessional light, should be integrated together, making a richer spatial experience.
7. Design Part II: Brief
This chapter commences the second design stage of the research project, the application of the previous researched techniques in the development of an architectural proposition. This chapter specifically focuses on establishing an architectural brief, defining the function of the proposition, determining the location for the design and analysis of the characteristics of the site in regards to precessional sunlight exposure.

7.1 Criteria for the Brief

Throughout the development and analysis of the research, from the current state of knowledge through to the experimentation of light and space, reoccurring conclusions and features were drawn in each chapter about the requirements in determining an appropriate function for the building design.

The following are the key criteria for the selection of a building function:

- Activities that can be enhanced with the addition of natural lighting features;
- Ability to improve people’s experience within the spaces through the use of light variations;
- Engagement of people in the observation of light and space;
- Allow a range of lighting conditions that will positively affect the performance and use of the space;
- Multidisciplinary use of spaces;
- Different spaces with utilization ranging from a few people to a large audience;
- Where space utilization is enhanced through the use of innovative lighting schemes;
- Encourage aesthetic appreciation through a healthy engagement with natural light;
- Use of light and dark spaces; and
- Different spatial arrangements, allowing:
  - The fusion of artificial and natural lighting,
  - Various transitions of precessional light
  - Visually and physically stimulating atmosphere

Based on the listed criteria, the building function should be a public use facility that promotes activities related to natural light, such as health and fitness, and encourages both viewing and participation in a range of spaces and during various times, that are enhanced by precessional light, the manipulation of natural light and supplemental artificial light when required.

From this analysis, the building function can be a spectator and participating based facility. In the context of New Zealand, it would be fitting for a sports facility that includes an arena of some type and training facilities.
7.2 Introduction

Sports and physical training (PT) have historically been viewed as separate activities. Programs such as Bootcamp and CrossFit, combining the competitive nature of sport with the exercise component of PT, are gathering a huge fan base around the world, as people search to lose weight and get fit and healthy whilst having fun. This individual sport challenges the body and mind, conditioning participants to become mentally and physically tougher and stronger.

However there is a new craze, that is both an audience and participative activity that is becoming the fastest growing sports organization in the world, Ultimate Fighting Championship (UFC). This is a mixed-martial art sport involving two fighters within an octagon ring competing to defeat their opponent; whether it is a win by a ‘technical knock out,’ or the highest score after a number of five-minute rounds. ‘High Intensity Interval Training,’ challenges even the most fittest and is a place where mental and physical toughness is born and nurtured beyond what is thinkable.

“They experience the rejuvenating feeling that can only be found through camaraderie. The discipline maintained in fitness bootcamps ensures that participants learn to take command of his or her life. Soon, the endurance part takes a back seat and other psychological factors seem to take precedence.”

The fighters and participants give each fight all they have, demonstrating what we are all capable of doing, as we all have a fight inside, even if that is the fight to stay alive.

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Fight Club

The project is to design a UFC facility that integrates the experimentation of precessional light with building form. The design will centre around the main fighting space, and seek to divide the journey to the space into a series of interconnected spaces that exhibit various spatial and lighting conditions. The theme of the design is around the idea of conflict between light and dark; peaceful and strenuous atmospheres; fighter and fighter; and physical and emotional spaces.

Facilitates

- Official (International Standard) Arena
- Unofficial (Underground) Arena
- Training Gym
- Transitional spaces
- Toilets and Changing rooms

Objectives

- Investigate different materials and innovative lighting techniques to manipulate precessional light;
- To create visually stimulating and methods of light manipulation spaces through utilizing precessional light to alter the atmosphere and visual perception of a space, its luminance, contrast, colour, direction and distribution;
- To explore the physical opportunities light can provide and apply it to an architectural space; and
- Utilize artificial and natural lighting.

‘An experimental building for an experimental lighting strategy’

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Figure 7.1: Bubble diagram of main spaces that lead to the Official Arena

- Foyer
  - Toilets
  - Info desk/Ticket booth

- Staff
  - Main Office
  - Meeting Room
  - Managers Room
  - Lunch Room
  - Changing Rooms [Male/Female]

- Hall
  - Unofficial Arena

- Circulation
  - Champion Space

- Official Arena
  - Main Arena
  - Toilets
  - Video Room
  - AV Server Room
  - Lighting Server Room
  - First Aid
  - Champions Changing Rooms
  - Judges Changing Rooms
  - Referee's Changing Rooms
7.3 The Site

In producing an architectural design that is sensitive to light, the proposition could be placed anywhere that is exposed to full light whether it is opened to the skies in the country or within a city centre. Attributes for the site selection include:

Adequate and uninterrupted day and night light;
Close proximity to the activities of the age demographic, 18 to 30 year olds;
Be close to water or have space to utilize water in the design of the architecture; and
Be located in near a major population centre.

Based on the attributes above, the fight club facility would be best suited in Auckland’s CBD, the largest and fastest growing city in New Zealand. The site selected is on Captain Cook’s Wharf, along Auckland’s prime waterfront.

7.3.1 Characteristics

At the bottom of Auckland’s CBD, Captain Cook Wharf is situated on Waitemata Harbour, directly north of the Britomart precinct, being separated by Quay Street, which runs perpendicularly to the site. The wharf is inline with Gore Street with Marsden Wharf to its east and Queen’s Wharf to its west. Being close Britomart, the hub of public transport to Auckland city, means the site is metres away from a thoroughfare for people commuting to and from the city. The site is on a flat-leveled wharf stretching 285 metres long by 76 metres wide. It is composed of 500 millimetres thick reinforced concrete slabs sitting on wooden piles submerged in the harbour floor.

