건축표피 재료의 시각특성 및 호감성에 대한 연구

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A Study on the Visual Characteristics and Preference for Architectural Exterior Materials

Focusing on the theory of neuroaesthetics and evloutionary aesthetics

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Abstract

Material is one of the critical parts to construct architecture. However, using materials to shape the aesthetics of the architecture has always been a challenging part for designers. Somehow, through recent projects it seems that there are some common relevance in the use of architectural materials. Therefore, of this research used neuroaesthetics and evolutionary theories to investigate architectural materials, started from defining the meaning of architectural exterior materials and their aesthetic value, discovered the shortcomings of current research on building materials, then analyzed the human brain's perception process of visual stimuli from the scientific perspective to confirm what visual characteristics can be perceived immediately. Next, introduced neuroaesthetics studies to discuss the generation of beauty cognition. The survey on the ventral and dorsal pathways clarified the process of how humans generated aesthetic cognition and human indeed be conscious of the perception of beauty through visual stimuli. To dig into the commonality of beauty and what visual component could arouse humans beauty consciousness, used the advanced research of evolutionary aesthetics. To confirm the results of humans perception of visual characteristics and their preference of visual properties of materials, two stages of investigation has been conducted. Through the results, it can be clarified that humans have a higher degree of favorability towards specific visual elements. Exploring the reasons can have a grounded association with neuroaesthetics and evolutionary aesthetics. At the same time, it is confirm that even those who have not received aesthetic education have a certain degree of ability to appreciate beauty.

Keyword

Architecture exterior, Materials visual characteristics, Materials perception, Exterior design

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요약

건축 재료는 건축을 구상하는 중요한 부분 중 하나다. 그러나, 재료를 사용해도 건물의 아름다움을 다루어지는 것이 늘 쉽지 않고 도전적이다. 하지만, 요즘 건축 프로젝트에 대한 관찰을 통해 건축 재료의 사용에 관련적인 공통성이 있다는 것을 밝혔다. 따라서, 본 연구는 신경미학과 진화미학의 선행연구와 건축 재료를 탐구하기로 했으며, 새로운 관점과 개념으로 재료의 시각적 특성 및 이에 대한 선호를 집중하여 논의하였다. 건축 표피 재료가 가진 의미와 미적 가치의 정의로 시작하였는데 이에 대한 기존 연구를 통해 아직 검토하기 어려운 점을 발견했다. 그래서 과학적인 관점으로 인간의 뇌 시각 자극 처리 과정을 살펴본 후, 미적 인식의 생성을 논의하기 위해 신경 미학 연구를 도입했다. 복측과 배측경로에 관한 조사는 인간이 어떻게 미적 인식을 생성했는지에 대한 과정이 명확히 했으며, 인간은 시각적 자극을 통해 아름다움에 대한 식별이 될 수 있는 사실을 알게 되었다. 또는 미의 공통성과 어떤 시각 요소를 인간의 미의식을 불러일으킬 수 있는 것을 살펴보기 위해 진화미학적인 선행연구를 도입하여 이 근거로 인류의 선천적인 미학적 감각이 생존본능과 연관이 있다는 사실을 밝혔다. 이어, 시각적 특성에 대한 인간의 인식 결과와 재료의 시각적 특성에 대한 선호를 확보하기 위해 2 단계의 설문이 수행되었다. 결과에 따라, 인간이 특정한 시각 요소에 대한 높은 호감성을 가지고 있다는 것을 명확히 할 수 있었다. 그 이유는 앞서 언급했던 신경미학과 진화미학과의 근본적인 연관성을 가질 수 있었기 때문에 미적 교육을 받지 않은 사람들도 기본적인 능력으로 아름다움을 감상할 수 있다고 확인하였다.

Contents   1. Introduction

1. Introduction

1-1. Background and Purpose

Architectural materials, as a part of the building, is one of the most important elements, combined with the structure, function, environment and other conditions of the architecture, it gives the building a stronger meaning and significance. However, in addition to the contents mentioned above, the designers also need to consider the style of the building, the visual effects they want to express, and the wide range of reflections before deciding what materials to use on the architectural exterior. Although this problem is challenging to be solved, we have still discovered that numerous contemporary architectural designs seem to have a certain commonality in the choice of materials. This situation raised our curiosity about "why those architectures which people think are beautiful general have such common points about the use of materials?" Seems like this commonness has certain association with our aesthetics cognition, and this perception will be triggered when appreciating the architecture so the tendency towards using particular materials

has might become an unconscious decision or just because be attracted by its appearance. Therefore, this research will be devoted to discussing the visual characteristics of materials which often used in modern architectures and so on, introducing neuroscience and evolutionary aesthetics to explore how essential visual properties of materials arise our cognition of beauty and figure out how humans arouse their aesthetic perception through their appreciation of architectural exterior.

1.2 Study Method

The main concern of this research will be investigating the visual characteristics of architectural materials and humans preference. Therefore, clarifying the relevant research content of "architectural exterior" and "materials," understanding the scope and method of each study through existing research on materials is the first step which will be started. Next, figure out the operation mechanism when the brain recognizes various visual stimuli to comprehend how people distinguish the visual characteristics of materials so that a complete cognition model

will have been output. Then, introduce the advanced research of neuroaesthetics and evolutionary aesthetics to explore why humans have such a penchant for these visual characteristics so that we could finally use the experiments to confirm whether the results summarized according to the studies are consistent with the actual situation.

In this research, two stages of investigations will be processed. The first stage of the investigation will dedicate to verifying if human's immediate perception about the visual characteristics of materials is accorded with the description of the previous studies when appreciating the architecture. To ensure the accuracy of each sample, this stage of the experiment will focus on the group who "have never received any art education." Moreover, the second investigation will be connected with the previous results of the first examination, which will remove the prominent visual characteristics by graphic software, then evaluation through the online questionnaire. In this part of the survey, the purpose is to inspect whether the hypothesis of humans aesthetic perception that inherits neuroaesthetics and evolutionary aesthetics is consistent with the experimental results. Ultimately, it is expected that the results could be combined with the theories of the whole study, and help other researchers to verify the relationship between visual characteristics of architectural materials and humans preference.

2. Architectural Exterior and Materials

2-1. Advanced Studies of Materials

It is factual that the correlation between building exterior and materials, the significance of materials, and their aesthetic value are the problems that the designers and researchers persistently pursue and explore. As a result, a thorough comprehension of the scope through existing studies of architectural exterior and its

relevance of materials is required. Based on the academic platform "Research Information Sharing Service(www.riss.com)" of South Korea, used the keywords "architectural exterior" and "materials" concurrently to search, as of October when this research was written, a total of 46 domestic journal papers have been published. Ththese searched papers can be classified by their studying direction, content, and matters of concern. So according to the mentioned above, it can be summarized into the following table 1.

[Table 1] Current Research of Materials

Subject	Content	Note
Properties of material	Investigate the essence of material	Application of new technological materials
		The physical properties of materials, the method to perform its properties, their relationship between architectural structure and environment
Regional building material research	Discuss the material selection tendency of the region through its culture, weather, geography and traditional architecture	
Case study of famous architect's works	Analyze the architect's implication for using certain materials and their point of view of materials through their works	
The perceptual value of the material to the viewer	Explore the feeling which materials could bring to humans	The experiment usually conduct by putting some variations to the materials to test if the subject will have any different feelings about it

Next, extended explain the value and significance of the architectural exterior materials based on advanced research. In the paper published by Kwon and Kim, it is mentioned that "Material is a tool that embodies the overall image of the architectural exterior, and it is also

the direct object that constitutes the exterior." This statement reveals the meaning of materials to the architectural exterior and their correlation. Furthermore, through comprehension and organizing the analysis of dematerialized expression of materials, there is the result that its immaterial performance is derived through the perceptual enactment of the physical properties of material itself, which then reflects the conclusion that human beings and architecture are harmonious. Subsequently, they referred that "The material performance of contemporary architecture can originate the potential value of materials through the expansion of perception and the manifestation of behavior.[1]"

The other researcher Kang stated that human experience of materials could perceived by visual. Therefore, human can notice the texture of materials through vision and give adjective description to each material. Based on this discourse, Kang tested each subject's perception of stone, brick, tiles and glass used in different architectures and requested them to describe their sensation through adjectives. This experiment confirmed that different exterior materials could use their physical state to explain viewers' dissimilarity in perception. At the last of the research, Kang said that perhaps architects could predict what image the public will feel from materials used in building exterior through more in-depth studies[2].

