Examination of Logical Structure in Photo Series Using Electroencephalography and Eye Tracking Techniques

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Abstract: Creating a photography series has strong importance in photography but the aesthetic properties in photo series have different behavior than standalone images by well-known photographers. Since the invention of photography in the early 1800s, yet there is no specific structural way for its aesthetic management rules. This paper is proposing a scientific method which is connecting the photography's aesthetic principles with the cognitive subconscious. At this estimating method, tracking the eyes' movement and its relationship with the electroencephalography, which is a "technique for recording and interpreting the electrical activity of the brain." In particular, the relationship between eye-tracking and electroencephalography has been tested empirically in the two sets of images. The first set was a photography series (Broken Manual by Alec Soth), and the second set, standalone images of various photographers. Thirty art were students involved in measuring delta, theta, alpha, and beta waves through electroencephalography and also tracking the eyes' movements within Convolution Neural Networks (CNN). The final result of the data that has been found in this research area, illustrates that, in contrast to the second set, there is meaningful relationship between the photographs of the first set and also there are relevant differences between the two sets. (0.001=p). This work will advance the growing literature on the producing photography series and aesthetic management measure in visual arts.

Keywords: Photography Series, Aesthetic, Electroencephalography, Eye-tracking, Visual Arts.

I. INTRODUCTION

The transgressive aspect of digital photography was apparent even before its widespread adoption, and now with smartphones and similar gadgets along with embedded cameras it has been the proliferation of taking pictures and sharing which have become ubiquitous. Knowing the need to understand images in photography, each image must be categorized to be able to get analyzed.

On the topic of photography critique, the digital photography causes lower quality in terms of proportion with in the photographs [1].
In evaluating photographs, the digital photography usually take a lower place in terms of proportion within the medium.

Professional photographers place their work based on a specific subject or concept to create works which usually ended up in making photo series. This is why the photography series formed based on the rules and photography techniques which are being used by photographers to show an outstanding and specific goal [2]. One of the most important photo series in the history of photography is taken by group of 10 photographers that were

sent out by Farm Security Administration of United States to document USA in a time of Great Depression in 1930s. The goal was to photograph the effects of poverty on everyday life in rural and slum areas, such as the rural farmers at work and at home in their small-town communities, and migrants looking for work. Images such as 'Migrant Mother', by Dorothea Lange that became a defining symbol of the Great Depression, showcased the strife and fortitude of millions of other Americans at the time. The similarity of the subject in this field, and the photographers' ways of looking in this episode created a large photo series which is an important archive in photography [3].

Sometimes photographers use simple visual factors to manage a series, but at some point this becomes difficult and the photo series becomes a personal narrative and thought process of the photographer which is the result of their years of experience. Occasionally photography series like a movie or a fiction book tells a story. Also documentary and journalist photographs, that simply pictured events through photography lens [4]. Most of the time these images are accompanied by captions to explain the subject.

Other photography series such as sequence photography of Duane Michals represent the fictional artistic narrative of the artist. Storytelling is one of the axises of connecting images to each other.

Coordination and harmony between visual elements is the other aixs which is more important. Visual sequence first known by Eadweard Muybridge work [5] which later result in invention of cinema [6]. In the images of Eadweard Muybridge, beside the story telling, there are coordination of visual elements which create a sequence [7]. Based on this, the goal of this paper is to find a mmethodological approach for understanding a photo series. By using different ways to analyse, which could impact on the way of looking and figuring out the organization of visual elements in creating a photo series.

In this research work, the analysis of images has been categorized into two parts. First, the examination is based on visual pleasure in the visual cortex of the brain, which is part of the cerebral cortex that processes visual information. Secondly, due to Semir Zeki's research, it has been proved that the images have impacted the occipital lobe in the back of the head.

In this project, the visual effects of artworks on the brain, not only has been utilized for measuring their beauty content, but also for evaluating the works that are labelled as ugly, and the final result was quite impressive and effective [8]. The images examined in this project are divided into two groups. The premier group is the photo series called *Broken Manual* by Alec-Soth that was created in the span of four years (2006-2010). The second group is a collection of various images of different photographers.