7.3.2 History

Completed in 1922, the wharf was named after the famous sailor and navigator Captain James Cook. It is on the fringe of reclaimed land that was once called Commercial Bay, constructed as a dock by ’Ports of Auckland’ for loading and storing of goods. It originally held four sheds arranged in two rows with a central street dividing the rows as a service railway track enabling transportation of goods along Quay Street to the other Wharfs. Over the past few decades, the sheds have been deconstructed and the railway decommissioned, and now sits as an underutilized space used for newly imported cars awaiting inspection before being transported to dealerships.
Figure 7.4: South-East view of site (Yellow) from Queen's Wharf

Figure 7.5: South view of site (Yellow) from Quay Street

Figure 7.6: Midday North-West view of site (Yellow) from the end of Queen's Wharf

Figure 7.7: Evening North-West view of site (Yellow) from the end of Queen's Wharf
Figure 7.8: Panorama of Auckland’s waterfront and CBD
Figure 7.8: Panorama of Auckland's waterfront and CBD
Figure 7.9: Plan of Auckland’s Waterfront, displaying Gore Street alignment with Captain Cook’s Wharf (Yellow)
Figure 7.10: Site Analysis of Captain Cook’s Wharf (Yellow)
7.4 Sun Analysis

The following study looks at the different times throughout the year where sunlight and shadows are the least and most exposed to the site, being the Summer and Winter solstices. These studies are based on Auckland's 2013 calendar on a cloudless day providing full sun exposure to the site and surrounding harbour and buildings.

Figure 7.11.1: Axonometric diagram of the suns precessional trajectory of a summer solstice

Figure 7.11.2: Diagrammatic plan of the suns precessional trajectory of a summer solstice

Figure 7.11.3: Summer Solstice - 8am shadows of Auckland’s Waterfront
The Summer Solstice (December 21st Solstice) occurs annually when the solar elevation angle is at its greatest in the sky, at 76.6 degrees. From the series of images in [Figure 7.11.3 – 7.11.5] it can be presumed that the site is clear of shadows throughout the day.

Figure 7.11.4: Summer Solstice - 12pm shadows of Auckland’s Waterfront

Figure 7.11.5: Summer Solstice - 4pm shadows of Auckland’s Waterfront
The Winter Solstice (June 21st Solstice) occurs annually when the solar elevation angle in this case 29.7 degrees is at its lowest in the sky. From the series of images in Figure 7.12.3-7.12.5 the site is clear of shadows throughout the day.
7.4.1 Analysis

This analysis of the solstices implies that annually, the wharf level has maximum sunlight and daylight exposure, as the surrounding buildings do not have any impact on the light exposure to the site. Being close to the water permits possible intermitted reflected light impact onto the future design proposition.

Figure 7.12.4: Winter Solstice - 12pm shadows of Auckland’s Waterfront

Figure 7.12.5: Winter Solstice - 4pm shadows of Auckland’s Waterfront
The mass is characterized as being tall and thin, casting a large shadow over the Wharf and surrounding seawater. The relationship between spaces within a mass of this form will be vertical and mean that the spaces predominantly get horizontal sunlight.

The mass is characterized as being short and wide, casting a smaller shadow, compared to the previous example, over the Wharf. The relationship between spaces within a mass of this form will be horizontal and mean that the spaces get vertical and horizontal sunlight.

The ideal mass to develop the project with is of a low height mass, which receives good sunlight exposure on the horizontal and vertical surfaces of the mass. Further a mass that allows each major space within the design to have full sunlight exposure.

Midday (Solar Noon) elevation angle 76.6 degrees
Longest Day (December 21) 14 hours 41 minutes
Sunrise 121 degrees (from North)
Sunset 239 degrees (from North)

Midday (Solar Noon) elevation angle 29.7 degrees
Shortest Day (June 21) 9 hours 37 minutes
Sunrise 69 degrees (from North)
Sunset 299 degrees (from North)
In reducing the right side of the mass, the afternoon sunlight means the west surface (vertical) is exposed to sunlight, as well as the diagonal top surface. As the top surface complements the solar elevation angle of the afternoon sunlight, anything above 18 degrees will provide light onto this surface, and will not produce a shadow, anything below the 18 degrees, when the sun is setting, will result in a shadow being cast and no light exposure on its top surface.

In the same scenario with afternoon light, having the mass angled the other way means the diagonal top surface is exposed to sunlight until the sunsets. No light will reach the east surface (vertical) and this elevated side will produce casted shadows, from around midday.

In these examples [Figure 7.15.1 & 7.15.2], there is no clear form that would be more beneficial to capture sunlight than the other, as afternoon light will benefit from [Figure 7.15.2] form, but will be in reversal for the morning light as [Figure 7.15.1] would be better. It is therefore important to incorporate both angled top surfaces in the development of the project.
Design Part II: Architectural Application
This chapter covers the design of the architectural proposition, specifically taking five sequential spaces that are key in leading spectators on a journey through the building, and manipulating them to get the best shaped space to receive light. Each of the five spaces will use a different technique in manipulating light that not only best suits the function of the space, but demonstrates the variety of different ideas made from the discoveries of the previous chapters.
Design
There are two conditions for the design of the proposition.