In addition, Jeon and Kim also inherited the results of Kang's research on the sense of materials, conducted a comprehensive study on the mixed-use and perceptual value of materials, concluded that "The color and texture of materials can determine the figure of architecture.[3]" After analyzing the above existing

studies, the contents of these research and the related topics in table 1 are sorted out(see table 2).

[Table 2] Significance of Architectural Exterior Materials Mentioned in Advanced Studies

Researcher	Description	Classification of materials research
Kwon, & Kim, 2017	Material is a tool that embodies the overall image of the architectural exterior, and it is also the direct object that constitutes the exterior.	Properties of material
	The expression of materials in contemporary architecture can be interpreted as deriving the potential value of materials through the expansion of perception and the manifestation of behavior.	
Kang, 1986	The texture of materials can be perceived visually. Therefore, the adjective's meaning can be given to each material as an associative action on the material perceived by visual.	The perceptual value of the material to the viewer
Jeon, & Kim, 2000	The color and texture of materials have great influence to determine the image of architecture.	The perceptual value of the material to the viewer

2.2 Method and Limit of Advanced Studies

It is distinct that there have been numerous studies about the correlation of architectural exterior and materials. Most of the research directions are concentrated on exploring the physical properties and performances of materials, their association between building construction, or trying to elucidate its perceptual value conveyed to humans. However, the former emphasizes explaining the material in a more

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1) H., Kwon, & H. Kim, A Study on Expressivity of Contemporary Architectural Surface by Material Properties, Journal of the Korean Society Design Culture, 2017, Vol.23, No.2, pp.41–42.

2) B., Kang, A Analytic Study on the Image of the exterior wall materials, Journal of the Architectural Institute of Korea, 1986, Vol.2, No.6, pp.115–122.

3) H., Jeon, & S. Kim, A study on Influence of the exterior wall Materials Upon A building Image – Focused on Cases in Composition of the Exterior Wall Material, 대한건축학회 학술발표대회 논문집 – 계획계, 2000, Vol. 20, No.1, pp.229–232.

artistic, abstract way, and such this description is usually difficult for people in the non-professional field to understand. Also, the perceptual value depicted by the latter has the subjective consciousness of the viewer, and the cultivation of subjective apprehension is often acquired through learning, living environment and experience, so when it applied to the explanation of materials often leads to aesthetics gaps. As a result, it is not only difficult for the architects to abandon the "aesthetic value" of materials but also the process of selecting materials is often challenging because of the subjective awareness of aesthetics. Although there have been lots of studies about the materials, it still encounters the limit of drawing a conclusion when explaining the association between universal beauty and the materials.

Besides, previous studies verified that the materials play a crucial role in visually leading the image of architecture. In other words, having a good knowledge of the physical properties of materials is possible to consider the entire design process from a more connotative and thoroughgoing perspective, also perform its value. However, it is factual that the most efficient method to experience the presented beauty of architecture with materials is through visual to sense and expand further perceptual so that viewers can immerse themselves in the aesthetic which it conveyed. Therefore, studying the aesthetics significance of architectural materials with rational and objective aspects is required. First of all, through the operation of the brain to investigate what kind of visual stimuli humans will respond rapidly, then probe the aesthetics of materials visual characteristics with the theory of neuroscience and evolutionary aesthetics, provide an innovative and persuasive interpretation of it.

2-3. Processing of Visual Stimuli in the Brain

After human receive various information through the eye, the brain responds promptly to analyze and process it to realize our visual cognition. In fact, numerous advanced studies have confirmed that the brain processes visual stimuli by receiving them from the retina and transmitting to the primary visual cortex(V1) through the lateral geniculate nucleus(LGN) located in thalamus[4]. Therefore, it can be said that V1 is the first area to accept and react to the visual stimuli from the retina[5]. Also, V1 conducts the preliminary processing of the received visual information and then deliver it to the adjacent V2, where it will carry out the complex visual information compared with V1[6]. In general, the visual stimulation processed in V1 includes direction motion, spatial frequency, retinal disparity, and color[7]. Regarding the order of perception about visual stimuli, Moutoussis and Zeki mentioned in their research that "Color is seen before orientation, and motion is perceived after orientation.[8]" As a result, according to the discourses above, it can be verified that in the static behavior of appreciating architecture, "color" is the earliest element that the brain can be activated.

The next theme to be discussed is spatial frequency. As mentioned before, spatial frequency perception can be perceived in V1, while it is achievable to perceive more details of it in V2 with the expanded receptive field[9]. Spatial frequency is a characteristic that measures

4) E., Chinellato, & A. P., del Pobil, The Visual Neuroscience of Robotic Grasping, Springer International Publishing, 2016

5) A., Bartels, & S., Zeki, The theory of multistage integration in the visual brain, Proceedings of the Royal Society B: Biological Sciences, 1998, Vol.265, No.1412, p.1.

6) X., Lyu, & T. Cho, Analysis of Shape Generation Methods in Architecture from the Perspective of Cognitive Neuroscience, Korea Society of Basic Design & Art, 2019, Vol.20, No.2, p.97.

7) K., Grill-Spector, & R. Malach, The Human Visual Cortex, Annual Review of Neuroscience, 2004, Vol.27, No.1, pp. 649-677

8) K. Moutoussis, S., Zeki, A direct demonstration of perceptual asynchrony in vision, Proc Biol Sci, 1997, Vol.264, No.1380, pp.393-399.

the periodic changes between light and dark units of visual stimuli to recognize its visual properties. It can be distinguished by "high spatial frequency(HSF)" and "low spatial frequency(LSF)." HSF identifies the denser cyclic changes of the light and dark units so that the brain can perceive more intricate parts such as borders and edges. In contrast, LSF tends to perceive the overall contours, gradation, and color of the image[10]. When the visual attention field is more spacious, the sensibility to the information in the field is weaker, which means that spatial frequency will tend to be lower [11][12]. For example, when appreciating architecture, the visual attention field is wider since architecture is the object that grabs one's attention. Based on the spatial frequency theory, the perception of spatial frequency is inclined to be inferior in this situation, so the cognition of materials visual characteristics such as transparency, translucency, and luster could be effectively inferred by LSF is confirmed. On the contrary, using the arrangement, order, and color of materials to create the patterns on the architectural exterior correspond to the details of the HSF perception, which is borders or edges. The human brain can, therefore, rapidly recognize the patterns in this stage.

According to the descriptions above, it is comprehensible how the brain receives visual stimuli and forms the perception to the architectural exterior. Each visual characteristic of materials that can be recognized in the brain and their perceiving location are summarized in the following table 3.

