University of Cincinnati

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I, Lorrin E Kline, hereby submit this original work as part of the requirements for the degree of Master of Architecture in Architecture.

It is entitled:

A User Centered Design Application in Eye Tracking Technologies: Children's Perceptions Within the Built Environment

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33016

A User Centered Design Application in Eye Tracking Technologies: Children's Perceptions Within the Built Environment

A thesis submitted to the Graduate School of the University of Cincinnati In partial fulfillment of the requirements for the degree of

Master of Architecture

in the School of Architecture and Interior design of the College of Design, Architecture, Art and Planning

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ABSTRACT

As architecture molds to advances in technology, so does the way architecture is thought and conceived. Architecture could be perceived as a function, with an additional layer of information that could be thought of as perception. This psychological layer brings meaning to architecture through the use of light, texture, color, and sound to one's personal experience within the built environment. However, every user of every structure is different. We all have different needs in which the built environment provides for. It is up to the architect to decide what is best for that given design. More often than not users of that space are not involved within the design process. Children, for instance, never have a say in what their needs are within a space, it is just made for them. To better understand user needs, design strategies have been implemented to gain user feedback throughout the design process. The use of eye tracking has become a way in which designers can gauge user feedback on new designs. Eye tracking becomes a way in which the user's eye determines what attracts their attention and for how long. This thesis will begin to use eye tracking as a study in which designers undergo the design process seeking a child's perception of the built environment to make design decisions as well as becoming more involved throughout the process. The research will question whether implementing eye tracking studies into the design process helps understand whether testing its user aids to create better design for them or falls short. This thesis will focus design features though tactics of seeking visual attention.

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All illustrations are created or photographed by author unless otherwise noted.

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INTRODUCTION

Architecture could be seen as two layers that need to meet the needs of people. The first being function or utility of the building, and the second being a psychological or emotional level. Design decisions are made to meet the needs of the buildings purpose, but are we deliberately designing for the users themselves? To design architecture to meet the needs of a user, we must first understand the user its self. I believe it is just as important to serve one's psychological needs because of the perceptions and the emotions that we attach with place. What is it that we are going to remember most about the structure itself? The architect works hard to provoke emotion within a building but often the building is never measured before the structure is actually built. These measures are now beginning to be measured on already built structures. So what does that mean for the future of design? If these physiological and social needs of users are detected in an earlier stage, the designer can implement these ideas into early concept stages of the design process.

What does it mean to create a user centered design? For this research, I have chosen to study children in the learning development stage where the built environment begins to influence memories and build a foundation of different types of environments . A building should help to influence our ability to

learn. At this young age, their perceptions and relationships to space are very different than from those of adults. Though a certain space in a building may be allocated to children, there are not many cases where we are designing specifically to them, other than a school. There are not many public places that are designed based off of a child's psychological needs. With this research I hope to begin to understand how a child sees space and to be better able to design for them in the future.

One way these concepts are beginning to take shape in the design process in through the use of eye tracking. Eye tracking gives you the freedom to see where the user is drawn to without having to ask specifically what they are looking at. Mostly used in product and website testing eye tracking pilot studies have begun to surface within architectural design, in regard to what elements users are specifically fixating too. Later, this thesis will show studies that architects assign relatively different levels of dominance to spatial features than non-architects, as well as consistency in their gaze patterns. From this study it is known that an architect sees a space differently from most other user groups. With this in mind it is hard for an architect to understand how a user may or may not react to a space.

PERCEPTION

Architecture is a visual field of work. Each designer or architect has a truly different outlook on the perception of the built environment. Ittleson explains that perception is apart of our living process. We create particular points of view within the world around us through our different life experiences.[1] As we enter a space regardless of age, an individual will see a space in a completely different way than the person standing beside them. Our past experiences help to create how we perceive in the present. "Our perceptions give us the only world we know. It is the world in which we act, and we act in terms of our perceptions. Our perceptions provide us with predictions as to what will probably happen if we act in a particular way."[2] When entering a space, there is already a preconceived notion placed in one's mind of how a space should be before you enter it, which based off of past experiences. The way in which we perceive a space will either add up to those expectations or fall short. Architecture, on its own, has a way of adding or subtracting from the already preconceived notions perception has on the world around us. This review will help to better understand how perception will be recognized within this thesis.

[1] Ittelson, W. (1969). Visual space perception. New York: Springer.

[2] Ibid.

FUNCTION VS. SENSORY

Perception can be divided into two values, one of function and the other of sensory. The function values refer to those that "bring us into contact with the world outside of ourselves."[1] On the other hand sensory values refer to perception as things that we know and understand about the world. These ideas are consumed through the medium of our sense organs.[2] It is important to note that for the purpose of this research, perception will be based on the values of function. The human connection to the built environment is a function of perception. The interaction between person and built space create a significate meaning to the way in which value is placed on an environment.

This thesis will also take on ideas of externalization. Externalization can be described as "a concrete situation that makes a transaction of one's perception in recognition of their personal behavior through which they create their own psychological environment."[3] This breakdown of isolated situations begins to delimit ideas of perception. For the purposes of this study, these transactions must be broken down as individual parts that create a greater whole.

EXPIRENCED SIGNIFICANCE

The processes of perception can be broken into four categories of classes of experienced significance. The first being *thing significance*, where we experience things

as wholes. This "refers to the world of objects and people in so far as we experience them as entities apart from ourselves processing their own characteristics and spatial – temporal locations."[4] The second, *sequential significances* where "events of one kind are constantly occurring around us, new events following the previous in a never-ending series of sequences."[5] *Action significances* then "follow as sequences to our own actions have special significance in the perceptual process."[6] Which lead to the last of the significances, *evaluative*. "Evaluation among these alternatives is made on the bases of the relative probability that each possible outcome will lead to the desired sequences, will produce desired results."[7] Every individual processes these different types of experienced significance, however architecture and place will mainly be experienced as a whole.

Architecture creates a lens that the world is experienced through. Pallasmaa describes architecture in a way that "it structures of the 'flesh of the world' through spatial and material images that articulate and give meaning to our basic human existential situations."[8] The built environment alters opinions and memories from person to person. In a way, "architectural design changes our brains and our behavior."[9] The material, shape, and light penetration become factors that change one's behavior and emotion within a space. Though, "highly abstracted and condensed experiential entity which fuses the multiplicity of human experiences into a singular lived image, or sequence of images,"[10] is what creates an individual's embodied meaning to the built environment.

[1]Ittelson, W. (1969). Visual space perception. New York: Springer.

[2]Ibid.

[3]Ibid.

[4]Ibid.

[5]Ibid.

[6]Ibid.

[7]Ibid.

[8]Pallasmaa, J. (2015). Mind in Architecture: Body, mind, and Imagination: the mental essence of architecture. Cambridge, Massachusetts: MIT Press, pp.51-71.

[9]Johnson, M. (2019). Mind in Architecture: The Embodied Meaning of Architecture. Cambridge, Massachusetts: MIT Press, pp.33-48.

[10]Pallasmaa, J. (2015). Mind in Architecture: Body, mind, and Imagination: the mental essence of architecture. Cambridge, Massachusetts: MIT Press, pp.51-71.

EMBODIED MEANING

Architecture has a way of changing thought from an unconscious state to a conscious state as one moves through a space. John Paul Eberhard believes that, "The brain controls our behavior. Genes control the blueprint for the design and structure of the brain. The environment can modulate the function of genes, and ultimately the structure of our brains. Changes in the environment change the brain, and therefore they change our behavior. Consequently, architectural design changes our brain and our behaviors."[1] Behaviors change in a constant reaction to the built environment, but constant reaction behavior is needed for survival. "Architecture is ideally located at the intersection of these two complementary aspects of our lives, insofar as the ways we organize space and buildings simultaneously our need for physical habitation and our need for meaning."[2] Architecture opens the book for a dialogue. Meaning created from memory of a place where something happened, or the shear originality of the structure on its own. Johnson states, "The meaning of any object, quality event, or action is what it points to by way of some experience. Meaning is relation and the meaning of a certain object would be the possible experiences it affords us –either now, in the past, or in the future"[3]

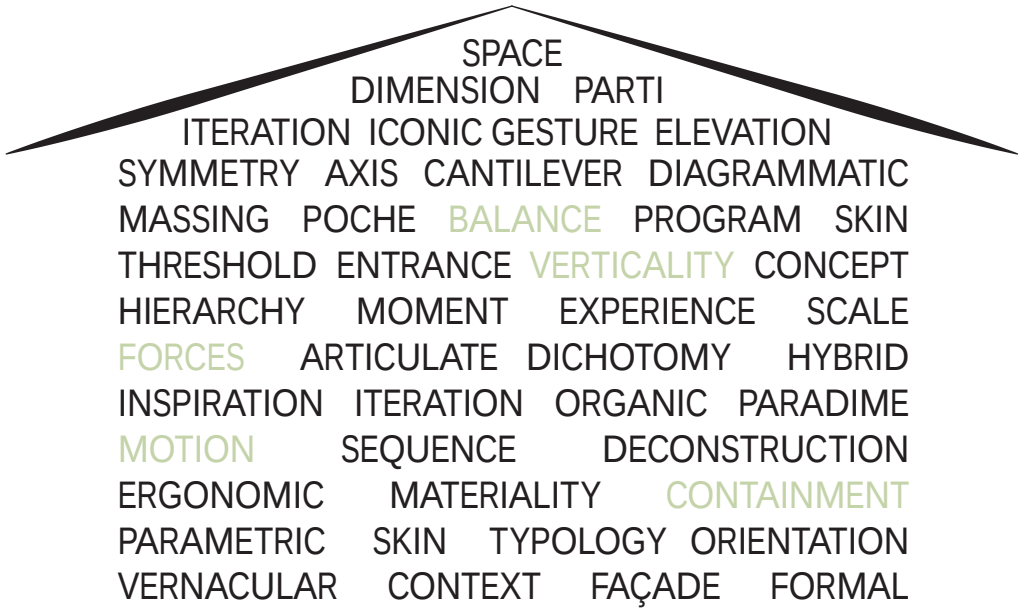

Figure 2 Johnson's Qualitative Dimensions of Experience

QUALITATIVE DIMENSIONS OF EXPERIENCE & MEANING

"Architectural structures are experienced by humans as both sense-giving and signifying. That is, that architectural structures present us first, with a way of situating ourselves in or being "at home" in, and making sense of our world, and second, they provide material and cultural affordances that are meaningful for our survival and flourishing as meaning seeking creatures."[4] Johnson's theory of qualitative dimensions is what gives tactile experiences of how one encounters architecture. He described them as image schemas. An image schema is how the body reacts

[1] Eberhard, J. (2015). Mind in Architecture: Architecture and Neuroscience: A Double Helix. Cambridge, Massachusetts: MIT Press, pp.123-136.