The first is in relation to the research question, to create constantly changing light arrangements; ‘Monumental Light’ gestures will be utilized, to completely alter the visual perception of light within a space. This gesture, affected by the: luminance, contrast, colour, direction and distribution of light will fill the space with light for a certain period, then revert back to the original light conditions.

The second is that for light to be distinguishable, darkness must be present. Darkness is not the opposite of light, but rather the absence of light. When using the term darkness, it implies a contrast of light, which at the same time complements light.

The idea of the spaces is that each subsequent space will contrast the adjacent space(s), whether light or dark, but also complement the other as each space is part of the whole, and should not be considered isolated. For instance, the ‘foyer’ is different and in a sense opposite to the ‘arena,’ but together each complements the other, in the scheme of the transition and the journey through the building.
The two opposing spaces of this scheme are the ‘Foyer’ and ‘Arena’ spaces. The spaces between these will link them together. The proposal is that as spectators transition from outside to inside, there is also the transition from light into darkness. The procession of the spectator through the building will see light being re-introduced incrementally.

The sense of withdrawal into darkness will be enhanced by level changes. When moving into a darker space, the ground level descends, enhancing the feeling of mystery and anxiety, and when light is introduced the ground level ascends.

* It should be noted that the following sun studies are from the middle of the day when the sun is at the highest ‘Solar Elevation Angle’ in the sky.
8.1 Foyer space

The foyer is the transitional space between the outside and the inside environment. The light of this space will be a reduction of the outside environment, making it appear darker.

The foyer is a long space to help in the removal of direct and indirect (ambient) light.

Although the ‘monumental light’ within the space will be compartmentalized, the light moving into the space will change colour depending on the solar elevation angle and position of the sun.

Influence

Figure 6.4.8: Light passing through two polarized filters as casting yellow light
Figure 6.4.9: Light passes through a single polarized filter casting white light

Figure 8.1.1: North-South section through the rectangular space
Light moves into the space through a vertical gap at the top left corner, drawing spectators through to the left end of the space.

Figure 8.1.2: Reducing the height of the space
Reducing the height of the middle section, visually divides the space into two. This subsequently blocks part of the view towards the left end, reducing the light in the space when entering from the right.

Figure 8.1.3: Introduced a horizontal gap at the north end of space
Changing from a vertical to a horizontal gap, means that light entering horizontally into the space is restricted. Using the angular side (left) provides space to move down a level, and makes it appear to spectators moving through the space that the light at the end travels beyond the floor.

Figure 8.1.4: Plan of space with a perpendicular red line indicating the horizontal gap
To provide a greater range of precessional light into the space, that is to allow direct and reflected light to displace a greater horizontal distance within the foyer, angling the ceiling section inwards [Figure 8.1.8] lets more light in, permitting light to be casted further into the space, making light movement perceivable, rather than in [Figure 8.1.7].

Summer solstice sun is at its greatest in the sky with a solar elevation angle of 76.6 degrees. Light moves directly into the space, without being reflected.

Autumn and Spring Equinoxes with a solar elevation angle of 53.0 degrees. Most of the light moves directly into the space, while the other portion is reflected towards the angled wall.

Winter solstice sun is at its greatest solar elevation angle of 29.7 degrees. All light is reflected into the space, even closer to the angled wall, than the other two examples.
Producing three different angled reflective surfaces provides more scattered light within space that has a greater displacement in the space than the previous examples.

Producing three faceted reflective surface elements provides scattered light within space that has a greater displacement in the space than the previous examples and is ideal for the development of the space.

Figure 8.1.10: Split reflective surfaces (red) angled high
Providing two reflective surfaces that are angled high produces a light that is reflected towards the top of the space.

Figure 8.1.11: The effects of precessional light within the space

Figure 8.1.12: Split reflective surfaces (red) angled low
Providing two reflective surfaces that are angled lower than previous example produces a light that is reflected towards the bottom of the space, especially seen in the 53.0 degree example.

Figure 8.1.13: The effects of precessional light within the space

Figure 8.1.14: Three different reflective angled surfaces (red)
Producing three different angled reflective surfaces provides more scattered light within space that has a greater displacement in the space than the previous examples.

Figure 8.1.15: The effects of precessional light within the space

Figure 8.1.16: Faceted reflective angled surfaces (red)
Producing three faceted reflective surface elements provides scattered light within space that has a greater displacement in the space than the previous examples and is ideal for the development of the space.

Figure 8.1.17: The effects of precessional light within the space
Adding polarized panels in this arrangement not only indicates the rough time of the day, yellow indicating the morning and blue the evening, but it enhances the bright colours of twilight. The yellows and blues are evident when the solar elevation angle is less than 25 degrees.

LED lights are imbedded into the gaps provided to light the space at night. The lighting is programmed to have a higher luminance level at sunset and sunrise and a lower luminance level during the middle of the night.
Figure 8.1.24: Perspective of a typical late summers afternoon looking towards the hall
Figure 8.1.25: An evening perspective, being artificially lit by LED lights and the surrounding city light
8.2 Hall space

The hall is the darkest space and is the adjacent space to the foyer, leading towards the arena space. The hall is deliberately dark and unlit, so that the other senses are heightened, like the auditory sense, but also allows a sensitivity to light that makes the succeeding spaces appear brighter and creates an appreciation for the different lighting experiences.

The hall requires a long space, so that when moving from one side of the space to the other, the spectator’s eyes can adjust to the darkness.