[Table 3] Perception model of visual characteristics

Location	Perceptual process	Visual characteristics
V1	Visual stimuli -> LGN cells located in thalamus -> Primary visual cortex	Color
V1 - V2	Visual stimuli -> Primary visual cortex -> Low spatial frequency (LSF)	Transparency
		Translucency
		Luster
	Visual stimuli -> Primary visual cortex -> High spatial frequency (HSF)	Pattern

3. Aesthetic Preference of Materials

3.1 Neurological Analysis

In this section, the first thing need to be confirmed is how the visual cortex cells of the brain analyze visual stimuli and transmit them to the corresponding areas. After the retina receives visual information, bipolar cells and retinal ganglion cells will transmit the signals to V1 through the optic nerve to generate visual cognition[13]. these cells in the cortex of V1 and V2 have the immediate sense of vision(including color, shape, movement, and depth, which are the elements mentioned in section 2.3), the cortex of each processing system is composed of equivalent particular cells and pathways from them to the specialized areas directly and indirectly. After the cells in V1 receive the stimuli, they will continue to convey information to other corresponding areas via the ventral and dorsal pathways. The ventral pathway is used to process the perceptual analysis of visual input. It will eventually reach the inferotemporal cortex(IT

9) E., Chinellato, & A. P., del Pobil, The Visual Neuroscience of Robotic Grasping, Springer International Publishing, 2016

10) Y., Hwang, & T. Cho, A Model of Creating the Characteristics of Form through a Neurologic Analysis - characteristics of form in architecture, Journal of Basic Design & Art, 2018, Vol.19, No.4, p.538.

11) W., Zhou, & X., Ouyang, Response Properties of Human Vision Systems to Different Spatial Frequency Components, Journal of South East University, 1989, Vol.19, No.6, p.12.

12) C. W., Eriksen, & St. James, J.D., Visual attention within and around the field of focal attention: a zoom lens model, Perception & Psychophysics, 1986, Vol.40, No.4, pp.225-240.

13) Chun-I., Yeh, College of Science - National Taiwan University, http://www.science.ntu.edu.tw/

cortex) which responsible for short-term visual memory. It exhibits susceptible and high-resolution selective features for characteristics such as shape, pattern, and color[14]. In other words, the visual stimuli contained in the appearance features will intuitively generate perception. The dorsal stream flows into the posterior parietal cortex(PPC), which is responsible for language and vision, and it shows a more significant response when recognizing old things than new stimuli(Henson et al., 1999; Eldridge et al., 2000; Konishietal, 2000; Cabetal, 2001). That is, to interpret the received visual information through long-term memories to emerge semantic associations, thereby forming cognition of things. For example, when appreciating Gaudi's work "Sagrada Familia," the general public may be surprised and magnificent only through its appearance, while people with relevant education may have different feelings about it because they know the history of its construction or are familiar with the architect himself.

Recalling the state of our appreciation of architecture or artwork, the sensation of feeling "like" and "beautiful" is often accompanied by emotions of joy, excitement, and surprise. Therefore, if it can explain humans perception of beauty, it is related to the generation of emotions, in other words, the conjecture of "Humans are born with the ability to appreciate beauty." is probably practicable.

The above inference had been explored in the study by Biedermand and Vessel. They stated that "In 1972, Snyder and Pert discovered that opiates target certain molecular receptors located on the surfaces of brain cells. When opiates bind to these opioid receptors, they modulate the activity of the cells." They also argued that "The mu-opioid receptors responsible for the regulation of pain and rewards are the key to the pleasures we derive from acquiring new information." Then based on the observation result of Lewis and other research(1980) on the cerebral cortex of macaque, it was confirmed that the receptors are distributed in a gradient that gradually increases in density along the ventral pathway. The distribution of opioid receptors in the initial stages V1 to V4 was loose, while the final cognitive stage reached the highest density. That means that the brain can emerge positive aesthetic perception through the ventral pathway due to the phased superposition of the opioid receptors' distribution, because numerous opiate receptors are dispersed in the sensory areas, a strong cognitive response have been emerged[15]. Chatterjee has also suggested that the emotions involved in aesthetic experience might be related to a reward system of pleasure subserved by opioid and cannabinoid neurochemical systems(Berridge, Robinson, & Aldridge, 2009)[16]. This discourse indicates that the visual information contained in the objects is judged by the perception process of the ventral stream so that the cognition and emotional connection dominate the humans perception of beauty and indirectly confirm that the ability to appreciate beauty is indeed inherent.

Since verified this discussion, then how does the aesthetic cognition cause individual differences? It may could be explained by the function and the perceptual process of the dorsal pathway. Leder and other researchers analyzed the perception of humans while conducting aesthetic activities based on the "Stage model of aesthetic information interpretation." This model was output through the cognition process by experience and

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14) T., Meyer, & N. C. Rust, Single-exposure visual memory judgments are reflected in inferotemporal cortex, eLife, 2018, Vol.7

15) I., Biedermand, & Vessel, A. E., Perceptual Pleasure and the Brain, American Scientist, 2006, Vol.94, No.3, pp.247-253.

16) M., Pearce, D. Zaidel, O. Vartanian, M. Skov, H. Leder, A. Chatterjee, & M. Nadal, Neuroaesthetics: The Cognitive Neuroscience of Aesthetic Experience, Perspectives on Psychological Science, 2016, Vol.11, No.2, p.13.

memory, indicating that such this procedure is accompanied by escalating emotional states, came out of an assumption that aesthetic feelings and cognition could be related to emotional activities. Finally, they suggested that perceivers need to gain professional knowledge to improve the ability to master art[17]. In other words, when humans acquire more expertise of art, they can emerge more semantic association and episodic memories when undertaking aesthetic activities to expound their perception. When the understanding and ability to master artwork are higher, more satisfaction can be obtained in the aesthetic process and positive emotions. Therefore, it can be inferred that although the appreciation of beauty is an innate ability of humans, personal growth background, culture, and education would still result in differences in individual perceptions.

The recent fMRI studies have also shown that these two pathways have complementary response capabilities in recognizing visual stimuli(Valyear et al., 2006; Thoma, & Henson, 2011)[18]. That is, aesthetic cognition of humans is formed by mutual recognition of the ventral and dorsal pathways. It can be presumed that the beauty perceived by the ventral pathway is a "common" beauty, which can be stimulated to a certain extent by cognitive objects, while the dorsal pathway is based on common beauty perception, then strengthened by one's own experience and knowledge to generate a higher degree of beauty perception.

3.2 Evolutionary Aesthetics Analysis

There are various elements in contemporary architecture. It is not difficult to find that the use of certain specific architectural materials seems to be particularly common, such as the commercial buildings made of glass curtain walls and apartments built with gray concrete, plaster, and bricks. From the perspective of design, the reason why the above materials are often used to construct the architectural exterior is not only because of practical considerations but also due to the certain degree of "attractiveness," which is the aesthetics they contain. In previous section, the aesthetic perception generated by neuroaesthetics and the reasons for causing the cognitive differences between individuals has been confirmed, so it is required to comprehend "How the ventral pathway perceives common beauty." Regarding this, the development of evolutionary aesthetics based on biology and evolutionary theory seems to be the most convincing. The former section referred that "The ability to appreciate beauty is innate to human beings." In other words, the perception of beauty can also be interpreted as a biological instinct. Concerning biological instincts, to explain it from an evolutionary perspective, it is said that "Emotional response is a powerful motivating force for human behavior. Therefore, behaviors aroused by emotions must have a positive contribution to survival and propagation in the long-term evolution of humankind(Orians, & Heerwagen, 1992)[19]." It can be inferred that the survival instinct is controlled by the emotions generated through the brain and will be stimulated according to the beneficial conditions. As a result, the biological instincts gradually evolve in the constant pursuit of more stability and survival. Until now, this kind of instinct has existed in our perception with other forms. According to this description, it can be said that the cognition of beauty is an instinctive perception that inherits the survival instinct and gradually advances so that it can emerge the

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17) H., Leder, B., Belke, A. Oeberst, & D. Augustin, A model of aesthetic appreciation and aesthetic judgments, British Journal of Psychology, 2004, Vol.95, pp.489–508.