The foundation of this research is based on comparison between the two groups of photographs. The following step is the assessing of eyes' behaviours by means of artificial intelligence (AI) via using prediction in evaluating their behaviour by tracking their movements based on Convolution Neural Networks (CNN). Recently the method of prediction of movement in neural network showed good results [9]. Analysis of the eyes' movements while looking at images provides a lot of information about the brain's observation. In addition, comparison and relation between the two mentioned methods, is a suitable and fundamental base for scientific analysis of photo series.

The second part of the research is related to the field of electroencephalography and its analysis and measuring of beauty. The third part is in relation to eyes movement and the necessity of their analysis while looking at the images. The fourth part, explains in detailed structure the exact methodology of doing all the process. The fifth section is about the final output results and the evaluation of the method along with some statistical tests.

Level-2. Neuroesthetics Studies

The subject of beauty in photography could be the central point to analyze the photograph. Some think of aesthetics as the result of human's study and understanding of beauty. The management of beauty is useful in the creation of a concatenate of beauty. Hans Hansen introduces aesthetic leadership as a promising approach in recent studies, that the inclusion of leadership models and the exploration of subjective leadership qualities, makes an aesthetic perspective in leadership especially attractiveness and timely [10]. Proportion, harmony, clarity, and perfection are part of the concepts that Thomas Aquinas addressed as the elements of beauty. The first definition of a beautiful object in his point of view is that looking at the object should go along with the pleasure to the viewer. In the second definition, he calls the objects beautiful when the actual comprehension causes joy and pleasure to the viewer. It seems that the first definition is for the visual aspect, and the second definition is for the content of the photograph. Thomas Aquinas does not limit the comprehension of beauty just to feelings, but he also includes the rational and logical understandings [11]. Plato in *The Republic* also says that beauty in objects might change or get destroyed. Some people might able to perceive the beauty and some of them may not at all [12]. Roland Barthes expresses the objects as part of cultural signs, that could each have special meaning in different cultures, and based on that, images might represent different meaning for each individual [13].

Aesthetics in different domains such as philosophy may have different definitions and meaning. Tolstoy in his book called *What Is Art?* Relates aesthetics to ethics [14]. On the other hand, the Empiricism believes that each object with beautiful nature should be considered beautiful. Philosopher Edmond Burke thinks that the human's body is like a machine that is in need of a reason for each reaction. Gabriel Starr scholar of humanities, science and aesthetic nerve studies in his book named *Feeling Beauty: The Neuroscience of Aesthetic Experience* suggests this hypothesis that the experience of nerve aesthetic is based on nerve's advanced architectural structure [15]. The contemporary art historian, Gregory Minissale, says about the conceptual art and the ability of light and aesthetic that this science can experimental results and be able to violate the past's theoretical and philosophical results [16]. Also Semir Zaki in his essay expresses that not every beautiful thing could be counted as an art, and beauty is not also the only reason for artistic works. Based on this count, he analysis the condition of aesthetics for art works [8]. In this reaserch, the participants, unlike the work of Professor Semir Zeki[1], had previous art background and educated in that field, but they have so many other similarities such as age, education, sight, being right hand, and no history of mental illness or nerve disorder. Based on the founding data, the result of the examination expresses, using the photography structure and rules can cause the organic coordination between the images

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[1] Semir Zeki is professor of Neuroesthetics at University College London, specialized in studying the organization of the visual brain and has since also contributed to studying the neural mechanisms, engaged during affective experiences, such as those of beauty, love, and desire

of the photo series that the viewer unconsciously focuses and understands.

In relation to the subject that was introduced earlier, Haeinn Lee and his team in their research on the effect of good and bad design on the brain, used the electroencephalography machine to look at the extended impacts of the element of design on the brain. Based on their experiments they found out that human's brain has a much faster reaction to bad design. Their tests on nerve's aesthetic showed that curved lines create more pleasant feelings in the mind in comparison to lines with sharp angles. Also the symmetrical forms draw attention more than the asymmetrical forms [17].