[2] Johnson, M. (2019). Mind in Architecture: The Embodied Meaning of Architecture. Cambridge, Massachusetts: MIT Press, pp.33-48.

[3] Ibid

[4] Ibid

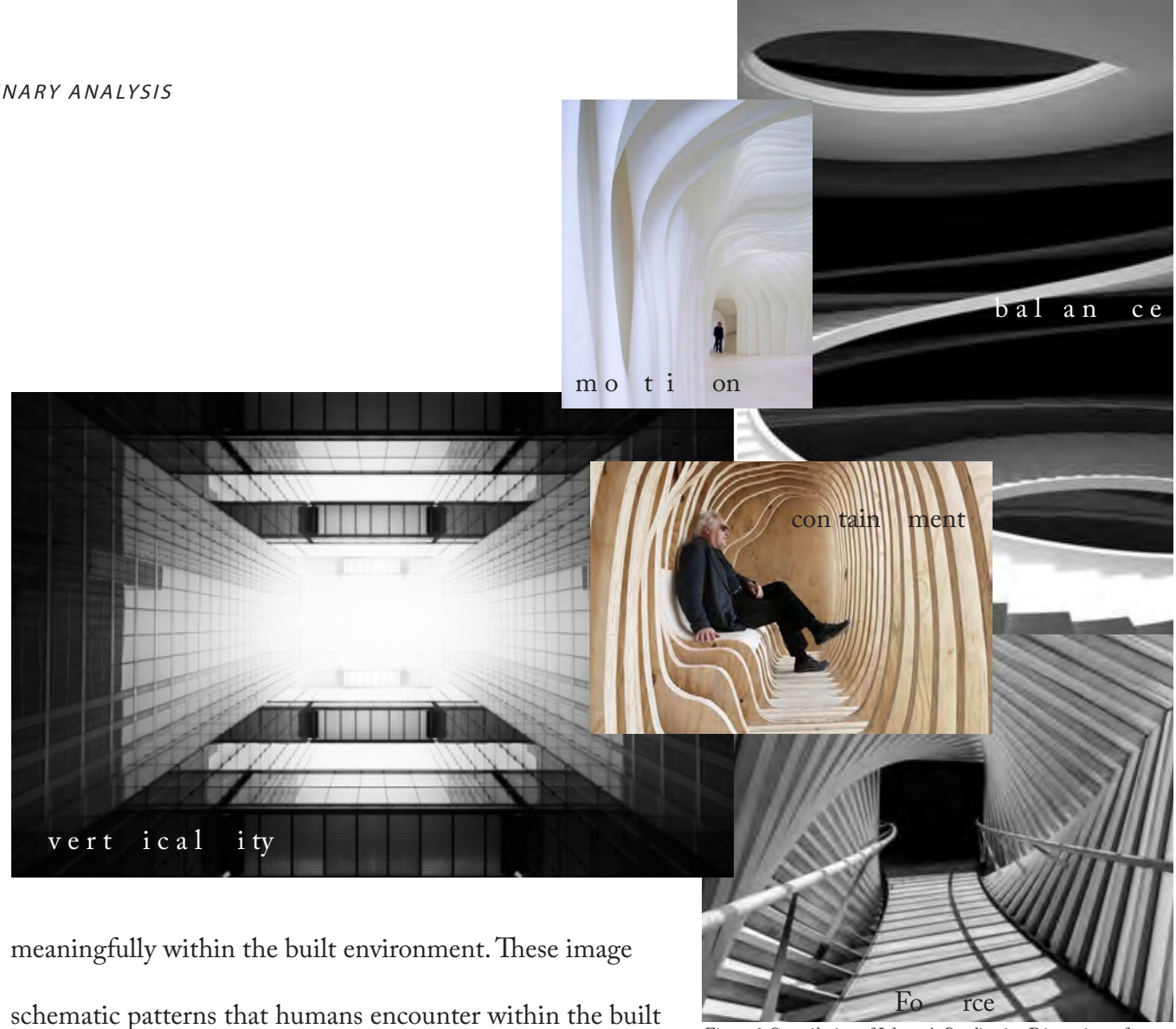

Figure 3 Compilation of Johnson's Qualitative Dimensions of Experience

meaningfully within the built environment. These image schematic patterns that humans encounter within the built environment are described as containment, verticality, balance, force, and motion.[1] These qualitative dimensions will later be used in the design and project portion of this thesis. As design qualities, these dimensions begin to create more dynamic environments than those of flat open areas. Diagramed above are the five qualitative dimensions which Johnson describes as some of the more important schemas within the realm of architecture.

QUALITY VS. QUANTITATIVE ARCHITECTURE

With the rise of technology and building performance, in some cases architects are relinquishing power and design fulfillment to the buildings performing qualities rather than its experiential or aesthetic ones. "We live in an age of metrics focused on measuring building performance with little value placed on the quality of the individual experience."[2] Building design is rigorous process between architects, stakeholders, and users. Recently in the past few years building design has taken a personal focus on aesthetics forgetting the exploration of what it takes to understand its audience.[3] However, in every case, one characteristic will always outweigh the other. Though it is the architect's job to find the common ground, the way in which these characteristics are driven is through the client. Without the immersion of client connection to the project, the architect makes decisions based off of what they think the client will need, not necessarily what they actually need. "The benefit of linking neuroscience to practice is the ability to immerse ourselves in all aspects and effects of design by taking a more holistic approach to problem solving which includes as it is a very basis a more thorough understanding of the human experience."[4]

[1]Johnson, M. (2019). Mind in Architecture: The Embodied Meaning of Architecture. Cambridge, Massachusetts: MIT Press, pp.33-48.

[2]Farling, M. (2015). Mind in Architecture: From Intuition to Immersion Architecture and Neuroscience. Cambridge, Massachusetts: MIT Press, pp.181-195.

[3]Farling, M. (2015). Mind in Architecture: From Intuition to Immersion Architecture and Neuroscience. Cambridge, Massachusetts: MIT Press, pp.181-195.

[4]Farling, M. (2015). Mind in Architecture: From Intuition to Immersion Architecture and Neuroscience. Cambridge, Massachusetts: MIT Press, pp.181-195.

USER CENTERED DESIGN

Every individual has different needs within a given structure. Sometimes those needs are met, other times they fall short. Architecture is a direct reflection of architects thought. Because of these ideas, user centered designs are being brought back into the design process as they once were. A man by the name of Yona Friedman explains that architecture stemmed from a simple interaction of user and product. This being the user developed the product. As the complexity of design continued so did the process of making and conceiving. This making the process into what we see today. The builder becomes introduced to the design process to translate the users' needs into building construction.[1]

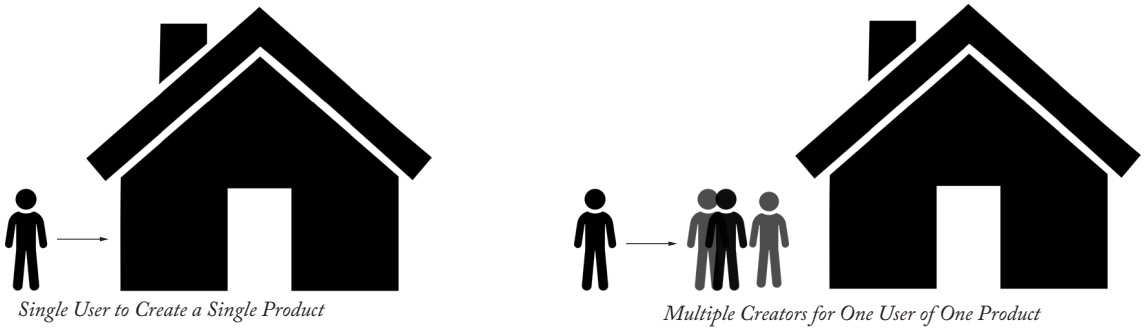

Figure 4 User vs. Product Through the Years

[1]Corem, Yaniv. "UDesign: Toward a User-Centered Architecture." 2010, 1-101.

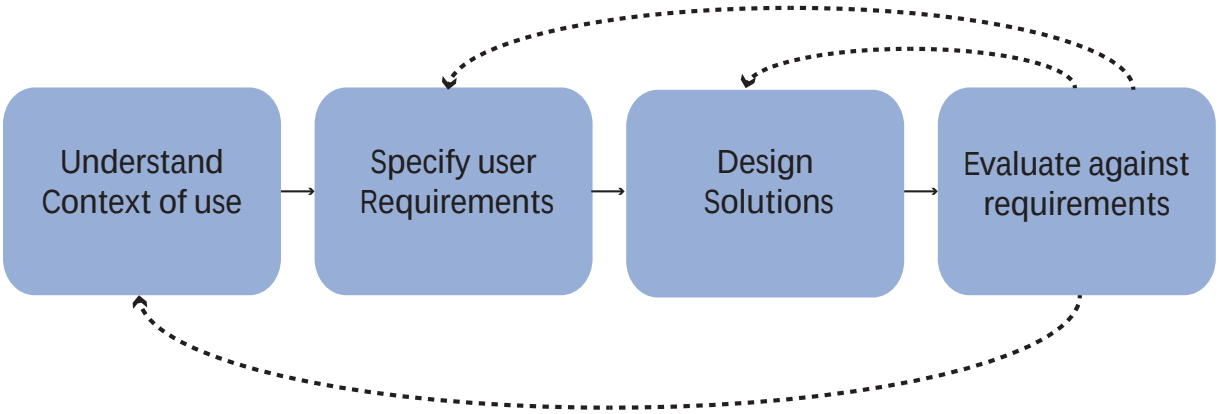

Figure 5 User Centered Design Process

Friedman claims that "architects adopted the average user approach"[1] Because of this he developed a two-loop system. The first loop still being used as all of the available design solutions. This includes preventive design solutions that may not necessarily make sense together. In the second loop Friedman begins to tailor the user group to the community, as a way of informing the how their decisions will affect them. The two-loop system can be looked at on a local level, where decisions are affecting the individual themselves and on the global level where design becomes an integration into the community as a whole.

In the normative design process all decisions are based on the average user. What happens when a building is tailored to a specific user group, but the average information is used to gauge their needs? This thesis begins to focus on tailoring design to the needs of its users. Sometimes user feedback is transmitted back through questionnaires or markups. This becomes a way of quantifying the user data. However, quantifying the design application adds new user understanding to the design process. Some ways in which the design application can be quantifiable by its user, is through a series of tests like heart rate, EEG, or eye tracking when discussing or looking at design.