18) E., Chinellato, & A. P., del Pobil, The Visual Neuroscience of Robotic Grasping, Springer International Publishing, 2016

19) K., Han, Re–Examining the Savanna Hypothesis in Terms of Scenic Beauty, Preference and Restoration, Journal of Geographical Science, 2005, Vol.41, p.27.

corresponding perception through semantics or episodic.

To understand the commonality of beauty through evolutionary aesthetics, it seems that survival instincts of creatures and preferences for the environment must be understood. From the study of Moura and other researchers, they mentioned that researchers like Ulrich(1983), Kaplan and Kaplan(1989, 1995), Orians(1980), Orians and Heerwagen(1992) have all expressed creature preferred to the landscape in which with plenty of plants and contains clean water because it is beneficial to survival and propagation[20]. Based on this statement, it seems that the stimuli that can be associated with "suitable for survival" and "evokes survival instinct" are the key to it. As a result, it is crucial to expound which elements involved the living environment in the past.

Concerning the things related to "suitable for survival" and "evokes survival instinct," the first thing that comes to mind is water and food. Han pointed out that no matter from the aspect of "evolution theory" or "cultural theory," it is considered that humans will have a strong and direct reaction to an environment with water (Ulrichf, 1983, 1993; Orians, & Heerwagen, 1992)[21]. Meanwhile, "food" is a source of nutrition for creatures, and the quality of food will also have a significant impact on survival. In human development, several wars triggered by the competition for water and food also indicate their importance to a certain extent. In addition, the "environment" that satisfies the primary living conditions is also highly related to survival. Han's research shows that humans seem to have the most positive response to natural environments with high complexity, medium open space, and large amounts of water. Moreover, Lee and Cho (2016) also stated that, compared to landscapes that are too simple or complex, humans have a good impression of landscapes that are easy to set directions and explore places due to appropriate complexity[22]. From the above discussion, it can be confirmed that the elements were valued and beneficial to existence. Based on these, it is possible to infer how humans have a favorable preference for visual characteristics.

3.3 Aesthetic Cognition of Materials

Through evolutionary aesthetics, it has been concluded that "water," "food," and "environment" are connected to the stimuli, which could be related to the keywords "suitable for survival" and "evokes survival instinct." Hence, further exploration is to discuss the semantic association caused by these natural elements, to find the relevance of the preference for visual characteristics. It is an instinct that creatures pursue water to survive so that the shining luster emerged by the reflection of sunlight on the water surface attracts their attention. Clean water typically have a positive impact on subsistence, "water" then create the semantic association with the adjective like "transparent," "pure," "shiny," "glossy," and so forth. Because of this, it can be inferred through evolutionary aesthetics that human beings have an assured favorability for stimuli with "transparency" and "luster." Concerning the distinction of food quality between high and low is mainly distinguished by the appearance. For example, plants produce high sugar ingredients through sufficient photosynthesis and create a solid and polished epidermis[23]. Also, most of

20) J. M. B., Moura, W. S. Ferreira Junior, T. C. Silva, & U. P. Albuquerque, Landscapes preferences in the human species: insights for ethnobiology from evolutionary psychology, Ethnobiology and Conservation. 2017, Vol.6, No.10, p.4.

21) K., Han, Re-Examining the Savanna Hypothesis in Terms of Scenic Beauty, Preference and Restoration, Journal of Geographical Science, 2005, Vol.41, p.39.
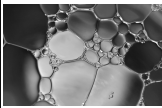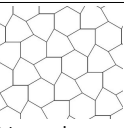
22) M., Lee, & T. Cho, A Study on the Order of the Spatial Shape based on Neurology, Korea Society of Basic Design and Art, 2016, Vol.17, No.4, p.322.

23) D., Kwon, & T. Cho, A study on the appeal

the foods rich in nutritional value have a crystal clear, hydrated, full and bright colored appearance, so that they will naturally be considered as "suitable for survival" and pursue it certainly. Since its evolution, the appearance which foods rich in nutrition can also be associated with vocabulary such as "smooth," "bright," "moist," "vivid," thereby enhancing human preference for specific colors, luster, translucency and other visual properties. According to the description, glass, plastic, metal, silk, satin textile, and other materials all have the characters connected to the above keywords. Therefore, it can be supposed that humans generally have a certain degree of favorability towards architecture built with the aforementioned materials.

The favorability for pattern order also seems could be reasonably explained from the perspective of evolutionary aesthetics. The contours of various trees, leaves, landscapes and natural phenomena have existed in the perception of the brain since the past, making some patterns differentiated from nature arouse human pleasure and evolved to current human preference for specific patterns. For example, the fractals developed from the outline of the mountain ridges and clouds, the bifurcation evolved from lightning and branches, the Voronoi which from honeycombs and bubbles are all patterns and orders that exist in nature[24]. Moreover, ethologist Morris also stated that symmetrical or repetitive visual patterns are the elements that can grab human's attention[25]. Based on the above inferences, it can be shown

that humans have a certain degree of favor for these components that have evolved from evolutionary aesthetics and then have semantic or episodic memories with the brain.

[Table 4] Semantic Association with Natural Elements

Element	Image	Semantic association	Visual characteristic
Water		Transparent	Transparency
		Pure	
		Shiny	Luster
		Glossy	
Food		Smooth	Translucency
		Bright	Color
		Moist	
		Vivid	Luster

[Table 5] Patterns Origin from Nature

Episodic memory	Image	Type of patterns
Mountain ridges		
Cloud		Fractal
Branches		
Thunder		Bifurcation
Honeycombs		
Bubble		Voronoi

4. Investigation

To verify if the aforementioned hypotheses have corresponded with the actual situation, two stages of investigation will be conducted.

4.1 Method and Result of the First Investigation

The first stage of the investigation is an experiment about the "Perception model of visual

structure of glossy material through analysis of supernormal stimulus, Journal of the Korea Institute of Spatial Design, 2019, Vol.14, No.3, p.131.

24) S., Yun, & T., Cho, Understanding the order of the natural shape and a public space design as the universal beauty, Journal of Korean Institute of Spatial Design, 2011, Vol.5, No.7, pp.29–36.

25) M., Lee, & T. Cho, A Study on the Order of the Spatial Shape based on Neurology, Korea Society of Basic Design and Art, 2016, Vol.17, No.4, p.322.

characteristics,"which mainly discussed in section 2.3. In this stage, what kind of visual characteristics on the architectural exterior would have been perceived immediately by the subjects will be verified. Therefore, at this stage, the subjects of the experiment are mainly those who "have never received any aesthetic education" due to the content mentioned before. Consider that aesthetic education probably brings to entirely different cognition and interpretation to aesthetic perception, probe the subject who have not been aesthetic-educated could examine more objectively whether human cognition of visual characteristics has corresponded with the output model(table 3).

The questionnaire was an online survey made by Google Form. The first stage of the investigation will follow the process as below. (see figure 1)
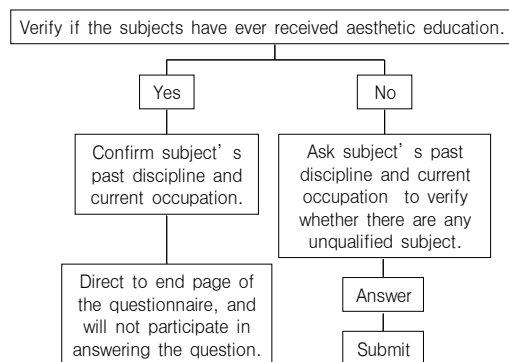
[Figure 1] Process of the First Stage of Investigation

As for the selection of samples, it will be selected based on the following conditions. ① In order to analyze the application of materials on the architectural exterior and for the further investigation, the three-dimensional architecture image will be used as the sample. ② The selected images should clearly perform the architecture's visual characteristics of materials or features. ③ The selected sample needs to be objective on a specific basis which could be regarded as "beautiful" architecture. Based on the
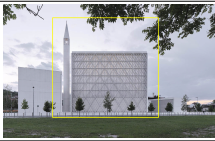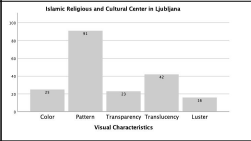
terms above, the architectures selected as the "Building of the Year" by the website Archdaily were eventually chosen as the samples for investigation. Archdaily is a website that gathers various information about architects and offices, also including various projects such as residential, office, public, interior, environmental, urban design and other related fields around the world. The website also contains a wealth of industry information and in-depth topics about the architectural fields. The prize "Building of the Year" held by Archdaily is divided into different themes, and users of this website can vote to select the best architecture in that category. As a result, the selection of "Building of the Year" is based on the perspective of "beauty" and "professional." Hence, it is feasible to serve as experimental samples.