The image below is one of the materials used in the explained experiment.

Fig 1. case study for the experiment research about the brain's response to bad and good design.

In the data found in the Jaron Colas and Po-Jang Hsieh, it was specified the decisions that people make in facing the objects are related to their previous data stored in their brain. Therefore we can say that in a new situation, the majority of people are using assumptions. This subject can be analyzed in matters related to art. It is possible that a person, who sees a new piece of artwork for the first time, would look at it through her/his supposition about art. In this research, well known artworks were given to the participants, in an attempt to engage the part of the brain that relates to assumption. The founding of Jaron Colas and Po-Jang Hsieh proves the importance of titling and captioning of artworks. Looking at the waves of the brain data measured by the electroencephalography machine, it promotes and highlights valuable information about the human's decision making process which is useful to study art. Antonio Damasio believes that in addition to the logical parts of the brain, humans also use the emotional parts in decision making. Researchers are now using Functional Magnetic Resonance Imaging (FMRI) technologies, which show blood flow to different areas of the brain during shopping and making decisions on purchasing. Various studies have been conducted on the effect of advertising on the brainwaves of consumers and customers [18][19].

Emotional scenes increase the alpha wave activity at the left electrodes. Various studies have covered the effect of interest in brands [20]. Alpha waves are typically associated with relaxation, on the other hand angularity relates to the lack of concentration as normally it can be characterized by creativity and dreamlike thinking. This wave is observed during consciousness, when the person is at rest. People in the delta frequency wave state are lethargic, immobile, inattentive, and have a low level of arousal.

Theta waves are slow waves with a sinus rhythm. Theta is associated with emotion, creativity, inattention, daily thinking, depression, and anxiety. The beta frequency wave is also the fastest and most active form of short-wave of the brainwaves. It is related to the intellectual activities, concentration and focus of external attention and orientation, and expresses the state of open eye and the state of angularity. In the delta state, people are typically lethargic, inattentive, and have a low level of arousal. Usually Theta waves can be seen during sleeping, resting and dreaming. Theta frequency activity in the midline of the forehead (FZ) is typically associated with working memory. Alpha frequency is generally associated with creativity and also has a positive relationship with cognitive function and memory, and its high activity increases attention and memory [21].

Level-3. Eye behaviours' Studies

Looking or watching is a prerequisite for discussion and research work in the visual arts, as also has its effects. Examining these effects while measuring brain waves can also lead to new research fields. In the way they look and behave, Jianming Zhang and his colleagues believe that the human eye has different behaviors that can be used to study the structure of images [22].

In recent developments, the eye-tracking devices have been used to analyze eye behavior, including mutations and stabilization of the eye. This system by its own can be widely utilized to analyze a huge number of works in the field of visual arts. Studies have also considered eye behaviors to analyze people's health and lives. In the research of MéLodie Vidal et al., as well as Ulrich Ettinger et al., [23] the behavior of the human eye in front of objects or while watching television is examined to extract algorithms for their health [24].

It can also be seen in connection with the present study that the behaviors of the eye and beta brain waves together can be used to study aesthetics in visual works.

On the other hand, due to the visual nature of photography, the eye tracker can be assumed a smart and very helpful device. The eye tracker informs us about the usefulness of the image by analyzing information such as where the viewer looks and also how they look. Fixation, saccades, and the direction of the audience's gaze are among the eye behaviors that the eye tracker can record. One of the important applications of eye glare analysis is aesthetic design. By means of utilizing the heat map, it is possible to recognize

the user's points of interest. In the current aesthetic analysis, only two-dimensional images are considered [25].