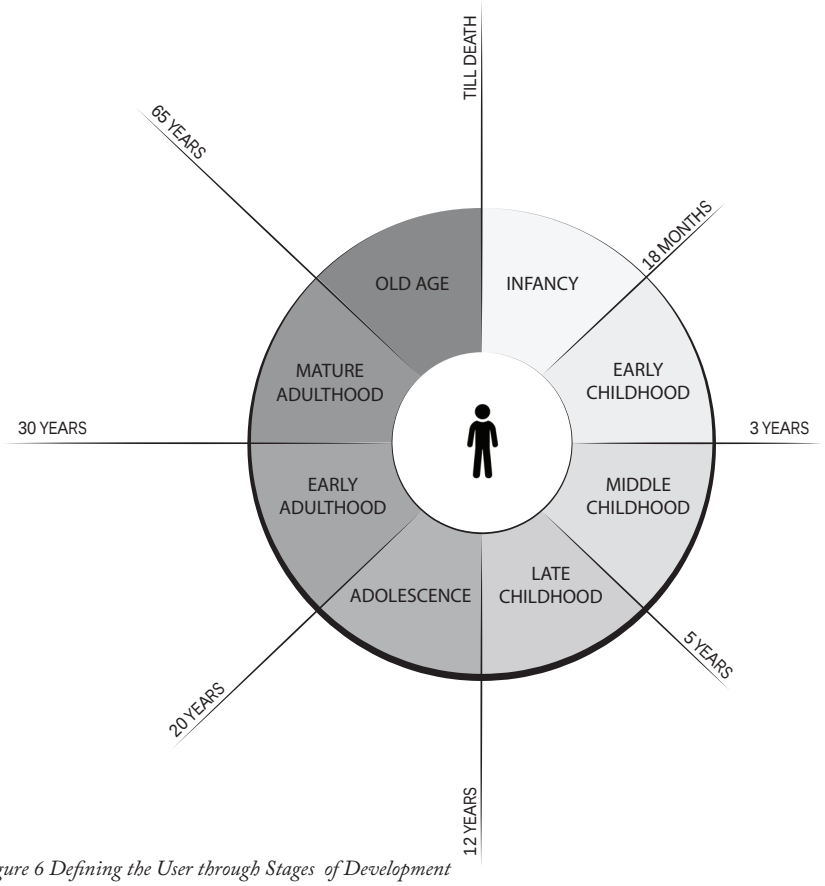

Figure 6 Defining the User through Stages of Development

[1]Corem, Yaniv. "UDesign: Toward a User-Centered Architecture." 2010, 1-101.

EYE - TRACKING

Eye tracking is a tool in which helps researchers to understand a user's visual attention. Across different fields of academia, eye tracking has become a way of interpreting user experience which may not be able to be described. The path of the user's eye and the duration of a user's gaze are a few

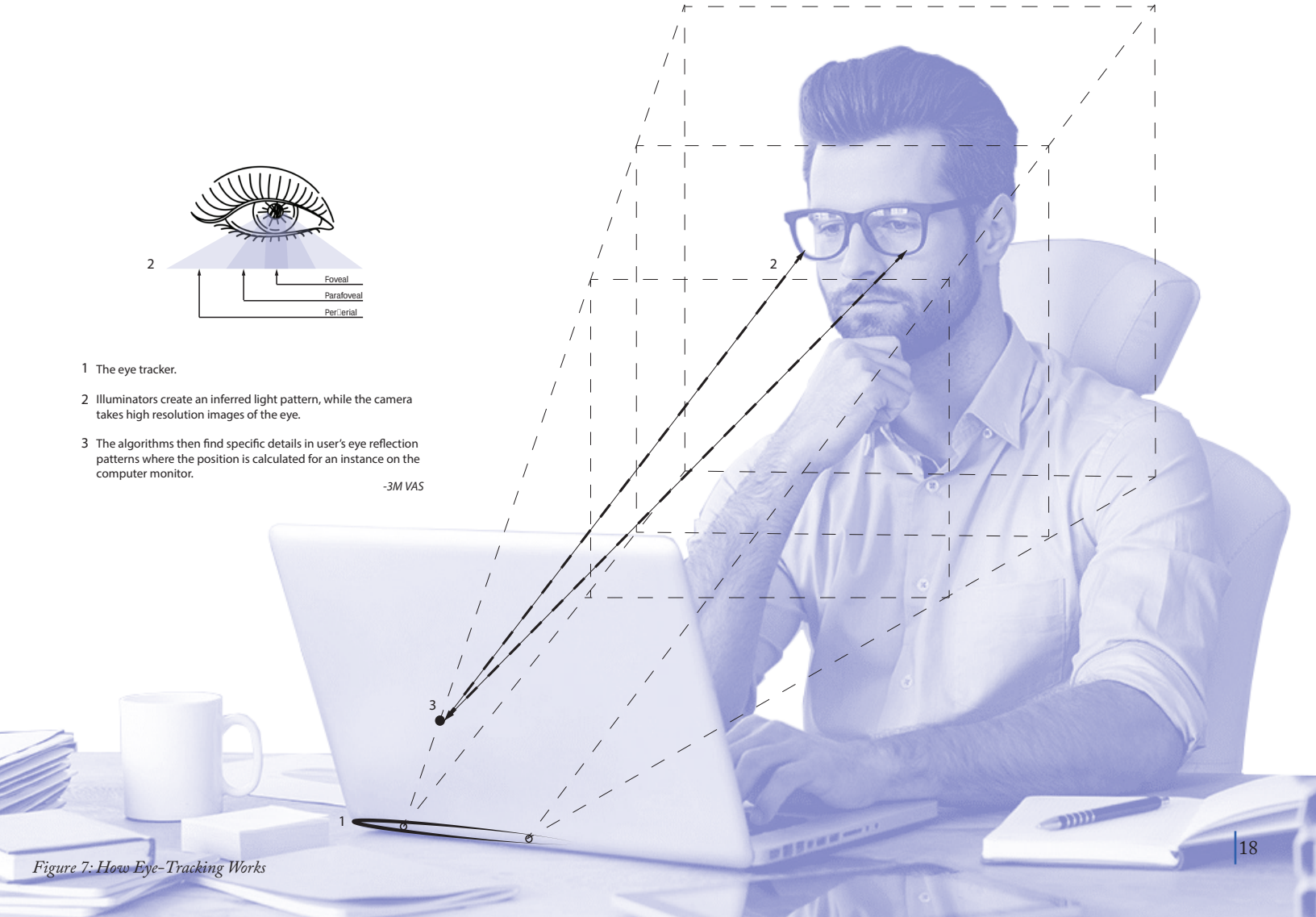

Figure 7: How Eye-Tracking Works

different ways in which eye trackers begin to quantify a given image. From the duration times and fixation points one can begin to breakdown how each participant's gaze plots and heat maps determine a user's attention of a particular image. This thesis will mainly use heat maps, gaze plots, and areas of interest to understand where the participant is focusing. There are a few different types of eye trackers in which product designers use, but for the purposes of this research a Tobii bar eye tracker will be used to conduct user fixations.

Figure 8 Original Face Image

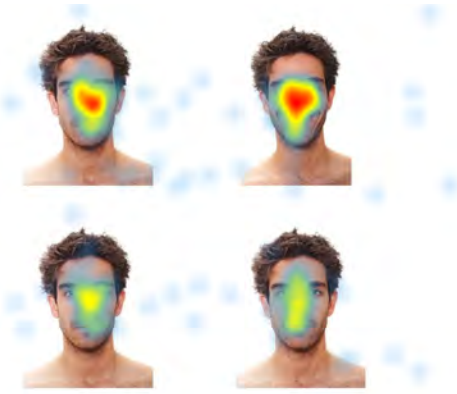

Figure 9 Heat Map

Figure 10 Gaze Plot

Figure 11 Area of Intrest

PREFORMANCE

The Tobii eye tracker consists of algorithms, illuminators, and cameras. Within the bar, the illuminators create an inferred light pattern, while the camera takes high resolution images of the eye.[1] The algorithms then find specific details in user's eye reflection patterns where the position is calculated for an instance on the computer monitor. Each participants eye will be traced over a set of images to create three different types of mapping outputs for researches to better understand user fixation. Eye trackers can only track patterns within the foveal vision.[2] The foveal vision can be seen in figure (7). This

demonstrates that the eye tracker will not pick up eye gaze patterns if the user is focused on their peripheral vision.

Once a study is complete, Tobii studio outputs three different mappings across an image to show the average or individual gaze. Shown below, are the three different types of mapping that can be used in determining participant fixation. The first is a heat map, which is a visualization tool to show the average amount of fixations and how long they fixated for.[3] The heat map is generated over the image with a red to green gradient. The red indicates the most fixations for the longest amount of time while the green shows the least fixations for the shortest amount of time. This map is a way to generalize fixation within an image. Most case studies shown later will use heat maps to value participants fixations. Another mapping tool is the gaze plot. The gaze plot is used to show exact fixation points for each participant and how long they are fixating for. Each fixation point is numbered as shown in figure(10). The line drawn from fixation point to fixation point is called a saccade. A saccade, "are rapid eye movements of the eye from one fixation to another to help the eye piece together a complete scene of what an individual looks at." [4] These gaze plots break down how each individual user sees an image. This tool becomes critical when looking at different user groups. The last output is the area of interest. Similar to the heat map, areas of interest create shapes on an image that generalize and number fixations and gaze time.[5] The area of interest is broken down into a quantifiable way rather than just visual way. Together, these mappings break down participant gaze which helps designers better understand their user group.

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[1] Bergstrom, J. and Schall, A. (2014). Eye Tracking in User Experience Design. Waltham, MA: Elsevier Inc., pp.3-11.

[2] Ibid.

[3] Ibid.

[4] Ibid.

[5] Ibid.

Figure 12 Close up View of Gaze Plot

CONSCIOUS VS. SUBCONSCIOUS

All five Senses help to convey embodied placement within the world, but sight seems to be the strongest in our perception. Goldhagen places an emphasis on how sight invokes the power of placement of human to structures, and how those spatial relationships develop reactions within those environments. The brain is in a state of constant reaction to place and its dynamic surroundings in a non-conscious ability. Goldhagen explains that "Cognition is a product of a three-way collaboration of mind, body, and environment."[1] Ann Sussman references Sigmund Frued's quote, "The mind is like and ice berg, it floats with

one – seventh of its bulk under water."[2] She describes this cognitive processing as the thigmotaxic, a stimulus that influences how we work without consciously thinking about, that governs our behavior from unseen depths. This stimuli at a constant, measures the environment in which is navigated through, negating data that seizes to capture visual attention. Designers seek to pull visual elements that are within our subconscious to consciousness. Visual attention can be recognized by a biological mechanical system in which the brain negates certain data within the visual environment.[3]

VISUAL ATTENTION

Before the development of Tobii researchers used a software called 3M VAS, or Visual attention software. This software is a simulated eye tracking system which predicts what people would see in the first 3-5 seconds of looking at an image. Their experts claim eye tracking creates five visual elements which trigger conscious viewing. 3M describes these triggers as "building blocks of visual attention."[4] Within those first few seconds of understanding an image it is thought to be unconscious thought or behavior. 3M describes these elements as a way of activating conscious viewing. These elements will be outlined below as edges, face, red/ green contrast, blue/ yellow contrast, and intensity.