According to the above-mentioned conditions, 30 images were selected in total. Each image include only one architecture, and the size of each image was set to the height of 750 pixels, with a resolution of 100 dpi, which minimized the factors that may cause differences in the visual perception of the subjects. There were five options that following the visual characteristics of the materials in table 3 respectively are color, pattern, transparent, translucent and luster. After the subjects had viewed an image, they need to choose the visual characteristics they saw most intuitively from the options. Each question was a multiple-choice question which the subjects could tick all that apply.

The questionnaire was opened since August 25th to the 27th, a total of 155 replies were received, 31 of them were the subjects who "have ever received aesthetic education." Of the remaining 124 replies, 9 replies did not meet the conditions in the part of answering their past major or the current occupation fields, so the final valid replies were 115. Based on these replies, used the software Microsoft Office Excel and statistical analysis software SPSS to analyze the investigation results. The results are summarized in the following tables.

[Table 6] Analysis and Results of the First Investigation
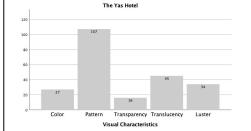
(1) Islamic Religious and Cultural Center in Ljubljana

Image	Result

Analysis

Composed by white steel frame to create the rhombus pattern and also through the gaps of pattern performed the translucent visual effect. The results showed that most subjects perceive the pattern(79.1%), while about 36.5% of the subjects perceive translucency.
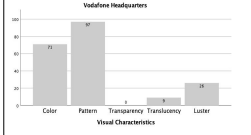
(2) The Yas Hotel

Image	Result

Analysis

About 93% of the subjects perceived the pattern characteristics from the steel frame instantly. Also through the mesh of the steel frame, there are 39.1% of the subjects recognize the translucency.
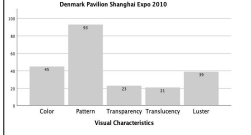
(3) Vodafone Headquarters

Image	Result

Analysis

The architectural exterior of this building is composed of the stone material with different shades to create a pattern-like visual effect. Follow up this effect, "pattern" and "color" are also the visual characteristics chosen by the most(84.3%) and second most(61.7%) subjects.

(4) Danmark Pavilion, Shanghai Expo 2010

Image	Result

Analysis

Most of the subjects became aware of the circular gouge pattern(79.1%) from the exterior of the architecture.

(5) Braamcamp Freire
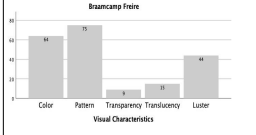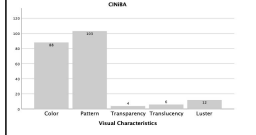
Image	Result

Analysis

The holes dug on the concrete wall seem to form a perception of pattern(65.2%) on a certain level. The halo reflected by the stained glass on the wall leads to 55.7% of the subjects perceived color.
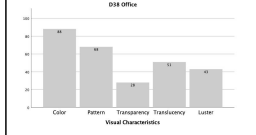
(6) CINiBA

Image	Result

Analysis

The architectural exterior formed by the magnified arrangement of red bricks from top to bottom caused about 89.5% the subjects chose pattern as the visual characteristic they perceived. The color that brick itself also aroused 76.5% of the subjects' perception.
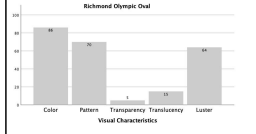
(7) D38 Office

Image	Result

Analysis

Approximately 76.5% of the subjects perceived the color of the architecture, and the exterior made of different stained glass triggered some people's perception of the pattern(59.1%).
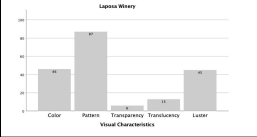
(8) Richmond Olympic Oval
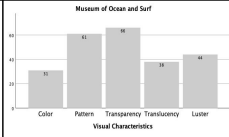
Image	Result

Analysis

The result shows that the blue color indeed attracted the attention of most subjects(74.9%). In addition, the color gradient and the material itself performed the property of luster so that about 55.7% of subjects chose this option. The arrangement of the materials also made the subjects perceived the visual characteristic of the pattern(60.9%).

(9) Laposa Winery

Image	Result

Analysis
This result shows that most of the subjects did perceive the dendritic pattern (75.7%) engraved on the concrete panel.

(10) Museum of Ocean and Surf

Image	Result

Analysis
This result shows that the glass material used in the building itself stimulates the perception of transparency(57.3%), while the stone used on the floor outside stimulates the cognitive response to the pattern(53%). A small number of people have formed their perception of luster(38.2%) from the interior lighting and the texture of the glass itself.

[Table 7] Results of the First Investigation(Unit: %)

No		Color	Pattern	Transparency	Translucency	Luster
11	RIJNSTRAAT 8	25.2	53	49.6	41.7	50.4
12	Zamet Centre	48.7	86.1	17.4	29.6	18.3
13	Town Hall Hotel	21.7	64.3	16.5	55.7	14.8
14	48 North Canal Road	68.7	81.7	31.3	38.3	28.7
15	Binh Thanh House	21.7	79.1	20	36.5	13.9
16	Carozzi Production and Research Food Center	75.7	67.8	13.9	28.7	25.2
17	School of Architecture at the Royal Institute of Technology	64.3	65.2	45.2	20.9	47
18	Jewel Changi Airport	29.6	76.5	45.2	37.4	40.9
19	Tangshan Organic Farm	14.8	29.6	43.5	60.9	37.4
20	Crystal Houses	53	83.5	23.5	40	26.1
21	Optical Glass House	36.5	56.5	27	63.5	28.7
22	KOI Cafe	78.3	60.9	11.3	33.9	11.3
23	Santa Fe de Bogota Foundation	60.9	84.3	4.3	9.6	15.7
24	Archery Hall & Boxing Club	36.5	36.5	17.4	56.5	47.8

No		Color	Pattern	Transparency	Translucency	Luster
26	C & P Corporate Headquarters	26.1	64.3	58.3	54.8	45.2
27	Leixoes Cruise Terminal	45.2	72.2	24.3	21.7	48.7
28	A House	55.7	81.7	12.2	10.4	36.5
29	Musee Yves Saint Laurent Marrakech	84.3	83.5	3.5	7	19.1
30	Apple Central World Bangkok	55.7	61.7	69.6	14.8	61.7

According to the results, human perception of visual characteristics on the architectural exterior can be verified, and to a certain extent, the results are quite consistent with the visual characteristics model derived in table 3.

4.2 Method and Result of the Second Investigation

The purpose of the second stage of the investigation is to inspect the subject's favorability for the visual characteristics of materials and verify if the results corresponded with the previous hypothesis. In the first experiment, an objective result of the architectural exterior's visual characteristics was obtained. Therefore, the factors can be appropriately created based on the results to carry out the second experiment.