At certain times, light enters at different places in the space for a short time, whether faint or overly bright, defining a space of different shapes and sizes.

Influence

There are mixed emotions about plunging into a dark space from a well-lit environment and the phenomenon can be either exciting or unsettling.

“You believe that you’re safe with your light, safe because you see clearly in a narrow area. And you’re afraid to lose that light, afraid of being absorbed, but then it’s the opposite: you actually see more, you see better, you see farther and, instead of seeing something very focused, you see everything.”

“In adjusting our eyes adaption phenomena will occur that you will see things that aren’t really there things that our eyes [our mind] produce”

Darkness reduces visual awareness of space, therefore the volume of space could be either large or small. This reduction of visual perception heightens the other senses like auditory, helping with comprehending the size and volume of the space.

The large space was chosen because there will be times where the space will be lit, and the extra height will reduce noises making the spectators feel isolated, like the champions that they will see fighting in the arenas.

The ceiling was reduced to allow a better surface area and exposure to sunlight for later development of the space.
The sprawled yellow light indicates the area that would be lit up when the solar elevation angle is 30 degrees, and the sun is 38 degrees northeast.

White light will enter the space at the height of the summer solstice (red indicates the sprawl of the light and not the colour of the light). This will allow 'monumental light', that will be seen for a few minutes annually, when the solar elevation angle is 76.6 degrees, and the sun is 0 degrees north.

The sprawled blue light indicates the area that would be lit up when the solar elevation angle is 15 degrees, and the sun is 70 degrees northwest.

The next series of images will look at defining smaller spaces within the larger hall. Although the hall will be predominantly pitch black, there will be times where the space is lit momentarily. This will be achieved by distributing light from different columns at different times, dictated by the solar elevation angle and the direction of the incoming sunlight to the building, creating different sized spaces throughout the day.
To make it appear that light is being emitting from a column, light not only needs to light the column but it must also appear to distribute the light out from the column. This could be done by projecting light down parallel to the column, making the column appear to be lit.

For this to happen light entering the space projects through a void space that is established between the roof plane and the column. For light to be projected parallel to the column a mirror is situated at the junction, so that sunlight of a particular elevation angle will be reflected parallel to the column.

To make the columns appear to be an emitting light, the light has to be moving away from the column. It is beneficial for this light to be distributed out from the column where spectators will see the effects, across the floor out from the column. For light to be spread across the floor, mirrors are placed at the base of the column.

Polarized glazing will be used to stop all unwanted light, mainly daylight and sunlight, from entering the space, which will not result in the reflected light being projected down parallel to the face of the column. The glazing is arranged in such a way as to only allow light to pass through at a designated solar elevation angle; anything that does not correspond to this is blocked out.
Figure 8.2.17: 50mm gap between the ceiling and the polarized glazing allowing maximum light penetration into the space, with an solar elevation angle of 76.6 degrees

Figure 8.2.19: 200mm gap between the ceiling and the polarized glazing allowing maximum light penetration into the space, with an solar elevation angle of 76.6 degrees

Figure 8.2.18: With this gap, the minimal light penetration into space is 69.8 degrees, a 6.8 degree variation

The issue with having the polarized glazing too close to the reflective mirrors in the ceiling means that a greater range of light at different solar elevation angles can pass through. This needs to be more controlled, which occurs when the glazing is moved further away from the ceiling, to decrease the range of light that may enter the space.

Figure 8.2.20: With this gap, the minimal light penetration into space is 75.5 degrees, a 1.1 degree variation

This is a more accepting variation, and will mean light can be controlled within the space for any length of time. This arrangement will be positioned above all the columns that require the light. Each polarized glazing sheet has a coloured filter on it to allow light to be transformed to a certain colour. The solar elevation angles and sun directions will determine the orientation and arrangement of the polarized glazing for the space.
Figure 8.2.21: Perspective of a typical morning within the hall displaying the blue light
Figure 8.2.22: Not only marking the middle of the summer solstice but also the middle of the day, the perspective shows the white light that fills the hall annually.
8.3 Circulation Space

| Official Arena | Circulation | Hall | Foyer | Unofficial Arena |

Coming in from the hall, the circulation space will be ceiling lit of a low light level, to allow the journey through the succeeding spaces to become brighter and more exposed to light. The light will be further enhanced by level changes, by either elevating the spectators up into the light towards the official arena space or plunging spectators down to the bottom of the space towards the unofficial arena space.

The space required will be tall so that light entering through the ceiling will seem to be distant and un-reachable. In plan, the space focuses towards the centre with ramps circulating around and through the centre.

Water will be integrated into the space, allowing light at certain times and solar elevation angles to be reflected from its surface to different parts of the space.

Influence

![Figure 8.3.1: North-South section through the rectangular space](image1)

Adding a pitched roof and ceiling not only links in with the hall, but provides a better surface to capture sunlight.

![Figure 8.3.2: Increasing the central height of the space](image2)

Extending the circulation pit beyond the floor of the hall, provides an opportunity to allow seawater through the bottom of the space as an element for light manipulation. Being tidal, and the centre of the space, the light will be able to reflect unique and constantly altering patterns along the sides of the pit.

Opening the ceiling up to light, making an oculus (indicated red), allows direct and ambient light to enter the space.

![Figure 8.3.3: Adding diagonal sides and removing a ceiling area (red) within the space creates an light pit](image3)

![Figure 8.3.4: Plan of the circulation and Hall spaces](image4)
Entering the circulation space from the hall, ramps on either side of the space slope upwards towards the official arena, while circulating down these ramps will take spectators through to the unofficial arena. Moving along the ramps is a gesture of ascending into the light or descending into darkness.