[1]Goldhagen, S. (2017). Welcome to Your World: How the Built Environment Shapes our Lives. New York, New York: HarperCollins Publishers, p.47.

[2]Sussman, A. and Hollander, J. (2015). Cognitive Architecture: Designing for How we Respond to the Built Environment. New York, New York: Taylor and Francis Group.

[3]3m.com. (2019). Visual Attention Software | 3M United States. [online] Available at: https://www.3m.com/3M/en_US/visual-attention-software-us/ [Accessed 2 Feb. 2019].

[4]Ibid.

EDGES

An example of edge is the way that floor meets a wall or the wall meets a ceiling. Edges work to define the shape that is encapsulating the human body in the built environment. Edges can be identified by the changes in material or a break in pattern. "The thigmotaxic defines the boarders of space and visual scanning reframes it."[1] This means, that in terms of navigation one often sticks to the edges or boundary of a space. By understanding this, designers and architects can plan for this behavior when space planning. With that in mind, it can be understood that "shapes carry weight,"[2] However it is also necessary to note the "innate preference for shape humans also have a clear bias for curves over straight or sharp lines."[3] The results of a 24-participant study looking at over 200 architectural images interject that, "The well-established effect of contour on aesthetic preference can be extended to architecture. Furthermore, the combination of our behavioral and neutral evidence underscores the role of emotion in our preference for curvilinear objects in this domain."[4]

Figure 13 Pacific Design Center

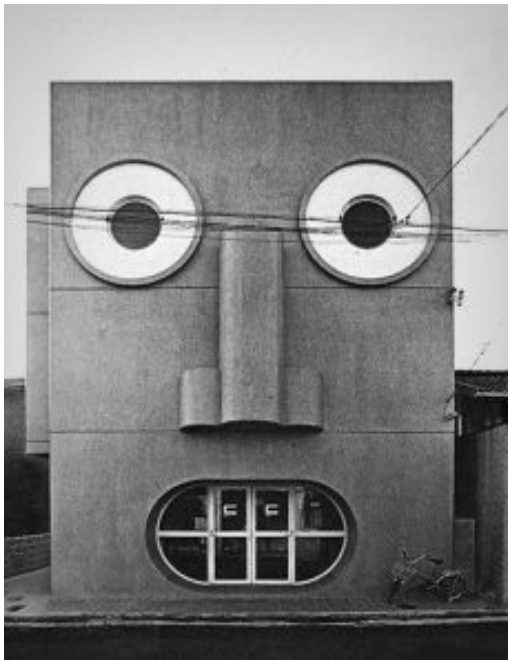

Figure 14 Face House in Kyoto

FACE

Physiologically, humans are programed to notice other humans within a distance of them. Back to hunter gatherer roots, recognizing the face was yet again another survival technique. Because of this, "the human brain devotes more area to face recognition than to recognize any other visual object."[5] Using this programing, humans try to configure and recognize faces within inanimate objects. Kandel calls this the "figural primitive, describes it as an oval right side up, with two points for the eyes a vertical line for the nose, and a horizontal line below for the mouth."[6] When looking at a building or driving down the road the figural primitive is used at constant, within a nonconscious state. "Faces in contrast to non faces can be perceived non-consciously and without attention, these findings support our hypothesis that the perception of faces or face like patterns may be more critical than previously thought for how humans perceive the aesthetics of the environment and the architecture of house facades of the buildings they are surrounded by in their day to day lives."[7] This can be recognized as "face-a-tecture" where the sub conscious tends to resemble faces within a structure.

[1]Sussman, A. and Hollander, J. (2015). Cognitive Architecture: Designing for How we Respond to the Built Environment. New York, New York: Taylor and Francis Group.

[2]Ibid.

[3]Ibid.

[4]Ibid.

[5]Vartanian, Oshin, Navarrete, Charrerjee, Fitch, Leder, Modrono, Nadal, Rostrup and Skov. (2013). Impact of Contour on Aesthetic Judgments and approach-avoidence decisions in architecture. Proceedings of the National Academy of Sciences, p.110.

[6]Sussman, A. and Hollander, J. (2015). Cognitive Architecture

[7]Kandel, E. (2012). The Age of Insight: The Quest to Understand the Unconscious in Art, Mind and Brain from Vienna 1990-Present. New York: Random House.

Chalup, Steven K., Hong and Ostwald (2010). Simulating Pareidolia of Faces for Architecture Image Analysis.

RED / GREEN CONTRAST

Based off of the RGB primary system and developed by Wright and Guild in a color matching experiment in 1931, RGB was vectored into a color synthesis.[1] Each color was presented in a directorial space. Because of this we have the color association of red / green and blue / yellow, shown in the figure (17) as the chromatic coordinates. It is important to note that red / green and blue / yellow contrast are stimulants in conscious viewing, however this thesis will not go into great detail as to the explanation of these chromaticity coordinates. The cells within our biological system fire faster when we see the color red, and in contrast fire slower when we see something green.[2] This goes back to physiological processes as hunter gatherers, looking for food. The contrast between these two colors have been programed through evolution as a tool for survival. Though we do not need these survival tools today, we are still programed to be visually attracted to these specific color contrasts.

Figure 15 Red / Green Contrast

Figure 16 Blue / Yellow Contrast

BLUE / YELLOW CONTRAST

Similar to red / green, blue / yellow has a high hue contrast in which colors are able to be distinctly separated

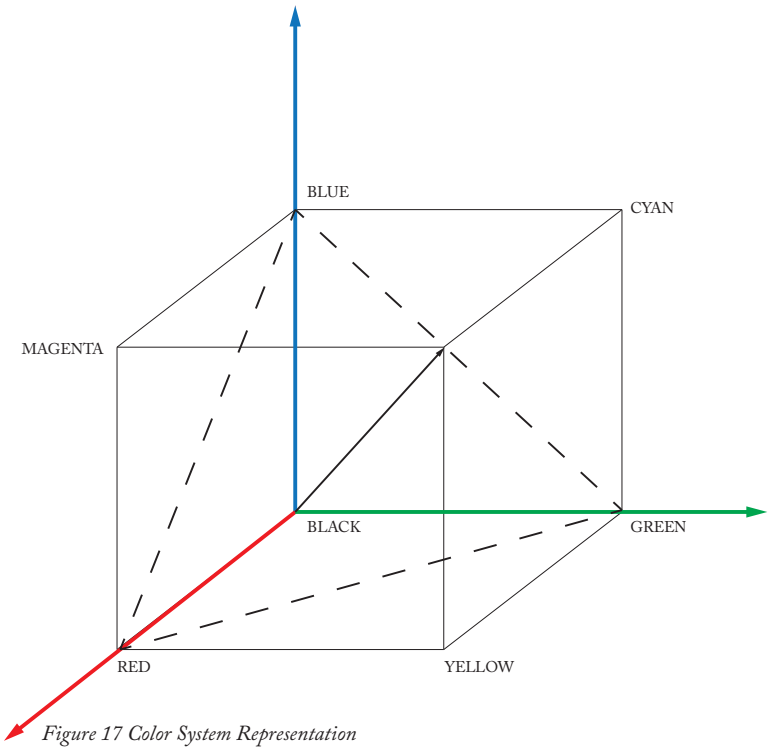

Figure 17 Color System Representation

from each other as shown in the diagram above. Blue / yellow become opposites within the RGB primary system, giving it high contrast between the two colors. [3] Though not as prominent as red / green, blue / yellow is often times used when associated with signage near water, as yellow is mainly used as a cautionary sign. Against the sky or water, the yellow contrast is brought out more by the blue backgrounds.

INTENSITY

Contrast as shown earlier becomes a way in which one consciously gives visual attention to an object or one's surroundings. When that contrast intensifies with light or hue, this also becomes an element of conscious viewing.[4] How quickly something changes from light to dark, or from bright to dim, are qualities that help to change and redirect one's visual attention. This change within the color can be identified as intensity.

[1] Shahrbano, Talebzadeh, and Shahrbabaki (2015). Contribution of Color in guiding Visual Attention and in a Computational Model of Visual Saliency. Universite Grenoble Alpes.

[2] Ibid.

[3] Ibid.

[4] 3m.com. (2019). Visual Attention Software | 3M United States. [online] Available at: https://www.3m.com/3M/en_US/visual-attention-software-us/ [Accessed 2 Feb. 2019].

UTILIZATION

First used in product technologies and website design, eye tracking has become an innovative way for designers to gain product feedback. Not just about where users were looking but why they were focusing on that specific point. Demographics of users have become an important role in eye tracking studies. All people see in a different way however, these qualitative mappings indicate that, some users began to make similar notions when analyzing the data. In some given layouts or design, users of all demographics would react in the same way. This is usually dependent on how much information is being processed within an image. These case studies begin to show how users of different demographics begin to make perspective correlations between the images and how eye tracking becomes a way for designers to receive qualitative feedback.[1]

Figure 18 Comparison of Adult Eye vs. Child Eye Gaze of Cluttered Web Page

Within the above and below images, Adult Gaze patterns are located to the left while the Child Gaze patterns are located to the right.

Figure 19 Comparison of Adult Eye vs. Child Eye Gaze of Uncluttered Web Page

Figure 20 Camparison of an Architect vs. Non architect Gaze.

CASE STUDY

ADULT VS. CHILDREN

Attention is reflected in eye tracking studies. In the case of adults vs. children's eye tracking study of a website design, researchers found that fixation times were less and

more sporadic in children.[2] The children's gazes covered the website more than the adults, however, both groups had similar fixation points. The difference being that the adult fixations were for a longer period of time. Depending on the website design however, fixation points and times became even more similar with a reduced or simplistic design. For example, the Apple website home page has almost identical fixation mappings because of the simplistic nature of the site design. Rather than the images above, which have more complicated web design. Because the hierarchy is harder to distinguish, gaze patterns are fixated all over the page.