The second investigation was also an online questionnaire made with Google Form, and the process will be followed as figure 2.
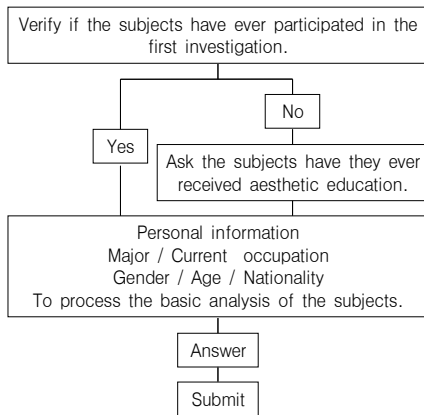
[Figure 2] Process of the Second Stage of Investigation
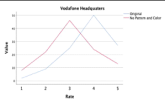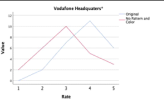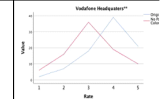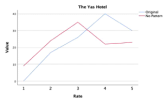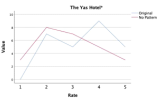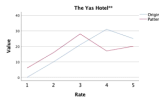
For the purpose of analyzing the preference of the materials visual properties comprehensively. The second stage of the investigation will not be limited to the subject who "have never received any aesthetic education," yet during the testing process, every subject still need to answer the question about if they have ever received any kind of aesthetic education so that it could help with the subsequent analysis. Furthermore, the sample selection of the second experiment was based on the results of the first investigation, and the following conditions are used for sample selection: ① The results can show its relatively prominent visual properties. ② Excluding the visual characteristics that are frequently perceived in different cases, for example, there are too many combinations of color and pattern which were perceived in different samples so that it will make appropriate selections in this part. ③ Images that are technically too complex and tough to edit with graphic software will not be adopted.
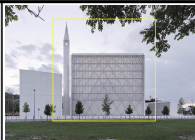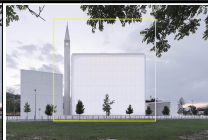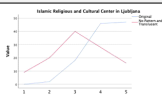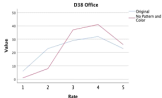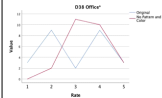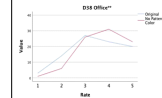
After excluding the above conditions, a total of 17 images were selected. Based on the results of the first investigation, the most recognizable visual characteristics of the architecture will be removed or changed into the other material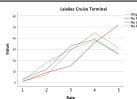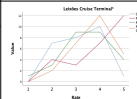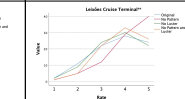s through the software Photoshop which is released by Adobe. Next, the subjects have to evaluate their personal favorability to each image on a 5-point scale, choose "1" means "really don't like it," and "5" means "really like it." The size of each image was set to a height of 750 pixels and a resolution of 100 dpi. Each page in the questionnaire represented an architecture and other edited photos. The images in a page were arranged randomly through the setting of Google Form. The subjects will make a preference evaluation after viewing an image. In this investigation, the subjects would not be indicated which image is the original and which pictures had been edited to ensure the objective accuracy of the result.
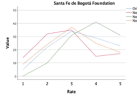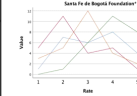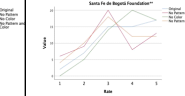
The form was opened from September 25th to October 1st. A total of 113 replies were received. Among these replies, 56 subjects(49.6%) had participated in the first investigation. The proportion of males is about 39.8% and females is 60.2%. The age group is mostly between 20-30 years old(53.1%), followed by 50-60 years old(16.8%), the lowest participation age group is 30-40 years old(5.3%) and under 20 years old(4.4%). In addition, the vast majority of the subjects were from Taiwan(95.6%), followed by three subjects from Korea, one from China and Hong Kong. The preference analysis will be divided into three categories according to subjects' answer in the questionnaire: (i) overall group; (ii) aesthetic-educated group, which is the group who have received formal aesthetic education(art school, school major or relevant lessons) or currently work in the related industries; (iii) general public which is the group who have never received aesthetic education. According to the results, it will have a brief interpretation to each group, and for the convenience of reading, each group will be described with their code. The whole results were analyzed through the software Microsoft Office Excel and statistical analysis software SPSS to analyze the results. The results are summarized in the following tables:

[Table 8] Analysis and Results of the Second Investigation

(1) Vodafone Headquarters	
Image	(A) Original / (B) No pattern and color

Preference line graph and average preference

(i) Overall	(ii) Aesthetic-educated	(iii) General public
(A)3.81 (B)3.11	(A)3.81 (B)3.04	(A)3.8 (B)3.13

Analysis

In this case, the shade of the architectural exterior was edited to eliminate the visual characteristics such as color and pattern. Analyzed by the three groups of preference line graphs, they all show clear favroability for the visual characteristics presented by image(A), and a neutral preference for image(B). Comparing the average preference of these three groups, the average preference of the group(ii) and the group(iii) for the original architecture is almost the same.

Result	(A) Original > (B) No pattern and color

(2) The Yas Hotel	
Image	(A) Original / (B) No pattern

Preference line graph and average preference

(i) Overall	(ii) Aesthetic-educated	(iii) General public
(A)3.73 (B)3.23	(A)3.46 (B)2.88	(A)3.82 (B)3.33

Analysis

This case eliminates the most easily perceptible characteristic which is pattern. The result shows that the subjects generally have higher favorability to image(A) which with the pattern on the surface, espacially in the group(ii). Also, in group(ii), the tendency to dislike image(B) is more apparent.

Result	(A) Original > (B) No pattern

(3) Islamic Religious and Cultural Center in Ljubljana	
Image	(A) Original / (B) No pattern and translucency

Preference line graph and average preference

(i) Overall	(ii) Aesthetic-educated	(iii) General public
(A)4.22 (B)3.19	(A)4.23 (B)3.0	(A)4.22 (B)3.25

Analysis

This case removed the pattern and translucent visual characteristics. From the line graphs, it can be noticed that the group(ii) and the group(iii) have a very consistent notion to this case, and both show high degree of preference for image(A).

Result	(A) Original > (B) No pattern and translucency

(4) D38 Office	
Image	(A) Original / (B) No pattern and color

Preference line graph and average preference

(i) Overall	(ii) Aesthetic-educated	(iii) General public
(A)3.38 (B) 3.73	(A)3.0 (B)3.54	(A)3.49 (B)3.79

Analysis

In this case, a colorless and pattern-less architectural exterior is edited by eliminating the splicing of color blocks on the surface. In this case, compared to image(A), the edited image(B) is more favored by the subjects, especially in the group(ii). Also, group(ii) show their extreme preference for image(A).

Result	(B) No pattern and color > (A) Original

(5) Santa Fe de Bogota Foundation			
Image	(A) Original	(B) No pattern	(C) No color	(D) No pattern and color

Left column

Preference line graph and average preference		
(i) Overall	(ii) Aesthetic-educated	(iii) General public
(A)3.38 (B)2.9 (C)3.82 (D)3.17	(A)3.27 (B)2.46 (C)4.0 (D)2.88	(A)3.41 (B)3.03 (C)3.77 (D)3.25

Analysis

Judging from the overall result, image(C) which removed colors is the most preferred, and only a few number of the subjects do not like this image(the overall preference degree 1 and 2 only accounted for 8.7% in total), while image(B) that eliminated the pattern and retained the color is generally unfavorable. From the perspective of the group(ii), image(B) is apparently not preferred, but the perspective of the group(iii) the neutral choices account for the majority.

Result	(C) No color ＞ (A) Original ＞ (D) No pattern and color ＞ (B) No pattern

(6) Leixoes Cruise Terminal

Image		
	(A) Original	(B) No pattern
	(C) No luster	(D) No pattern and luster

Preference line graph and average preference		
(i) Overall	(ii) Aesthetic-educated	(iii) General public
(A)3.58 (B)4.14 (C)3.65 (D)3.87	(A)3.19 (B)4.04 (C)3.46 (D)3.77	(A)3.7 (B)4.17 (C)3.7 (D),3.9

Analysis

From the line graphs of the group(i), it can discover that the trends of image(B) and image(D) are quite similar, and the overall preferences are relatively high. However, the group(ii) shows that there is no positive favorability for image(A) which is the original architecture. In the part of the group(iii), the curves of preference distribution for image(A), (C), and (D) are similar. Although the average preference is comparable, the average favorability for image(A) is the lowest among the four.