II. METHOD

Level-2. Group of test images

In this analysis two sets of images are intended for testing. The first group is a collection of photographs of the famous photographer and belongs to the group of Magnum Photos, Alec Soth, and the second group consists of various images of conventional photographers that do not have a predetermined relationship with each other. Soth images in a set pursue a goal or depict the same subject, so the elements of the image are arranged in a chain. This has led to the selection of Broken Manual. The images of the second group were selected by other well-known photographers such as Cartier-Bresson and Duane Michals, regardless of the type of genre or the type of photography.

Level-3. Eye Tracker Simulation

Eye tracker is a device used to track an audience's eye. This device is used in two ways, in one type it is struck in the eyes of the audience like glasses and in the other type it is connected under the display to track the view of the audience. Two types of eye behaviour, gaze and movement have been studied in this article. Majority of the research studies have shown that places that are more important than other parts of an image have a gazing feature, and in less important parts of the scene, eye movement are observed [26]. For example, color protrusions or color contrast in an image will cause glare points in the contrast area [27].

In this article, artificial intelligence has been used to analyze eye tracker information. According to recent studies, this method has shown good results in this field and also in this study. The average of gaze points and eye movements have been calculated to optimize the final result. In addition to mention in some of the articles [28], the effect of eye-tracking on image elements in advertising methods has been studied, as a result of which the gazing parts have been more important than other parts. In the other hand some of the researchers [29] utilized the eye tracker has a subsidiary tool for cropping images.

In addition to aforementioned researches, an eye-tracking simulator has been used to predict the audience's gaze. This system, which is made of neural networks, has shown a good prognosis for the age group of children to the elderly [30]. The utilized model in the present study is based on the above article and it has been implemented along with some minor modifications.

Level-4. Quantitative electroencephalography

To perform the brainwave test, first an announcement was made for conducting this research at Tabriz Islamic Art University so that fortunately 30 male candidates accepted to be tested.

First, in an explanatory meeting for all test takers, the research process was explained by detail and the function of the device expressed to reduce the feeling of fear and anxiety for them. In the next steps, the electrodes were attached to the test subjects' heads and the test was performed. There were two groups of images in this test; the first group viewed the Broken Manual series of photographs from Alec Soth, and the second group viewed a collection of randomly selected photographs. The images of the second group were not similar in terms of content and form in order to measure the relationship between the images. Table 1 illustrates the process of performing the test.

Table 1. CONSORT chart

Call announcement: Participants n=30

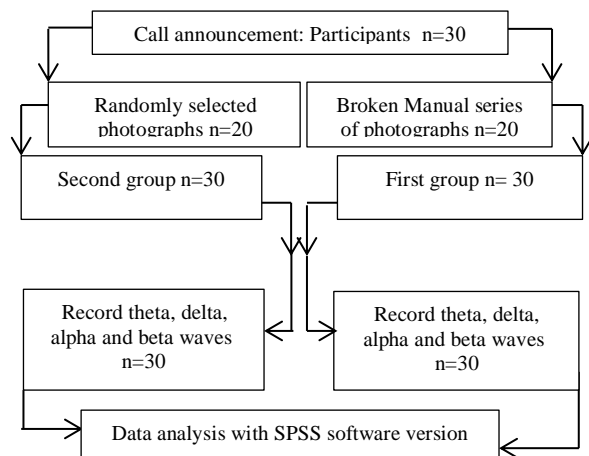| Randomly selected photographs n=20	Broken Manual series of photographs n=20
Second group n=30	First group n= 30
Record theta, delta, alpha and beta waves n=30	Record theta, delta, alpha and beta waves n=30

Data analysis with SPSS software version

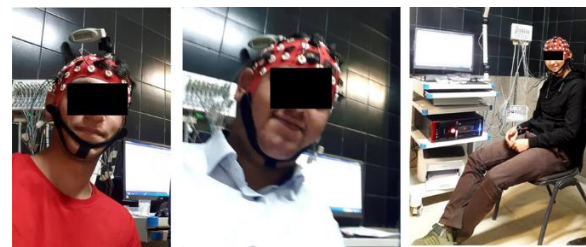Figure 2 shows images of participants preparing for the test.