ARCHITECT VS. NON ARCHITECT

Another case study used eye tracking as a way to understand the impacts of an architect's perspective vs. a non-architect's perspective. From the images, one can see the gaze pattern of the architect was much more centralized and focused on one object within the image. Whereas the non-architects gaze covered the entire image in the same amount of time. From this study it is understood, that an architect does see a space differently, than a non-architect. The architect also tended to follow the lines that created the space in a much more strategic pattern than that the non-architect would.[3] However, in both of these images contained people. As stated earlier, people tend to capture one's visual attention, as demonstrated in these figures within these images. The participant either began focusing on the person and then redirected their visual attention or their attention lingered for a small time then came back to the figure.

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[1] Lee, S., Cinn, E., Yan, J. and Jung, J. (2015). USING AN EYE TRACKER TO STUDY THREE- DIMENSIONAL ENVIRONMENTAL AESTHETICS: THE IMPACT OF ARCHITECTURAL ELEMENTS AND EDUCATIONAL TRAINING ON VIEWERS' VISUAL ATTENTION. Journal of Architectural and Planning Research, p.24.

[2] Bergstrom, J. and Schall, A. (2014). Eye Tracking in User Experience Design. Waltham, MA: Elsevier Inc., pp.31.

[3] Lee, S., Cinn, E., Yan, J. and Jung, J. (2015). USING AN EYE TRACKER TO STUDY THREE- DIMENSIONAL ENVIRONMENTAL AESTHETICS: THE IMPACT OF ARCHITECTURAL ELEMENTS AND EDUCATIONAL TRAINING ON VIEWERS' VISUAL ATTENTION. Journal of Architectural and Planning Research, p.24.

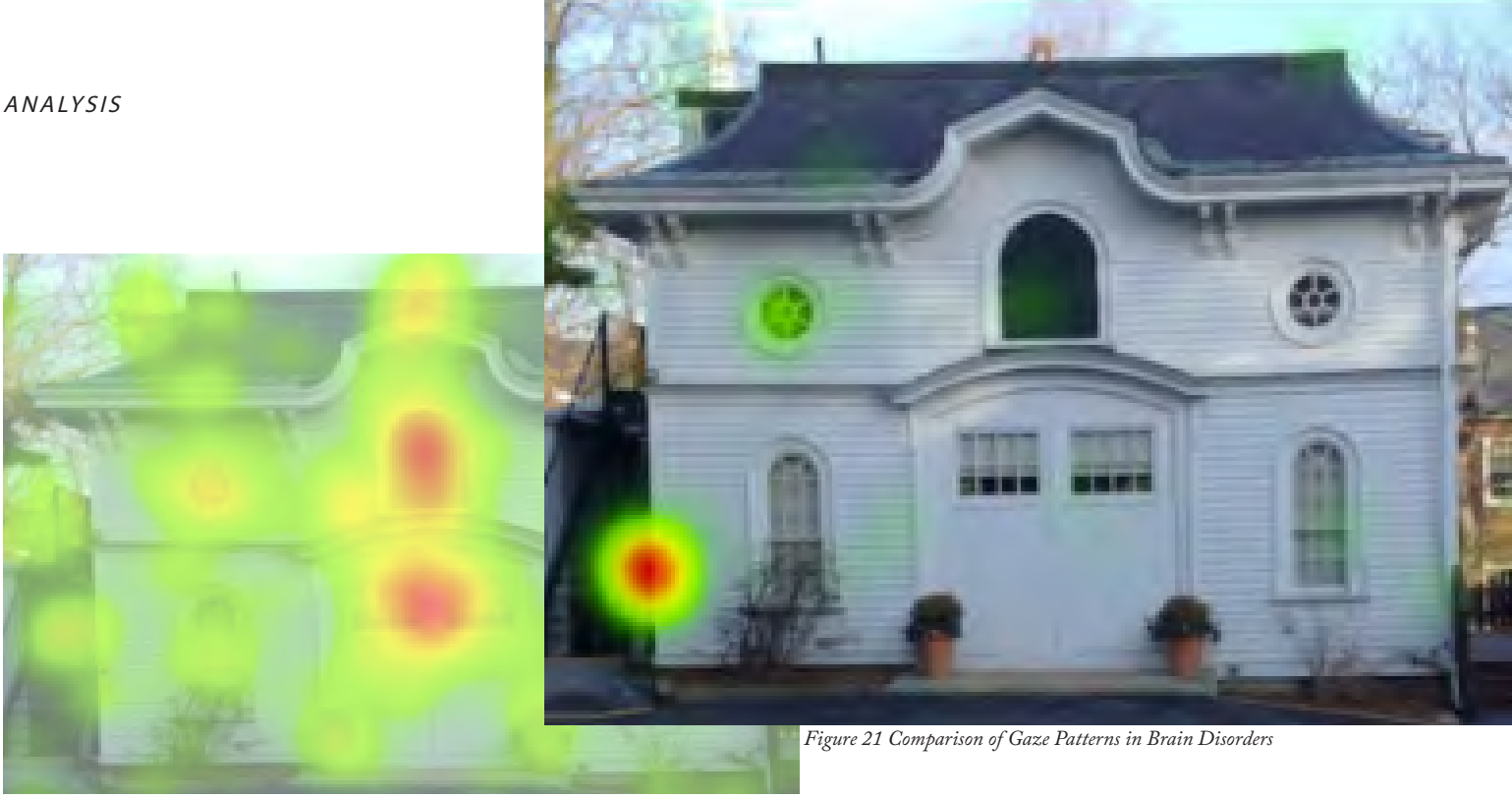


Figure 21 Comparison of Gaze Patterns in Brain Disorders

BRAIN DISORDERS

People with certain brain disorders respond to building details differently. "Cognitive scientists are fond of saying "fixations drive exploration" and this statement is true whether our brains are directing our eye to look at ads or architecture; what our brains get us to look at (or fixate on) unconsciously is what we'll focus on consciously; with biometrics we can "see" for the time in history how people with brain disorders like autism and PTSD don't fixate or take in reality in a normative way. We can only conclude, therefore, that architects with these disorders couldn't be called upon to provide the template for the buildings people need to see, to feel, and be at their best."[1] The images above show the difference of how people with a brain disorder react to the same image as those that do not.

HOW WE SEE ARCHITECTURE

The last case study was how one sees architecture. After studying many different facades, Ann Sussman found some key user behaviors within architectural design. One of the biggest points she makes is that people ignore blank facades.[2] She uses two images showing the front of a building one with windows and the other with them removed. With this, she found that people mainly fixated on the door. The only other fixation points within the image where the materials changed within the façade. People did not look at the blank white wall. Another point that Sussman argues is that "fixations drive exploration."[3] She describes this as the "key for understanding how our unconscious eye movements direct our conscious behavior."[4] This is "because unconscious fixations in turn direct conscious activity and behavior."[5]

Figure 22 Heat Map Window Comparison

[1] Sussman, Ann and Katie Chen. "The Mental Disorders That Gave Us Modern Architecture." Common Edge. Accessed December 03, 2018. http://commonedge.org/the-mental-disorders-that-gave-us-modern-architecture/.

[2] Ann Sussman, J. (2019). How Biometrics Can Help Designers Build Better Places for People. [online] Common Edge. Available at: http://commonedge.org/how-biometrics-can-help-designers-build-better-places-for-people/ [Accessed 5 Feb. 2019].

[3] Ibid.

[4] Ibid.

[5] Ibid.

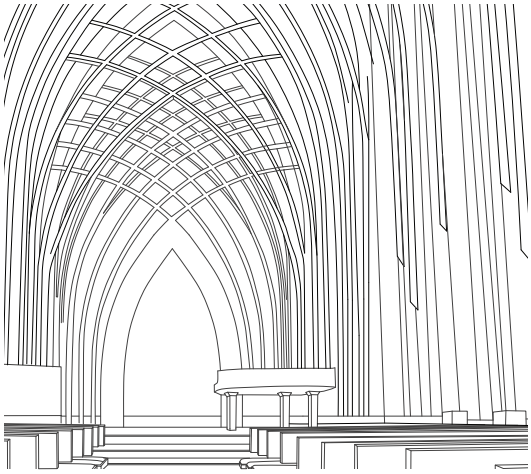
ELEMENTS OF SUBCONCIOUS REPONSES TO THE BUILT ENVIRONMENT

Visual attention is most cognizant within an individual when looking at the five elements of conscious viewing as discussed earlier; red / green contrast, blue / yellow contrast, face, edge, and intensity.[1] These elements not only help to make up for conscious viewing. Until this point, certain architectural environments could only be claimed to have an emotional effect based on one's perception. Now these elements along with the different claims of the architectural environment can actually be measured through eye tracking software. This section will look at physical characteristics within the built environment which create visual attention but have never been tested. In the following section, a study has been created by the author and will be shown how people respond to these principals within the unbuilt environment. Our connection to the outside becomes a part of our evolutionary past. These principals below depict why our subconscious tendencies help to guide responses within the built environment.

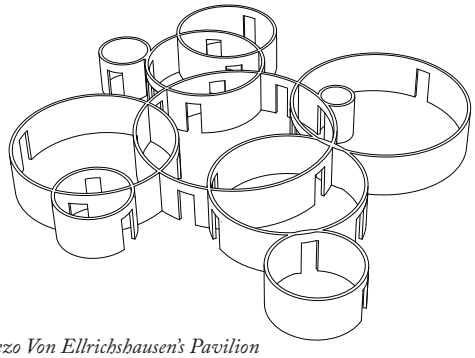
[1] 3m.com. (2019). Visual Attention Software | 3M United States. [online] Available at: https://www.3m.com/3M/en_US/visual-attention-software-us/ [Accessed 2 Feb. 2019].

BIOPHILIA

Unlike the following principals, this is the only one to focus within a context rather than being a specific object. Ann Sussman makes the point, that within the built environment we never really leave our evolutionary past behind. This helps to promote our dependence and connections to nature. In the modern world with so much built structure it becomes easy to lose a connection to the outside. Wilson describes the ideal image of place which has been derived from our ancestry, which includes vast terrain with scattered trees, near open bodies of water, and to be at a height looking down.[1] They physical built environment has taken on some of these traits with building location and building heights, but the strength of that connection becomes poor because of all the other contextual buildings usually surrounding it.