Result	(B) No pattern ＞ (D) No pattern and luster ＞ (C) No luster ＞ (A) Original

Right column
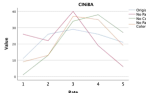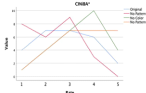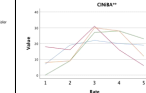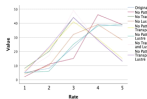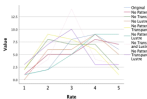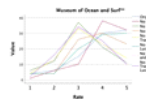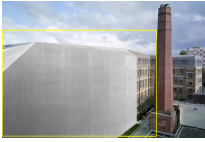
(7) CINiBA

Image		
	(A) Original	(B) No pattern
	(C) No color	(D) No pattern and color

Preference line graph and average preference		
(i) Overall	(ii) Aesthetic-educated	(iii) General public
(A)3.18 (B)2.62 (C)3.68 (D)3.37	(A)2.81 (B)2.27 (C)3.46 (D)3.58	(A)3.29 (B),2.72 (C)3.75 (D)3.31

Analysis

From the result of group(i), it can see that image(B) with the pattern removed and the color preserved is obviously the least preferred by most subjects, especially in the group(ii), and image(A) also has this tendency. In group(i), the line graphs of image(C) and (D) have similar trends, which are more favored by the subjects.

Result	(C) No color ＞ (D) No pattern and color ＞ (A) Original ＞ (B) No pattern

(8) Museum of Ocean and Surf

Image		
	(A) Original	(B) No pattern
	(C) No transparency	(D) No luster
	(E) No pattern and transparency	(F) No pattern and luster

Image		
	(G) No transparency and luster	(H) No pattern, transparency and luster

Average Preference		
(i) Overall	(ii) Aesthetic-educated	(iii) General public
(A)3.86 (B)3.96 (C)3.16 (D)3.68 (E)3.22 (F)3.88 (G)3.23 (H)3.19	(A)3.65 (B)3.58 (C)2.96 (D)3.5 (E)2.81 (F)3.88 (G)3.15 (H)2.85	(A)3.92 (B)4.08 (C)3.22 (D)3.74 (E)3.34 (F)3.89 (G)3.25 (H)3.29

Analysis

This case involves pattern, transparency, and luster, so three variable permutations and combinations were used to eliminate part or all of the visual characteristics to compare the differences in preferences of each sample. Judging from the line graphs of group(i), there is a strong preference for image(B), but from the perspective of group(ii), they prefer to image(F) which removed pattern and luster, than image(B). As group(iii), they apparently has a high degree of favorability for image(B), and the curve is consistent with the preference of group(i). In group(ii), the one that are less preferred is image(E), which removed pattern and transparency. In addition, in group(ii) and group(iii), image(G) that removed the transparency and luster both show a relatively neutral distribution. From the perspective of group(i), images (C), (E) , (H) show neutral degree of preference. On average, image(C) which eliminated transparency has the lowest preference.

Result	(B) No pattern > (F) No pattern and luster > (A) Original > (D) No luster > (G) No transparent and luster > (E) No pattern and transparent > (H) No pattern, transparent and luster > (C) No transparent

[Table 9] Results of the Second Investigation

	(9) Town Hall Hotel	
Image		
	(A) Original	(B) No pattern

Average Preference		
(i) Overall	(ii) Aesthetic-educated	(iii) General public
(A)3.11 (B)3.02	(A)2.69 (B)3.04	(A)3.23 (B)3.01
Result	(A) Original > (B) No pattern	

	(10) Laposa Winery	
Image		
	(A) Original	(B) No pattern

Average Preference		
(i) Overall	(ii) Aesthetic-educated	(iii) General public
(A)3.53 (B)3.3	(A)3.04 (B)3.27	(A)3.68 (B) 3.31
Result	(A) Original > (B) No pattern	

	(11) Denmark Pavilion, Shanghai Expo 2010	
Image		
	(A) Original	(B) No pattern

Average Preference		
(i) Overall	(ii) Aesthetic-educated	(iii) General public
(A)3.79 (B)3.66	(A)3.62 (B)3.65	(A)3.84 (B)3.67
Result	(A) Original > (B) No pattern	

	(12) Binh Thanh House	
Image		
	(A) Original	(B) No pattern

Average Preference		
(i) Overall	(ii) Aesthetic-educated	(iii) General public
(A)3.22 (B)3.59	(A)3.62 (B)3.65	(A)3.36 (B)3.57
Result	(B) No pattern > (A) Original	

|	(13) Carozzi Production and Research Food Center	
Imgae		
	(A) Original	(B) No pattern
	(C) No color	(D) No pattern and color

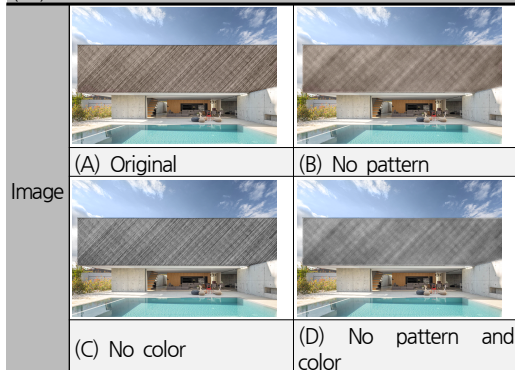| Average Preference			
(i) Overall	(ii) Aesthetic-educated		(iii) General public
(A)3.59 (B)2.65 (C)4.17 (D)3.18	(A)3.69 (B)2.19 (C)4.38 (D)2.96		(A)3.56 (B)2.79 (C)4.1 (D)3.24
Result	(C) No color > (A) Original > (D) No pattern and color > (B) No pattern		

(14) Musee Yves Saint Laurent Marrakech		
Image	(A) Original	(B) No pattern
	(C) No color	(D) No pattern and color
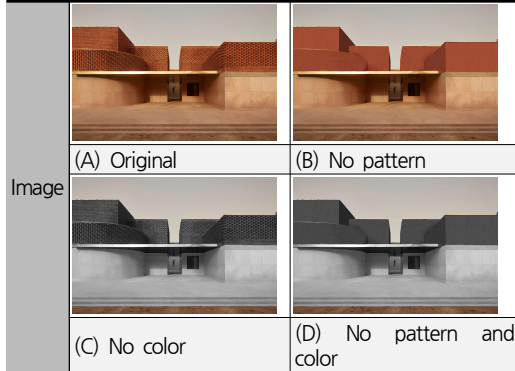
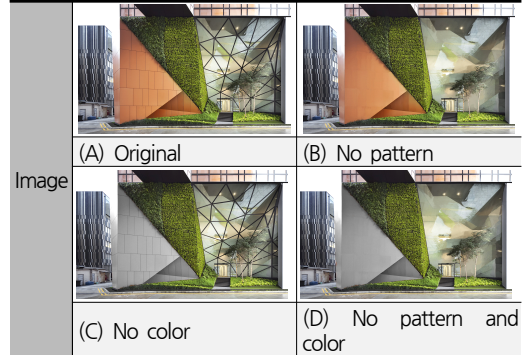| Average Preference			
(i) Overall	(ii) Aesthetic-educated		(iii) General public
(A)3.76 (B)3.27 (C)3.96 (D)3.48	(A)3.69 (B)3.31 (C)3.85 (D)3.38		(A)3.78 (B)3.26 (C)3.99 (D)3.51
Result	(C) No color > (A) Original > (D) No pattern and color > (B) No pattern		