Fig 2

Quantitative electroencephalography: uses the Neuroscan amplifier and the Electrocap cap, which is based on the International System of 10-20 and contains 64 electrodes, to record electrical wave imaging of the brain. For quantitative analysis, a complex FFT mathematical process has been used in which the recorded waves into numbers have been converted into graphs and images, and this process has been done with Neuroguide software. Reference electrodes A1 and A2 are also attached to the ears. The electrodes are placed on the head using a special cap based on the International System of 10/20. The waves were recorded using a sampling rate of about 500 Hz and with a frequency range of 0.1 to 40 Hz. The brain activity of each subject was recorded for 10 minutes with open and closed eyes at rest.

First, the recorded wave artifacts were removed as much as possible based on visual judgment, and an attempt was made to have at least a terrace of about 120 seconds of artifact-free waves for analysis.

III. FINDINGS

In this section, the results of data analysis are presented in two sections: descriptive and inferential.

Table (2) shows the descriptive statistics of brain frequencies of alpha peak, theta, alpha, SMR and beta in the aforementioned testbed.

Table 2. Descriptive statistics (mean and standard deviation)

Frequency band	position	mean	standard deviation
alpha peak	Group 1	10/84	2/81
	Group 2	12/15	2/81
Theta	Group 1	12/90	2/87
	Group 2	14/00	2/04
Alpha	Group 1	9/40	2/18
	Group 2	12/37	1/77
SMR	Group 1	8/09	3/56
	Group 2	9/62	3/46
Beta	Group 1	8/11	2/93
	Group 2	13/52	1/46

In this table, group 1 contains photos that are not a united series, and group 2 shows the Broken Manual series as a unite series. As Table 1 illustrates, participant' brain waves are different in each of the presented images.

Table 3. Mauchly's test sphericity

auchly 's Wa	Appr oximat e Chi square	d f	P			Epsi lonb	
				Green house-geisser	Huy nh-feldt	Lower bond	
Quali ficati ons							
15 0/8	168/86	9	00 /1 0	0/678	/716 0	0/250	

As the results of Table 3 shows, the assumption of homogeneous covariance homogeneity was not observed, P <0.005. Therefore, the Greenhouse-Geiser test was used, the results of which are reported in Table 4.

Table 4. Paired comparison test results

Variable	Group		t	SE	P
Alpha peak	Group 1	Group 2	-1/74	0/12	0/001
Theta	Group 1	Group 2	-0/75	0/45	0/001
Alpha	Group 1	Group 2	-1/52	0/72	0/001
SMR	Group 1	Group 2	-2/36	0/28	0/001
Beta	Group 1	Group 2	-4/74	0/57	0/001

In Table 4, the difference between the two groups was significant with P = 0.001 Thus, this result shows that the two groups have different attitudes of the respondents were of two types. In the next section, the analysis of eye behaviours' using the canonical neural network is visible. Figures 3 to 5 show clear examples of heat maps.
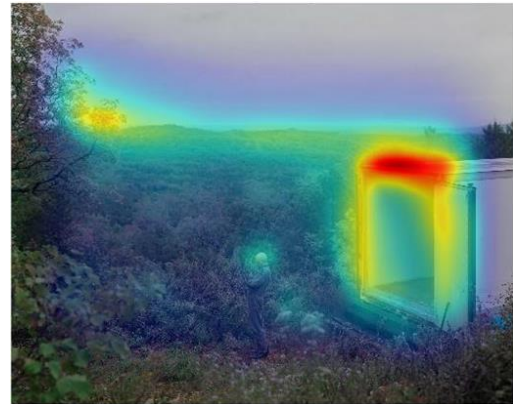