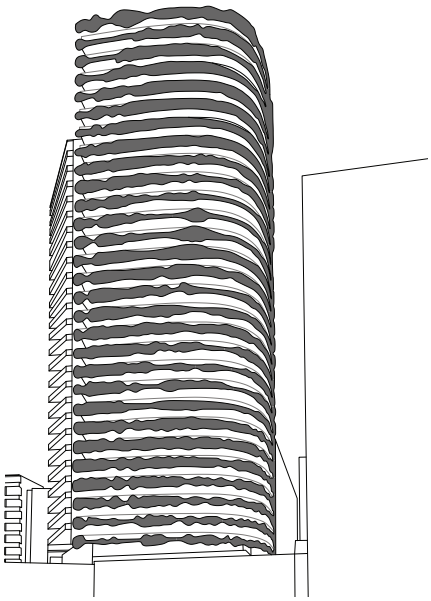
Mildred B. Cooper Memorial Chapel
Figure 23 Biophilia Example



Pezo Von Ellrichshausen's Pavilion
Figure 24 Thigmotaxis Example

THIGMOTAXIS

"People gravitate naturally towards the edge of public spaces. They do not linger out in the open."[2] This not just a theory, rather an integral part of our evolutionary past. A behavioral trait that plays a role in human navigation. One function of the thingmotaxis trait,



The Melbourne Building
Figure 25 Pareidolia Example

help a person sense escape routes and boarders of space, while also gathering necessary data to locate one's place in time. "Thigmotaxis defines the boarders of space and while visual scanning reframes it."[3] Because of this trait it is inevitable that as a part of human nature we are prone to linger towards an edge. This trait's functions to help understand within an eye tracking study why our gaze is thought to attract to edge conditions. Though there will not be a specific study related to this idea in this thesis, it is important to understand why a person is attracted to edge conditions.

PAREIDOLIA

As talked about earlier in the ideas of face within the eye tracking section, the body has five senses, but not all five parts are created equal. Vision is what the brain prioritizes as the most important as we are creatures of the visual world. Now understanding that people are always attracted to other people, as apart of human nature, that principal does not change when the face becomes a part of the built environment, or pareidolia.[4] This refers to how a person can make effortless illusions of face from within random objects. As spoken earlier within the built environment, one may refer to this as face-a-tecture that this tendency ends up playing a more significant role within the design of a structure than one may generalize. "These visual inputs likely contribute to making places appealing to people."[5] The research study to follow will show how people's visual attentiveness to faces as physical persons as well as pareidolia, or the association of random objects to face.

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[1] Sussman, Ann, and Justin B. Hollander. Cognitive Architecture Designing for How We Respond to the Built Environment. New York, New York: Routledge, 2015.

[2] Ibid.

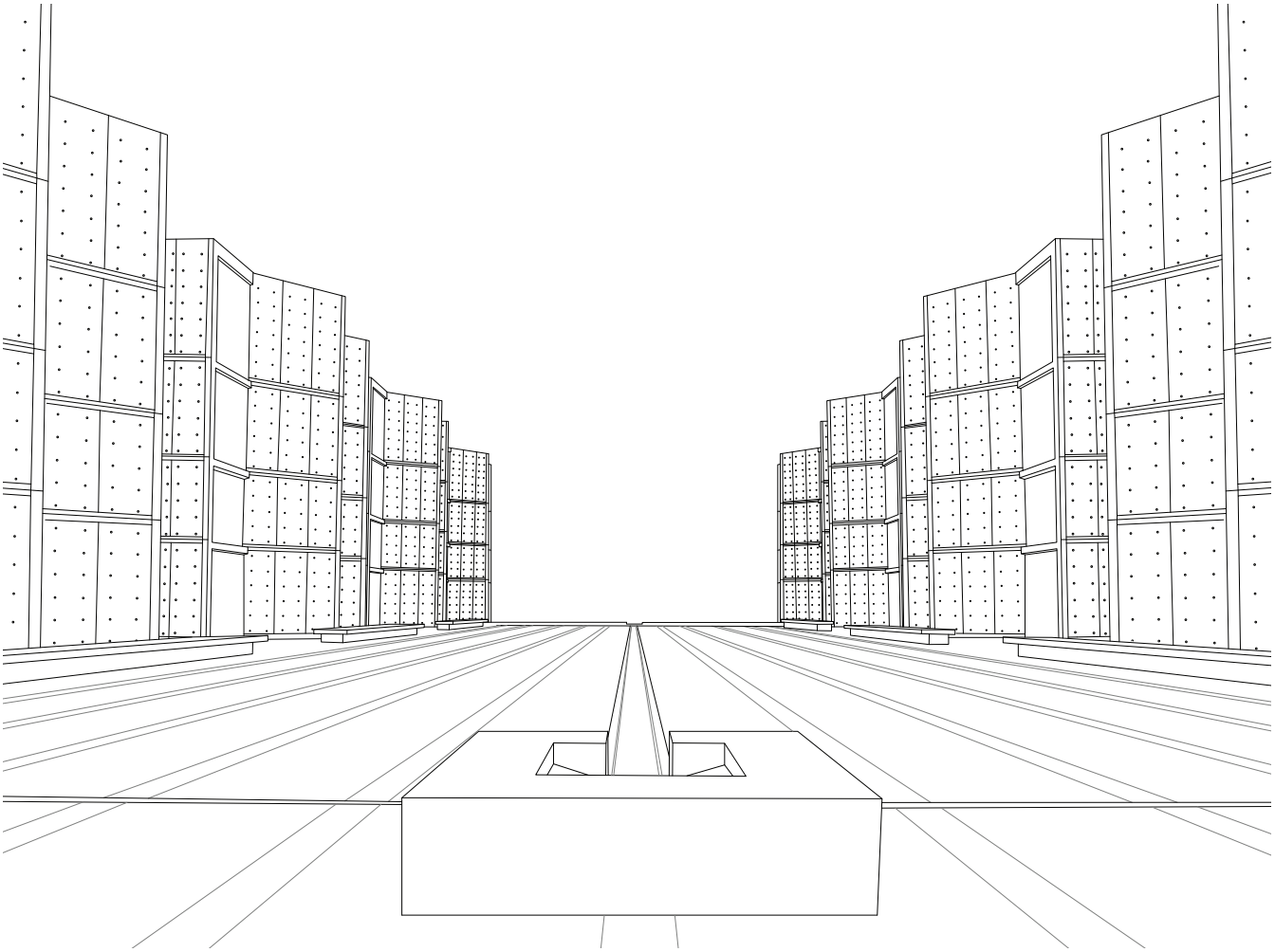
[3] Ibid.

[4] Ibid.

[5] Ibid.

BILATERAL SYMMETRY

Not only do faces carry strong visual attention, but so can different shapes. We have evolved to give preference of one object over another depending on size and shape within a few milliseconds. "In those brief moments our brain can subconsciously determine whether or not to flee or step forward well before our conscious mind gets into the act."[1] The power of bilateral symmetry evolved from the proportions of the human body to nature and the built environment. Across the built environment, symmetric plans and facades were often used to evoke power and wealth depending on scale. Today bilateral symmetry is so common, that it is "predicable, tedious, and something to avoid."[2] In a recent study psychologist have tested behavioral studies by adding symmetrical elements to faces and objects to see if their appeal was enhanced. The study reported that people consistently reported favoring the symmetrical images over asymmetric.[3] Knowing that humans continuously favor symmetrical environments, this research study will show how people react differently to symmetric and asymmetric environments.



Salk Institue
Figure 26 Bilateral Symmetry Example

CURVILINEAR

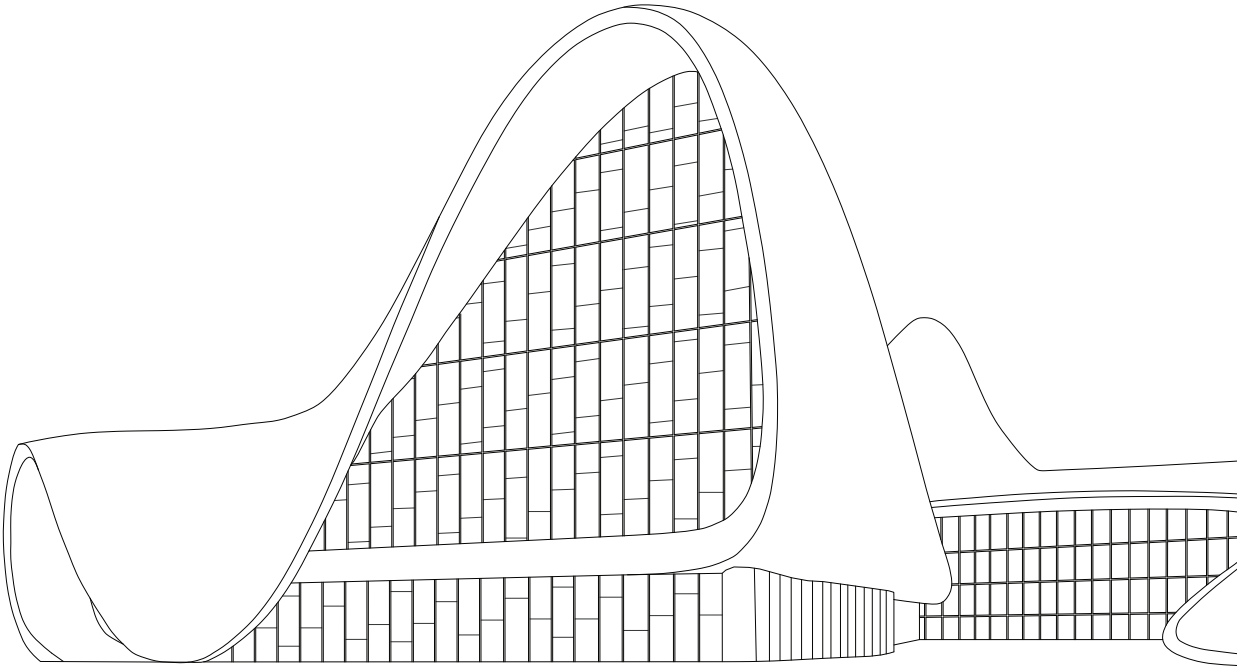
As a part of our innate preference for shapes, curves take a clear bias over sharp or straight lines. Studies have found that curves within two- and three-dimensional objects evoke feelings of happiness and elation, while sharp forms connected to emotions of pain and sadness.[4] This principal can be transferred within the realm of architecture. As a part of the evolutionary past, humans would scan their environment quickly looking for sharp and pointed objects as threats. Though this does not exist as a part of our everyday, it is something that we are still

[1] Sussman, Ann, and Justin B. Hollander. Cognitive Architecture Designing for How We Respond to the Built Environment. New York, New York: Routledge, 2015.

[2] Ibid.

[3] Ibid.

[4] Ibid.