(15) KOI Cafe				
Image	(A) Original	(B) No pattern	(C) No color	(D) No pattern and color

Average Preference			
(i) Overall	(ii) Aesthetic-educated		(iii) General public
(A)3.03 (B)2.9 (C)3.19 (D)2.5	(A)2.58 (B)2.5 (C)2.85 (D)2.35		(A)3.16 (B)3.02 (C)3.3 (D)2.55
Result	(C) No Color > (A)Original > (B) No Pattern > (D) No Pattern and Color		

(16) A House		
Image	(A) Original	(B) No pattern
	(C) No color	(D) No pattern and color

Average Preference			
(i) Overall	(ii) Aesthetic-educated		(iii) General public
(A)3.94 (B)3.42 (C)3.92 (D)3.51	(A)3.73 (B)3.0 (C)4.12 (D)3.42		(A)4.0 (B)3.55 (C)3.86 (D)2.54
Result	(A) Original > (C) No color > (D) No pattern and color > (B) No pattern		

(17) 48 North Canal Road		
Image	(A) Original	(B) No pattern
	(C) No color	(D) No pattern and color

Average Preference			
(i) Overall	(ii) Aesthetic-educated		(iii) General public
(A)3.35 (B)3.54 (C)3.79 (D)3.93	(A)2.73 (B)3.23 (C)3.42 (D)4.0		(A)3.54 (B)3.63 (C)3.9 (D)3.91
Result	(D) No pattern and color > (C) No color > (B) No pattern > (A) Original		

According to the results, about 41.2% of the cases show the highest average preference toward image(A) which is the original building. Suppose included cases that are not the most preferred on average but still have a high degree of affection (cases 5, 8, 13, 14, 15), then after comparing 17 cases, the preference for the original architectural exterior will reach to 64.7%. In contrast, cases 4, 6, 12, and 17 are the least preferred with the original architectural exterior. These cases show a high degree of relevance to pattern and color, while some other cases use pattern to create the exterior, which all national groups still prefer. Does this allow us to examine the order of pattern or arrangement density difference used in each case in-depth? For example, case 6 and case 12 both used the patterns with the denser arrangement, while case 11 and case 15 also used this method to perform the patterns on the architecture but did not cause such objection. Is the main reason for
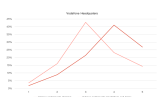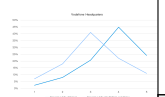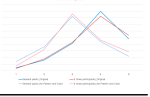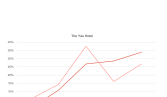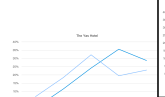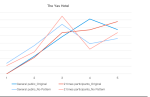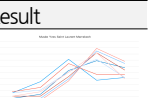
its influence on visual perception related to the order of the pattern arrangement, or is it because of the indirect creation of visual translucency through the pattern, thereby neutralizing the more negative visual responses? Furthermore, cases 9 and 10 show that the group of the subjects who have received aesthetic education seem to have strong negative responses than the general public. In addition, the use of color in these four cases is also required to further discussion. For example, case 4 uses stained glass to create a pattern effect and rich color on the surface while the subjects still prefer image(B) with a consistent appearance of color. In case 17, the images with higher average preference all received the colorless processes. Is it because the brick orange color used in the original architecture contrasts with the green plants so that failed to arouse the positive responses of subjects? Then, by observing the average preference of aesthetic educators and the general public, we can find that the aesthetic-educated group seem to be more sensitive to the colors used in architectures and reveal a stronger preference for achromatic color. Also, through cases 3, 6, 8, and 9, it can be found that the subjects generally show a favorable preference for maintaining the visual characteristics of transparency, translucency, and luster. Lastly, comparin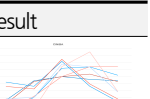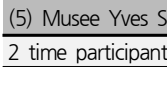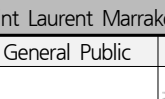g the average preference for the aesthetic-educated group with the general public, about 64.7% of the 17 cases presented the same sequences of average preference, which implicitly indicates that even have received aesthetic education, the general public still have the specific innate origin for cognition of beauty.

4.3 Comprehensive Analysis

The second experiment was carried out based on the results of the first experiment. This section will simply compare the distribution of preference ratios between the subjects who have participated in the first investigation and the general public of the second investigation. Since the participants in the two examinations were screened for "whether they have received aesthetic education" in the first stage, it can be indirectly confirmed that the participants in two experiments are all subjects without "aesthetic-educated." In addition, they are also included in the general public group of the second investigation. For the participants of the second experiment, the analysis method is to overlay the two line graphs and analyze them as "highly consistent," "generally consistent," and "non-conforming." (see table 10)

[Table 10] Comprehensive Analysis

(1) Vodafone Headquarters		
2 time participants	General Public	Result
		Highly Consistent
(2) The Yas Hotel		
2 time participants	General Public	Result
		G e n e r a l l y Consistent
(3) Islamic Religious and Cultural Center in Ljubljana		
2 time participants	General Public	Result
		Highly Consistent
(4) CINiBA		
2 time participants	General Public	Result
		G e n e r a l l y Consistent
(5) Musee Yves Saint Laurent Marrakech		
2 time participants	General Public	Result
		Highly Consistent

From the analysis of the table 10 above, it can be seen that the very first perception of visual stimuli were generally accompanied with the positive emotions. However, it does not mean that the positive emotions will definitely generated by the perceived elements. Apparently, it confirms that humans will indeed recognize the significant visual stimuli, and through the operation of the neurons, triggered the judgment of its preference.

5. Conclusion

This research started by defining the meaning of architectural exterior materials and their aesthetic value, discovered the shortcomings of current research on building materials, then analyzed the human brain's perception process of visual stimuli from the scientific perspective to confirm what visual characteristics can be perceived immediately. Next, introduced neuroaesthetics to discuss the generation of beauty cognition and found that regardless of whether it has a specific basis of art, the pleasant response generated in the brain stimulates the human perception of beauty. Then, with the advanced research of evolutionary aesthetics, it had been explored that humans' innate sense of aesthetics is related to the survival instinct. The elements such as water, food and the environment would trigger the instinct of creatures so that the adjectives like transparency, glossy, and shiny, which could be connected to survival elements, had evolved as humans beauty cognition.

In order to verify the inferences made in this paper, two investigations were carried out. The first was to examine the visual characteristics that humans could immediately perceive from the architectural exterior. There were 30 cases been selected as the sample to the experiments and these cases are generally recognized as beautiful architecture from the prize "Building of the Year" held by Archdaily. The second experiment followed the results of the first experiment, using 17 cases to examine the subjects' favorability for these visual characteristics. It was found that about 60% of the results showed a high degree of preference for the original architectural exterior, and part of the dislike of the original architecture was inferred to be related to the arrangement and distribution density of patterns and the color used on the building. However, the subjects generally showed a high preference for transparent, translucent, and luster architectural exteriors. At the end of the second investigation, by comparing the average favorability of aesthetic-educated groups with the general public, about 64.7% showed a consistent preference sequence, means that even if human have not received any aesthetic education, humans still have a certain innate foundation for the cognition of beauty. Finally, investigating the preferences between the subjects who participated in the two experiments and the general public, it has been concluded that although humans perceive significant visual stimuli rapidly, it does not mean that they will perceive pleasure through the elements.

According to this research, although there still have some issues which can be conducted with further in-depth investigation, it can be clarified that humans apparently have a higher degree of favorability towards specific visual elements. Exploring the reasons can have a grounded association with neuroaesthetics and evolutionary aesthetics. At the same time, it is confirm that even those who have not received aesthetic education have a certain degree of ability to appreciate beauty.

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