In plan, the east and west sides have been sloped inwards like the north and south walls to strengthen the pit space.

Reflective louvres are put in the oculus space to allow light direct access to the space with reflective light to be projected down into the bottom of the circulation space, in the summer solstice.

The louvres cast symmetrical light into the space, but cast winters light quite high up within the space.
The reflective louvres cast irregular light patterns into the space with the summer solstice sun. Direct light escapes the space in the winter solstice period. The angles of the louvres means that all direct light is blocked into the space and all reflected light is projected out of the space, towards the sky, which is not what the space requires.

The reflective louvres cast irregular light patterns into the space with the summer solstice sun. During the winter solstice period, light is project into the space further than the previous examples, towards the level of the circulation ramps. This makes the louvres a preferred choice to develop further.
To enhance the reflective and casts light into the space, prisms are arranging in a linear manner, not only generating the pure spectral colours, but also to move light further and deeper into the space.

To further enhance the movement of light within the space, plano-convex lens are positioned in the middle of the space to provide more light into the space. This is not required, as the space is not meant to be light filled throughout the day, but only occasionally.

The final exploration looks at a curved reflective surface. The light reflects off both this surface and the water generating rippled light that is directed up onto the north wall. This curved surface is positioned at the bottom of the space, within the tidal zone. This results in the curved object being submerged and exposed with the tidal movement. To mark the monumental light, the low tides and light penetration will not always synchronize, making the occasion when the rippled light more scarce.
Figure 8.3.23: A typical summer's midday experience of the ‘monumental light’ directing the rippled light upwards along the northern wall
Figure 8.3.24: An evening perspective with ambient city light filling the top of the space. Within the water LED lights are fitted at the bottom of the space lighting the water up
8.4 Official Arena Space

The arena is the destination space within the building. The spectators are elevated into this space, which is not only a stage for the fights but will be an exhibition of light and is the most well lit space of the building.

The space required is for a large square space, so that the centre of the space can house the UFC or host other functions.

The ‘monumental light’ within the space will utilize light that emphasis the boundary of the space, making the space appear small or large, by making the walls opaque or transparent.

Influence

Figure 6.3.5: Back-lit mesh providing background view
Figure 6.3.6: Front-lit mesh reducing background view

Figure 8.4.1: North-South section through the rectangular space
To enforce the idea of contrast within the design, the official arena is visually separate from the rest of the building and will take on a new form factor, whilst visually complementing the other building also. There will be a physical underwater tunnel linking the two buildings together.

Figure 8.4.2: Studies looking at the how light is received into different spaces with horizontal gaps at either end
The vertical surfaces are angled to find the best arrangement that captures the most light; as in the middle example.

Figure 8.4.3: Studies looking at the how light is received into different space with a gap in the centre of the horizontal plane
In reducing the floor area of the space, the horizontal light coverage is exaggerated.

Figure 8.4.4: The sides are inverted and the ceiling is angled to complement the roof level of the circulation space
By adding a reflective mesh screen to the sides of the space, it allows light to either pass through or be reflected away from the screen. The implications are that the changing precession of sunlight varies the ratio between light being reflected or passing through.

In a scenario when the luminance of the foreground is brighter than the background, because of reflected light, the screen appears opaque. However, if more light passes through and makes the background brighter, the screen thus appears transparent.

This lighting strategy is dependent on the angle of the light to the angle of the mesh.

When the space is artificially lit, light that is positioned in this manner can make the screen appear opaque. If these lights are reduced, the city lights increase and the screen becomes transparent.

By incorporating a chandelier within the space, the coverage of light is increased, highlighting the sides of the space. Allowing a gap in the centre of the chandelier means light can still pass through to the centre of the arena.

It should be noted that the internal arena thus far is the same as the east-west section.
The screen is composed of little reflective surfaces spaced out along the screen plane. For the phenomenon to occur and for light to make a transparent screen opaque, the reflective surfaces need to be angled correctly. To have the screen to appear opaque, the reflected light needs to be below the horizon line. The best example is the last where the reflective surface is 70 degrees. This is because in winter, precessional light will only be angled this way for a short time, and will hence only be opaque for a short time. This enforces the ‘monumental light’ gesture, where the walls make the space become enclosed, for a short time, then open and transparent for the rest of the day. The summer months will have a longer exposure of light to produce the opaque screen and the winter months less time.

To reduce the background luminance immediately outside the arena, another space or strategy needs to be put in place to reduce the background light but not restrict precessional sunlight from entering through the sides of the arena space.
Both examples show reflective light entering through the north section of the arena. The long length reflective surfaces block out direct sunlight into the space, allowing only reflected light to pass through. The angled surfaces [Figure 8.4.14] will better reduce the surrounding ambient light outside the arena permitting the conditions within the arena to generate opaque walls.

Figure 8.4.15: Slightly reducing the length of the reflective surfaces to allow summer solstice light to enter the space

Figure 8.4.16: East-West section through the arena

To accommodate circulation space required for spectators, the east and west elevations will require a different strategy to direct light through to the arena.