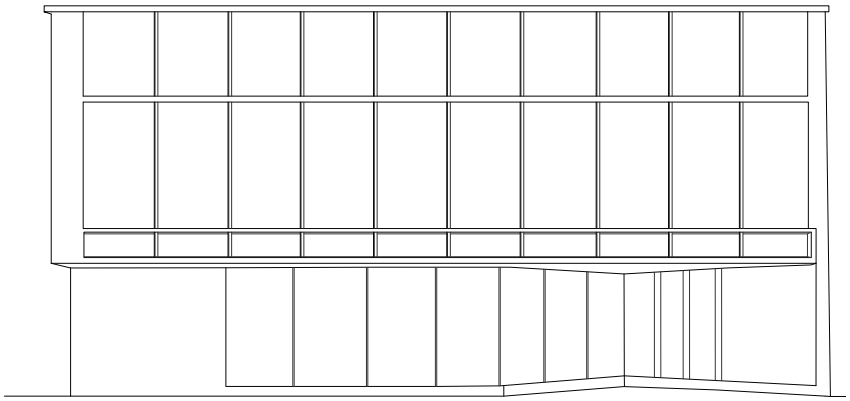


Heudar Aliyey Centre
Figure 27 Curvilinear Example

intently designing towards. "We are innately drawn to settings whose characteristics hold some survival advantage that may no longer have any practical value for us."[1] Within this study it will be shown later how a person visually attends to an object that is curved vs. one that is angular. Knowing that curves are favored within the ideas of shape moving forward this project will reflect these ideas through design.

BLANK FACADE

As mentioned earlier in the section How We See Architecture, one study concluded that people ignore blank facades and why. If it is known that a blank façade will be ignored, but how can this be used to an advantage within design? The façade gauges one's initial reaction to the structure. Blank facades become what we could call a repetitive pattern. When this repetitive nature happens within any object it can be quickly understood. Similarly, how a sharp edge could be quickly scanned and seen happens in the same manner to blank facades, rather the facades are just ignored.[2] They are subconsciously understood and not given attention because it is something that has not been around long enough for us to evolutionarily adapted to it.[3] In the earlier ages, places that were as large as a tall building today were never in danger of hurting us. Therefore, as a part of the human species today these tall structures repetitive structures can be ignored. As a principal for understanding how the eye tracking would react to a proposed design, this research study will show people's visual attention towards facades that are blank vs one that is design driven by fenestrations.



Ann Sussman & Janice Ward Case Study
Figure 28 Blank Facade Example

[1] Sussman, Ann, and Justin B. Hollander. Cognitive Architecture Designing for How We Respond to the Built Environment. New York, New York: Routledge, 2015.

[2] Sussman, Ann and Katie Chen. "The Mental Disorders That Gave Us Modern Architecture." Common Edge. Accessed December 03, 2018. http://commonedge.org/the-mental-disorders-that-gave-us-modern-architecture/.

[3] Ibid.

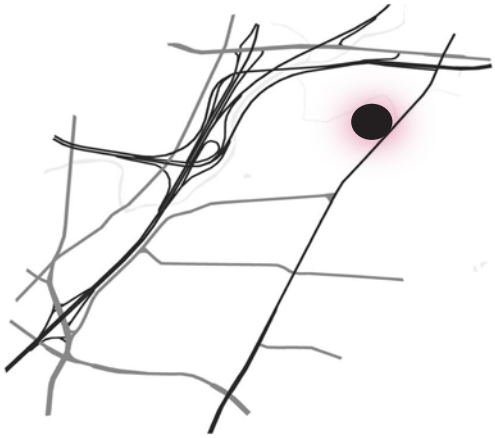
CHILDREN'S LIBRARY AND LEARNING CENTER

The design process behind this thesis could be applied to any project with any given user group, however it was deemed appropriate to use Cincinnati as a viable choice to test subjects from the area. This project opted to use children as a user group because their visual capacities change as they age. Until the age of about two years old children's depth perception is not fully developed so objects are seen as flat. It's not until they are older that depth comes into play in how they see the built environment.

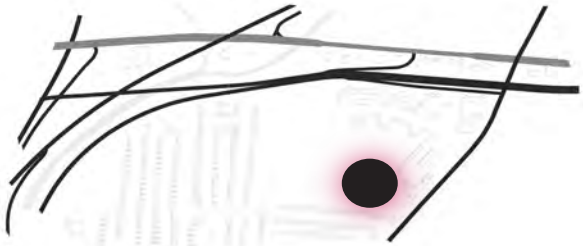
Figure 29 Aerial photo of the Site

Figure 30 Aerial photo of the Site

CINCINNATI



ROSELAWN



READING ROAD

Figure 31 Maps indicating site withinn Cincinnati

THE SITE

Looking into school locations and public facilities created just for children as a starting point, research pointed to a large varying population of education levels. One of the worst school records for standardization testing of children within the elementary school system was in Roselawn. As show in the map to the right of the testing records across all of Cincinnati, the light pink indicating the worst. It was also noted that the area didn't have a public library near most of the housing. The site of this project was derived from these testing levels and where elementary education could be improved. To do this, the project would create a children's library and learning center. This gives children

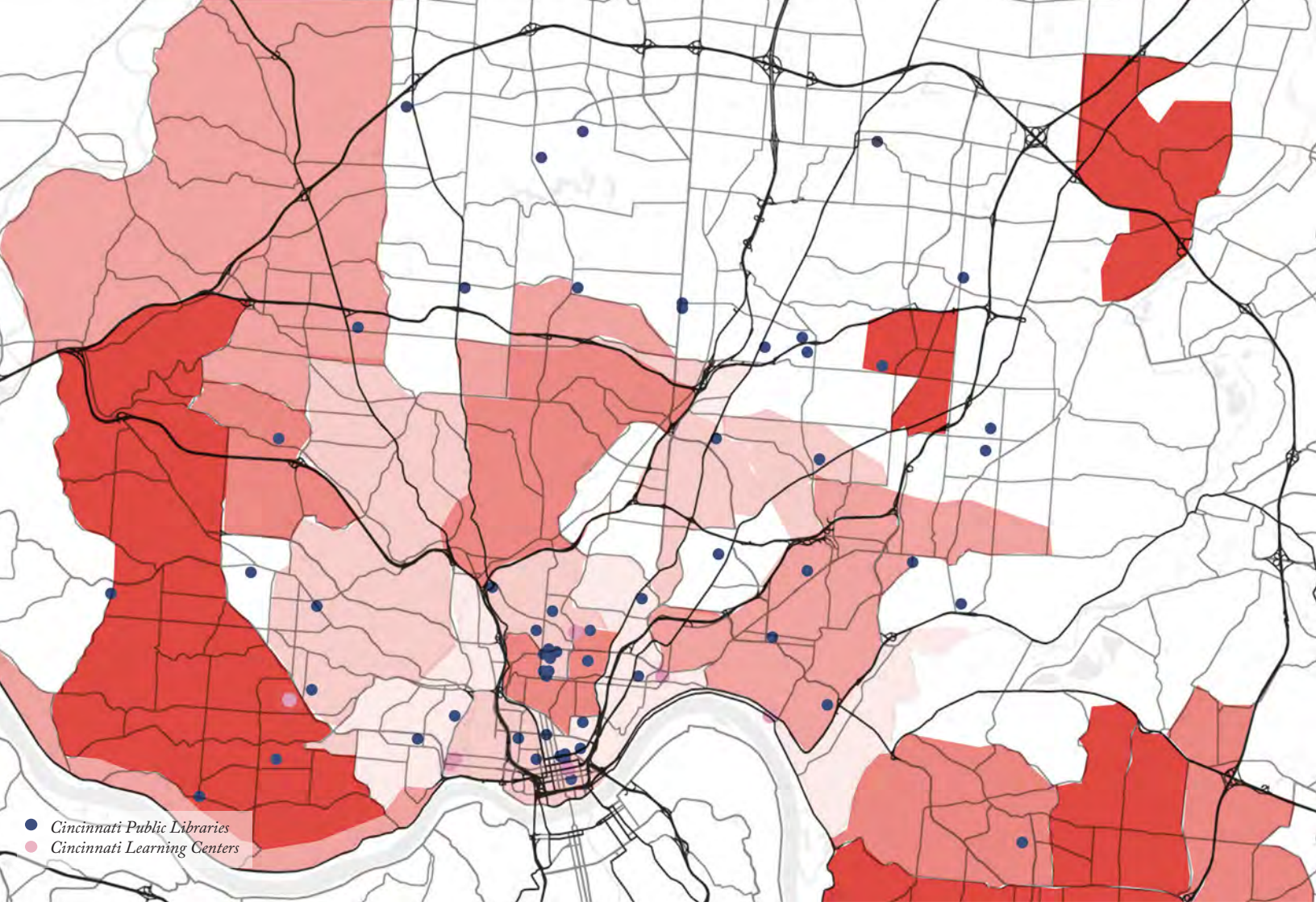


Figure 32 Map of Elementry School Testing and Cincinnati Public Libraries

and their parents the opportunity for help closer to home. The site is in a central location within Roselawn, with a large enough area for possible expansion if project deemed successful. This site also created safe play environments to the surrounding neighborhoods.

THE STUDY

As a part of this thesis, A study was created to compare and contrast two different user groups in how they react to a design proposal. First using design students, a study was conducted to gauge their reactions to a series of rendered images showing the design of this project. During the test, participants will be given two different images of the same nature to compare and contrast what types of elements they are visually attracted to. Thinking of the elements of unconscious viewing these images were created to test how they worked within a given structure. During the study there were no questions asked, each individual looked at the same set of images for 2.5 seconds per image. It is in the first two seconds our brains unconsciously react to their surroundings, and the study wanted to do its best to articulate just that.

KEY PLACE

These images have only so far been derived by designers. But they begin to inform design decisions that may not necessarily have been deliberate, but still came through during the study. In the first set of images of the exterior of the building, the design intent was to find what

Figure 33 Exterior Blank Facade

Figure 34 Exterior Finned Facade

be called the "key place." Often buildings designed for children use ideas such as a key place to have some place for the child as a place of destination. It starts to question how do I get up there? These images have a key place located in the center of the building. In both images, eyes were drawn to the key place, but one image participant lingered much longer on one key place rather than the other. This is because in one of the images the key place is centered in between two blank facades. As stated earlier, people tend to ignore blank facades, this statement can be proven true by this study. Participants' gazes traced all over the fins of the façade of the other structure, and never really came back to being centered on the key place. From this study it can be learned that designing a key place near a blank façade will draw attention to that key place more than near a façade with many visual elements.