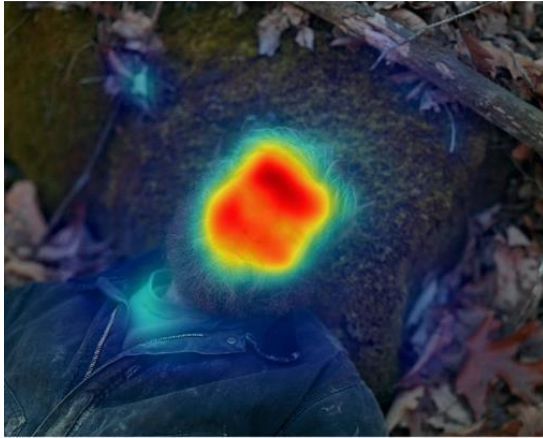Fig 3. gaze prediction of Broken Manual

Fig 4. from Broken Manual

Figure 5. form Broken Manual

As it can be seen in the images, the points that focus the audience's eyes are the points that the photographer intended. In Figure 3, the heat map represents that a person is living alone along with his cat in his vehicle. Figure 4 shows the dining table of a person living in a forest. The prediction in this image is to look at the most important components of the image, namely food. Figure 5 shows the face of a man lying down with his entire face focused in this photo. Figure 6 shows the heat map images of the Broken Manual complex.
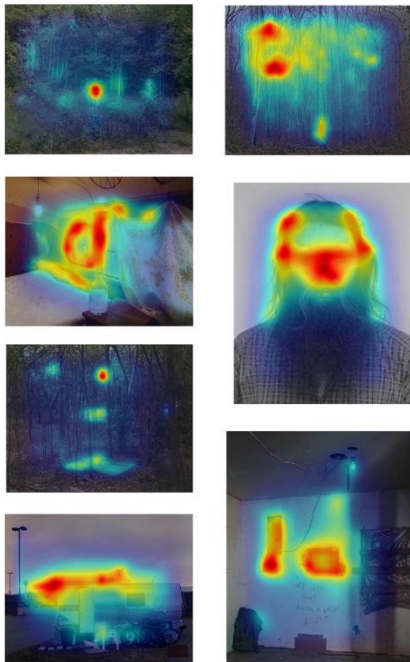

Figure 6

The heating map images obtained from the second group of photo sets show different glare points that can be seen in Figure 7.

Figure 7

With a little attention to the photos in the second set, it is possible to achieve that the gazing centers marked in red. These points indicate that the important subjects in each of the images are scattered, unlike the previous collection. This scattering indicates a mismatch between the content of the images. In the pre-meaning set, the chain was noticeable by the heat map. All the important elements in this collection were in focus and gaze. This means coordinating the content of all images in the series.

IV. CONCLUSION

It can be seen that a systematic series of photographs is created with pre-planned goals and with well-considered photographic rules. Although a precise and scientific definition requires further research on photographic series, the effect of proper composition in the appropriate genre of photography cannot be ignored, nor can the techniques and requirements of photography be ignored. By examining the Broken Manual, the regular use of composition can be seen in all photographs in the collection, so that the subconscious is perceived by the test participants. In his interviews about this series, Alec Soth said that the loneliness of people, their way of life and the place where they live. Important image is located. These focus areas included elements that were related in meaning and content to other images in the first group. With this study, it can be concluded that the photographic images created for a specific purpose will be accompanied by specific and identical features in the content and visual objects.

For example, the places in the Broken Manual series are connected in a chain manner and prevent the content of the collection from being separated, which in turn creates mental harmony in the audience. Also, in the photo collection of the second group, all the centers of attention were not related to each other. By comparing the results of the two groups, the valuable effect of a set of photographs and the power of its effect in the field of photography can be understood. Photographic images within a collection of photographs, contribute to the power and influence of visual content and convey this theme to the audience, and this can be a fundamental difference between a collection of photographs and single photographs, although many single photographs

are influential in the history of photography. Nowadays, with the advantage of digital technology, the effectiveness of single photos has decreased. As a result of pairwise comparison between the two sets, a significant difference is observed. This difference means that the people in front of the images had different perceptions of the sequence of the images. Thus, it can be concluded that the attitude towards these two collections has different result and feedback. In future research, the authors seek to test scientific methods on the visual arts in relation to the analysis and critique of works of art in galleries and museums.

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