Figure 8.4.17: Reflective surfaces (red) along the top surface of the angled louvres allow light to be reflected on the path towards the mesh screen

Figure 8.4.18: Reflective surfaces (red) along the top surface of the angled louvres allow light to be reflected underneath the path towards the mesh screen

Light that is reflected off the path and the angled louvres results in the background to the arena space becoming overly bright, in comparison to light that is reflected underneath the path. What was needed was a strategy to reduce background light to the arena but allow light to be directed into the space and the latter [Figure 8.4.18] example is the best solution.

Figure 8.4.19: East-West section through the arena showing the chosen light strategy from the angled louvres
Figure 8.4.20: An early summer’s afternoon, portraying light that is producing an opaque section on the wall (right)
Figure 8.4.21: An evening perspective showing artificial light shining from the chandelier and the artificial lighting that casts light down the walls creating an artificially lit opaque wall.
8.5 Unofficial Arena Space

The Unofficial arena is the other destination within the building and is used for training and informal UFC fights or other functions. This space will contrast the Official arena by being darker, but subtly brighter than the preceding circulation space.

The unofficial arena also requires a large square space with a low ceiling height but is slightly smaller than the official arena.

The contrast between the Official arena and the Unofficial will be further distinguished by utilizing artificial and natural light. The light effect within the space will show a quality of natural light movement and deterioration, by the use of illumination coating.

Influence

Figure 8.5.1: North–South section through the rectangular space
Starting with a rectangular section, that is square in plan, the unofficial arena is situated below the official arena, to establish some connection between the two spaces. The arena is completely submerged underwater to provide light that is manipulated by water.

Figure 8.5.2: The rectangular space is moved up directly beneath the official arena and is glazed to capture ambient light from the arena

Figure 8.5.3: Reducing the sides of the space creates a pitched ceiling that has more surface area, providing better light into the space

By creating a pitched ceiling, it not only creates the appearance of a more enclosed space, but also allows light from the water to enter the space.
Light being shone from the opposite side of the space transmits through the prism columns scattering light through the space.

Columns arranged in a uniformly lit space

Light being shone from the opposite side of the space energizes the illumination coating that is applied over the columns and walls. When the light is removed the glowing surfaces slowly diminishes.

LEDs are imbedded within each column. Having a dark environment means different LED patterns and arrangements create different illusions of space, in terms of depth and scale.

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Light being shone from the opposite side of the space, transmits through the prism columns scattering light through the space.

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Figure 8.5.11: Day lit space with water reflections projecting across the floor
Figure 8.5.12: An evening perspective showing the artificial floor lights and the illumination coating along the back wall of the space
Establishing the design with two flat surfaces

Raising two corners on each surface creates a hyperbolic paraboloid that provides greater surface area to capture better sunlight exposure throughout the day time period.

Sections of the hyperbolic paraboloid surface are manipulated to break the continuous surface, providing different spaces underneath the surface. The arrangement of the surfaces provides light exposure on every surface throughout the day.

Figure 8.6.1: Diagrammatic illustrations on the development of the architectural proposition
The two surfaces join together to create a single shell. Two more surfaces are introduced into the middle section of the newly established shell.

Unlike the established shell that has an irregular geometric composition, the new surfaces will form a symmetrical composition, which will complement and contrast the other shell.

The two surfaces are manipulated to fit into the context of the other shell.

The surfaces have been dropped into place creating the two building shells. These are then positioned on Captain Cook’s Wharf.
Figure 8.6.2: Plan view of the architectural proposition at 4 metres above sea level
Figure 8.6.3: Plan view of the architectural proposition at 3 metres below sea level
Figure 8.6.4: North-South section through the architectural proposition showing the journey though all the main spaces leading to the Official Arena.
Hall

Foyer
9. Critical Appraisal of the final design
The final design was set out to explore five specific spaces within the building. Each space was created and developed with the intention of using different techniques to manipulate precessional light with in order to see if the resulting light alter the visual perception of space.

9.1 Foyer Space
The intention for the space was to provide light that would display the angle of incoming light, indicative of the time of day, the same principle as a sundial. It was originally perceivable with the manipulation of mass and the reflective surfaces, which direct light into certain areas within the space. This was enhanced by the retrofitting of polarized glazing, the same arrangements that were developed in ‘Design Part I.’ This provided yellow and blue light within the space when the solar elevation angle is below a certain elevation angle.

9.2 Hall Space
Removing all light within the space, the hall was exploring the nature of using light, when permitted in, to create different arrangements of space, within the larger space. This was achieved by using polarized glazing to control light into the space, and allow light at certain elevation angles to enter and fill the space. This created moments where light would define the space, whether it was a triangle, square or hexagon shape in plan.

9.3 Circulation Space
The intention was to create a shaft of light that would fill the space. At certain times light will reach the water’s surface and reflect light throughout the space. As a narrow space, this was difficult but was achieved by using louvres at the top of the space, positioned to direct light towards the water’s surface, in a way that would permit light to be reflected off its surface. This was developed with a reflective curved object, to intensify the reflected light within the space and provide moments where it would be filled with reflected light, providing lit times, where the height is accentuated, or dark when it is reduced.

9.4 Official Arena
The space was exploring the nature of a screen that would switch between opaque and transparent. When light within the space is reflected back inwards, the appearance of light creates an opaque wall surface. When light passes through increasing background luminance, the screen became transparent. This results in the perception of space becomes closed off and small when lit opaque and large and open when transparent.

9.5 Unofficial Arena
The last looked into the application of illumination coating. This was not as successful as the other spaces, as it would occur when light was removed from the space. It required bright light or a long exposure to stay lit. This was through the use of artificial light and having a naturally decaying surface provided the space with a quality of light that transforms and alters.