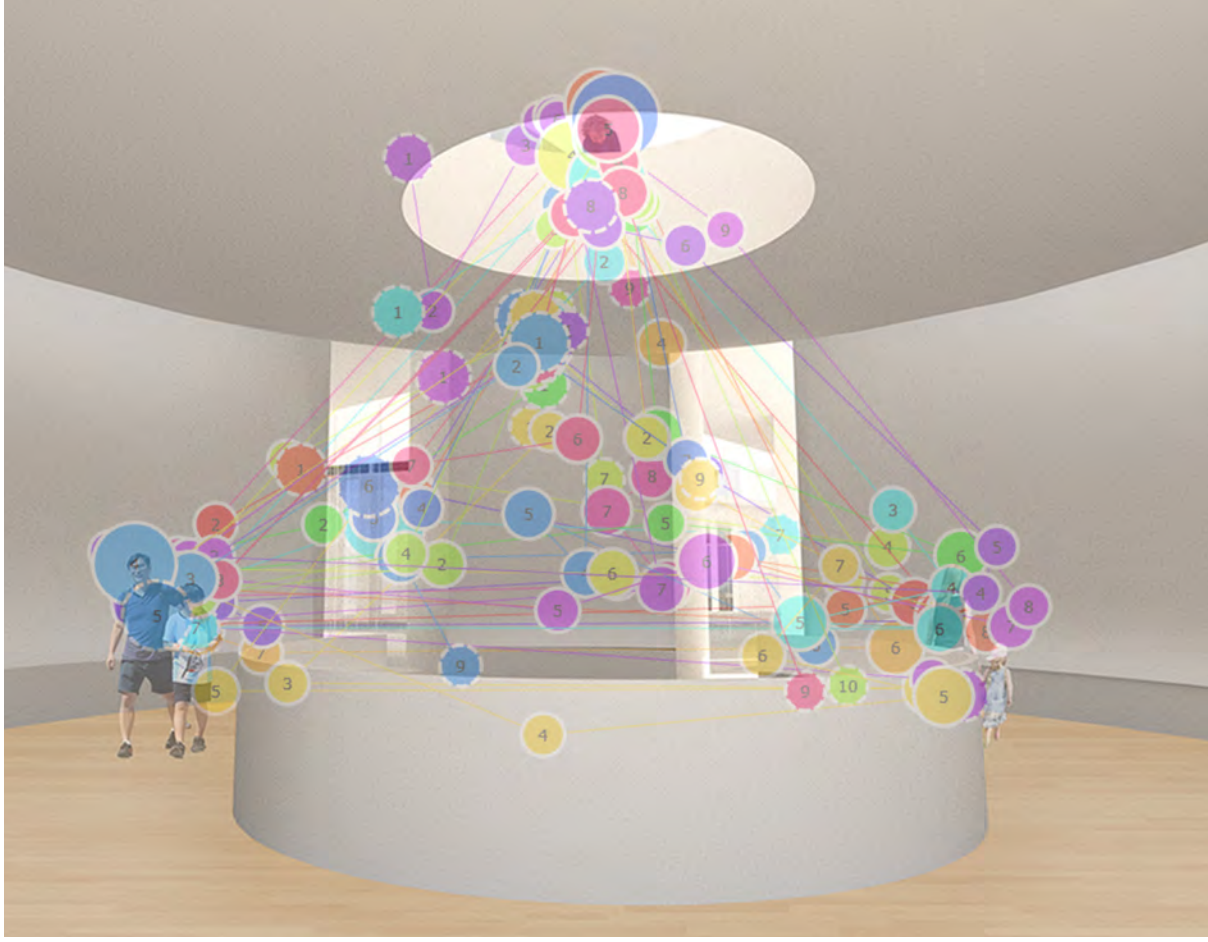


Figure 35 People in Eye Tracking Studies
These images were created to show how faces can be imbeded into architectual elements, and how peole react to them.

FACE

In figure(35) people become the center focus of the rendering. As talked about earlier, "people are attracted to other people." In the rest of this study there will not be people placed within the renderings of the space because the participant will only focus on them, rather than the built environment. This gaze pattern concludes that having people within was where the eye was in fact first drawing to and fixated the longest on. The size of the circles within the gaze plot represent fixation time or how long a person lingered on a particular part of an image. The circles were larger on the people rather than anything within the built environment.

FACE IN ARCHITECTURAL FEATURES

It is seen that people are attracted to faces in their surrounding context, it can be questioned what happens when there is a face within the built environment? How do people visually respond to that? In the figures below a play scape of a wall for children to climb up through was created as a part of discovery play within the library. In the given design options, one was created with a face placed inside of it, the other was not. People were visually attracted to the face more than the one that was designed without the face. This play scape is a feature within the building. If the design intent was for it to be one of the first things people wanted to use, adding a face like deign will give the structure immediate visual attention.

Figure 36 Face Playscape

These images were created to show how faces can be imbeded into architectual elements, and how peole react to them.

Figure 37 Ribbon Playscape

EDGE TO CURVE

The next set of images were distinctly used to look at a designed lobby space. Using a heat map to further examine participants attention, this set was to show the difference between curved and edged ceiling forms within the lobby space. In both images, figure 38 and 39, can be seen that peoples' attention began to focus on what would be through the set of doors when passing though the lobby space. The curved lobby ceiling however focused more to the lobby space than the rectangular edged lobby. The bottom of the curve became the central focus point rather than in the other image where the central focus was actually placed outside of the lobby space. However, in the creation of these images one will see a difference in the spaces that sit directly beyond the lobby space. The image of the rectangular lobby actually shows the face play structure while the other image does not. This was a mistake. The play structure that shows a face inside of it, will be more visually attentive than the lobby space on its own.

Figure 38 Curved Lobby

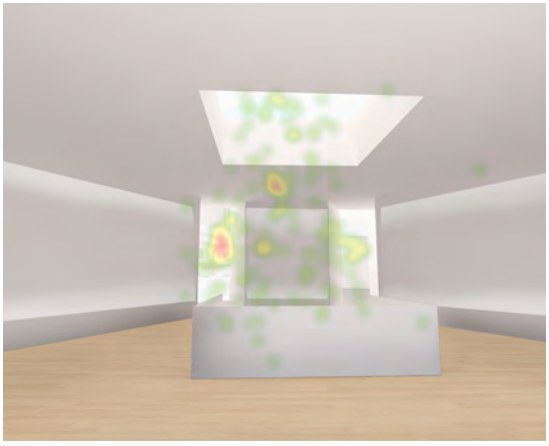


Figure 39 Edge Lobby

Figure 40 Traditional Dramatic Play

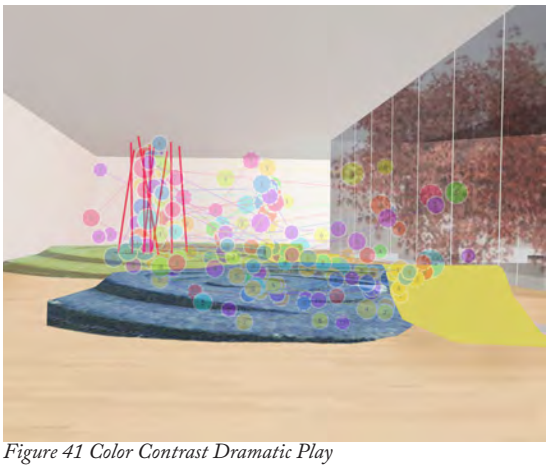


Figure 41 Color Contrast Dramatic Play

COLOR CONTRAST

Color contrast is an important aspect in understanding visual attention. This set of images, figure 40 and 41, differed from one another through the use of color. Adding a variety of color wans play-scape poles for the children to interact with created a gaze plot that was incredibly similar from the original gaze plot. In the rendering with many colors in is seen through the gaze plot that participants were clambered with trying to understand all of the color contrasts. Though no one's eye fixation will ever be the same often times, patterns will occur. These images do not have a pattern created by participants gaze, but they both fixated for a longer period of time to the back-blank wall. There was also a slight hierarchy given to the red poles and the yellow playscape. However, in the image with the just the green grass, participants eyes were drawn to both the interior and the trees in the courtyard. Within this image, eye gaze was similarly interested in interior and exterior.

BIOPHLIC

The last set of images show the relationship of how the built environment changes when plants and trees are added into the image. Biophilia, as explained earlier, is the connection to nature within the built environment. These images not only show a gaze plot, but also a heat map overlaid on top of it. In both of these images, with adding plant life, the play scape still remained the most attractive element within the image. Biophilic environments are visually engaging. Until now there was never really a way to see if the environment was truly giving

someone that connection. Though eyes were fixated mainly within the play scape, participants were drawn more to the plant life over the course of the image.

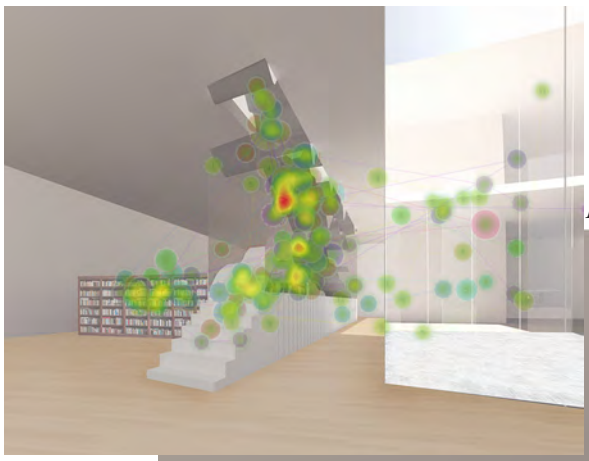


Figure 42 Library and Playscape

Figure 43 Biophilic Library and Playscape

CONCLUSION

After researching eye tracking software and how it has been used in the past, it has been quite a different experience doing my own examination. After proceeding with the first round of tests, I begun to understand what types of questions could be asked of the software and what types of information could be output because of it. Though with much to still understand with the possibilities of this software, I found it best to have an underlying question or focus within each image. Taking the eye tracking study without this base question became much harder to read and identify significance. The images that didn't have an underlying question in mind, I believed to have failed in the purpose of running the test. But the test successfully helped me to see what other types of questions I could be looking for within the environment. when there is a specific question in mind the eye tracking study becomes more beneficial to the designer to make decisions. I will keep this in mind as I move forward into the next set of eye tracking studies.

In the first attempt of the eye tracking study, I only used designers to gauge their feedback to continue design. In the project to come, children from the age of four to five will be asked to participate in the same eye tracking study. As shown in the above case studies, when comparing children and adult gaze patterns I expect to have similarities. In this case study I have created, I look for the fixations of children in my study to be much smaller than those of the adults. With these case studies I am able to modify the building design, to attempt to create a better connection of the built environment for the user.

These eye tracking studies help to gain user feedback much faster than asking many questions to a certain user group that may not be able to understand design decisions. Eye tracking gives a voice to those who may not be able to express their feelings like children, who we build and design for, but are not usually apart of the design process.

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