9.6 Key discoveries from design
The first being that like different times of the day, sunlight appears to be stagnate and unchanging through the middle of the day, and changes quite rapidly during sunrise and sunset. Spaces do not need to be changing constantly, but can be changed subtlety at certain times of the day. What is more important was the idea of creating “monumental light” gestures that completely alter the light within the space, like at twilight where sunlight and atmosphere create incredible light displays lasting for a few minutes each day.

The second is that as sunlight is constantly moving and changing bringing light into interior spaces could create the variety and constantly changing atmosphere that is needed within the space.

The third is that the higher the contrast between light levels within a space, the more impact and more obvious the light is within a space. Without the contrast between them, spaces become overly bright and unnatural in appearance.
The purpose of the project was to discover whether manipulating precessional light would result in moving light that transforms the atmosphere of a space, subsequently adjusting one’s visual perception of the space. Allowing light to move through the space along with modifying the colour, luminance, composition and size of the light, the atmosphere within the space produces an environment that permits the visual perception of a space to change.

Although the development of the research diversified and explored a great range of light and space examples, through Design Part I and II, these explorations were the product of the three fundamental objectives that the research project was structured on. These were:

- Research light in architectural and art installations spaces;
- Investigate different materials and innovative lighting techniques to manipulate precessional light; and
- To create visually stimulating and perceptually changing spaces through utilizing precessional light to alter size, luminance, composition and colour – the atmosphere of a space.

10.1 Research Light

The first objective was to break away from current understanding of light within architecture, to look at opportunities that modify light within a space, consequentially influencing the visual perception of a space. Selective examples were found from artists and architectural work that helped highlight key principles that were developed with precessional light, producing light transforming spaces.

10.2 Manipulation of Precessional light

In the development of the project, sunlight was seen as a precessional light source that offered varying colour and light intensities throughout the daylight period, providing a light that was constantly changing in its environment and therefore within space. Techniques to direct and manipulate light into a space were required to enhance the sometimes-slow vitality of midday sunlight to make the movements and variations of atmosphere obvious within a space.

The techniques and materials discovered and developed in the architectural proposition were successful, in the way that ‘Monumental Light’ gestures could be exploited. ‘Constantly changing’ was defined in the design by light that was always moving, and where light could significantly change within the space momentarily. This was achieved by utilizing a site that was open to uninterrupted sunlight exposure and spaces that would fluctuate in light with the change in outside weather conditions.

Each space was opened to sunlight, but the more successful spaces were those that utilized polarized glazing. In the first instance the foyer used particular masses and reflective surfaces to manipulate the light in a certain area of the space, but was enriched by polarized glazing. The glazing was arranged in such a way that the direction of light would dictate the colour that would penetrate into the space. In the second instance the hall space used polarized glazing to direct light of a certain ‘solar elevation angle’ through into the space. This meant that light would enter the space on occasion and last momentarily, defining a space within the large space.
10.3 Light influencing Perception of Space

The visual perception of light and space are inter-dependent, meaning that the visual perception of space cannot exist without being lit. That is why the edge of a space and the light within the space are important, and that this atmosphere of light determines how the space is perceived, like in winter, a blue lit space will make one feel cold, and a yellow lit space warm.

The idea of using light to define the dimensionality of space, to alter the perception of space, lead to explorations to use light in a certain way to get these specific results. The hall space achieved this by providing a dark space, which reduced the visual perception of the space and it was only by lighting the space that it could be visually recognizable. When lit, three sets of columns are lit in different patterns with different colours to shape the way the space is perceived, defining small and large spaces within the larger space. The final example is the opaque and transparent screen within the official arena. When the screen reflects most of the light back into the space, it increases the foreground luminance reducing the appearance of the background making the screen materialize as being opaque, resulting in the space being perceived as small and closed. When the background is lighter the screen becomes transparent, resulting in a large and open space.

10.4 Conclusion

The research has shown that by manipulating precessional light, you can produce a perceived change of that light. When this is introduced into a space, the changes in manipulated light introduced will alter a person's perception of that space.

While the research has investigated and developed specific aspects of light and light manipulation, it could be developed further to find other ways of lighting a space, or ways of introducing certain types of light into a space that produces 'monumental light gestures.' These gestures could also be utilized to enhance the experience of architecture and space.

Advancing technology coupled with new products and resources are making it easier to create a variety of different lighting interventions. However, without the further development of the manipulation of precessional light and the enhanced use of natural light for an aesthetic purpose, the creation of natural and healthy atmospheres within modern architectural spaces may be lost to artificially lit environments with purely functional purpose.

Finally, throughout history, light has always had a contrasting and complementary relationship with space, in its aesthetic and technical aspects. If light is developed into architecture with the purpose of creating emotional as much as performance lit spaces, “Today’s absence,” of these types of spaces, within our lives could be intertwined in “Tomorrow’s Presence.”
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Figure 8.2.12: The minimum threshold of light to enter into space with an angle of 69.8 degrees, whilst still being projected parallel to the column surface

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Figure 8.2.15: Sectional perspective of the polarized glazing allowing some light
to pass through and other light not to

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**Figure 8.2.18:** With this gap, the minimal light penetration into space is 69.8 degrees, a 6.8 degree variation

**Figure 8.2.19:** 200mm gap between the ceiling and the polarized glazing allowing maximum light penetration into the space, with an solar elevation angle of 76.6 degrees

**Figure 8.2.20:** With this gap, the minimal light penetration into space is 75.5 degrees, a 1.1 degree variation

**Figure 8.2.21:** Perspective of a typical morning within the hall displaying the blue light

**Figure 8.2.22:** Not only marking the middle of the summer solstice but also the middle of the day, the perspective shows the white light that fills the hall annually

**Figure 8.3.1:** North-South section through the rectangular space

**Figure 8.3.2:** Increasing the central height of the space

**Figure 8.3.3:** Adding diagonal sides and removing a ceiling area (red) within the space creates an light pit

**Figure 8.3.4:** Plan of the circulation and Hall spaces

**Figure 8.3.5:** Walls are thickened and ramps (circulation) is added

**Figure 8.3.6:** Plan of circulation with roof area smaller and narrower than the the floor area

**Figure 8.3.7:** Parallel louvres (red), angled to allow uninterrupted midday summer solstice light into the bottom of the circulation space

**Figure 8.3.8:** Vertical louvres partially allow and reflect midday summer solstice light into the space

**Figure 8.3.9:** Section through reflective parallel louvres (red)

**Figure 8.3.10:** Louvres reflect midday winter solstice light into the space

**Figure 8.3.11:** Fanning out louvres partially allow and also reflect midday summer solstice light into the space

**Figure 8.3.12:** Section through reflective fanning louvres (red)

**Figure 8.3.13:** Louvres reflect midday winter solstice light into the space

**Figure 8.3.14:** Each louvre is angled slightly differently partially allow and also reflect midday summer solstice light into the space

**Figure 8.3.15:** Section through reflective angled louvres (red)

**Figure 8.3.16:** Louvres reflect midday winter solstice light into the space

**Figure 8.3.17:** Triangular prisms arranged in a linear manner

**Figure 8.3.18:** Plano-convex lens distribute light vertically

**Figure 8.3.19:** Plano-convex lenses arranged in a vertical manner

**Figure 8.3.20:** Louvres capture midday winter solstice light

**Figure 8.3.21:** Curved reflective surface scatters light throughout the space

**Figure 8.3.22:** Louvres capture midday winter solstice light

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**Figure 8.4.1:** North-South section through the rectangular space

**Figure 8.4.2:** Studies looking at the how light is received into different spaces with horizontal gaps at either end

**Figure 8.4.3:** Studies looking at the how light is received into different space with a gap in the centre of the horizontal plane

**Figure 8.4.4:** The sides are inverted and the ceiling is angled to complement the roof level of the circulation space

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**Figure 8.4.6:** Chandelier provides both direct and reflected light into the space

**Figure 8.4.7:** Light outside space moving and reflecting off surface

**Figure 8.4.8:** Artificial light inside space moving and reflecting off surface

**Figure 8.4.9:** Study of summer solstice light (76.6 degrees) as it reflects off different angled surfaces

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**Figure 8.4.11:** Within the sides are little reflectors to reflect light back

**Figure 8.4.12:** Extending the space beyond the arena

**Figure 8.4.13:** Horizontal reflective surfaces reflect low light into space

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**Figure 8.4.15:** Slightly reducing the length of the reflective surfaces to allow summer solstice light to enter the space

**Figure 8.4.16:** East-West section through the arena

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**Figure 8.4.18:** Reflective surfaces (red) along the top surface of the angled louvres allow light to be reflected underneath the path towards the mesh screen

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Figure 8.5.3: Reducing the sides of the space creates a pitched ceiling that has more surface area, providing better light into the space
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North - East Perspective of Architectural proposition and Wharf
Evening North - West Perspective of Architectural proposition
Ground Floor Plan - 3
Architectural proposition and Wharf
Five Internal Spaces
Entrance into the Foyer

1.1 - Physical Model  White light transforms to yellow light as it moves through two polarized filters

1.2 - Physical Model  White light is not effected as it moves through a single polarized filter

1.3 - Physical Model  White light transforms to blue light as it moves through two polarized filters

1.4 - Morning Experience
1.5 - Midday Experience
1.6 - Afternoon Experience
Grand Hall

2.1 - Physical Model  Section through polarized filters and mirrors along the top of the column

2.2 - Physical Model  Sectional model of column detail

2.3 - Physical Model  White light representing midday sunlight, during the summer solstice, as it moves down the column and diffuses out from the column

2.4 - Physical Model  White light is blocked by the polarized filters

2.5 - Midday Experience

2.6 - Afternoon Experience

2.7 - Night Experience
3.1 - Digital Model
Representation of the physical model from presentation showing the effects of light as it reflects off the glossy surface

3.2 - Midday Experience
High tide light effects onto the wall surface

3.3 - Midday Experience
Low tide light effects onto the wall surface as light reflects off the glossy reflective surface

3.4 - Afternoon Experience
Low tide light effects onto the wall surface
Official Arena

4.1 - Physical Model  Uniformly lit model shows transparent mesh screen

4.2 - Physical Model  When white light is shone onto the right panel, it makes the mesh appear opaque

4.3 - Midday Experience
4.4 - Afternoon Experience
4.5 - Night Experience
Unofficial Arena

5.1 - Physical Model
The presence of light diminishes on the wall surface over time

5.2 - Midday Experience
Light exposed to the space provides glowing walls that also leave unlit imprints of casted silhouettes

5.3 - Night Experience
Light from a different position provides different unlit silhouettes on the wall surface
West Perspective of Architectural proposition and Wharf