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S. ZEKI AND NEUROAESTHETICS – A POSSIBLE FRAMEWORK TO OBJECTIFY AESTHETICS

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ABSTRACT
This article surveys the research and findings of neuroaesthetics, a subfield of neurology and empirical aesthetics. The main motivation for this line of research, which dates back to 2002 and probably even earlier, is a scientific study of the visual information processed by a human brain that is connected to or influenced by an aesthetic judgment. We discuss here mainly the work of S. Zeki, considered by many the founder of neuroaesthetics.
We argue that the active nature of the process of seeing, and its structured and modular character, has its pendant in the structure of visual art – which is created and evaluated by brain. Thus an inquiry into the structure of the visual brain can provide information on the nature of visual art. This is in accordance with our "structuralist approach" to study of art, and can in a way be considered as an extension and a critique of Zeki's position.
Keywords: aesthetics, neuroaesthetics, visual brain, perception, internalism vs. externalism.

1. Introduction

It is hard to imagine a meaningful discussion of aesthetics without reference to works of art. One may suggest to consider art as an experiment of a kind in the realm of aesthetics – the highly subjective notion of "beauty and ugliness" is thus transformed into an objective one with literally thousands of years of data available to us in the form of artistic work.[1] This is analogous to mathematics – which is also "unempirical" to an extent – for mathematicians, the process of formulating hypotheses is a kind of mental experiment.

Focusing on the visual art, one may ask what is the "mechanics" behind these experiments in art. Can artists draw or paint something which is completely beyond their visual experience? Or are they determined by the process of seeing? Unless the nature of "visual experience" is more qualified, the obvious answer is that almost by definition, a good artist transcends what he or she can see. Indeed, the modern art can be considered as supporting this position. Since Duchamp, the retina art is considered as a thing of the past and the ideas, inventions, and surprising and unexpected contexts are more and more important.

[1] This assumption should be taken as a methodological position only, without the ambition to reduce all aesthetics to art.

On a more closer look, however, the definition of "visual experience" can be more extensive and include imagination, willful distortions of image, mixing of contexts, addition of dream-like components etc. With this more general definition, the image components of a dream are always within the boundaries of visual experience, for instance. One may view Zeki as a proponent of the thesis that visual experience in this more general meaning is determined by the structure of the brain and is reflected in the works of art. More specifically, he postulates a link between the visual brain[2] and works of art in the sense that the former determines the latter in some way.

Such a claim is of course hard to verify unless we know more details about the actual structure of the human visual brain and the brain in general. In the late 1990s, with the advent of new modern imaging methods in medicine,[3] it started to be possible to study the visual brain objectively. Zeki can be seen as a pioneer in the new field of neuroaesthetics, created around this concept. New discoveries by Zeki on the visual brain showed that the visual brain is more complex and structured than previously anticipated (see Section 2 for more details). Based on these new results, Zeki formulated his key principle that the function of art is the same as the function of the visual brain:

> "… art has an overall function which is remarkably similar to that of the visual brain, is indeed an extension of it and that, in undertaking its functions, it obeys forcefully the laws of the visual brain." [22, p. 8]

We may rephrase the same idea without the word "function" as follows:[4]

> There is a structural resemblance between the visual brain and visual art. The structure of the visual brain has a constitutive effect on the structure of (visual) art.

By this principle, the study of the visual brain enables us to formulate hypotheses on the nature of visual art and aesthetics in general.

The contents of this paper are as follows. In Section 2, we concentrate on the biological structure of the visual brain. In Section 3, we discuss the connection between brain and art, based on the results developed in Section 2. In Section 4 we provide a summary of the results and suggest possible ways of further study to objectify the notion of aesthetics.

2. From the biological point of view

In this section, we discuss the structure of the human brain, and specifically its visual part, from the biological perspective.

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[2] A part of the cortex used for processing visual information.

[3] CAT (computerized axial tomography) in 1970s, SPECT (single photon emission computed tomography) and PET (positron emission tomography) in 1980s, MRI (magnetic resonance imaging) also in 1980s and fMRI (functional magnetic resonance imaging) in 1990s.

[4] "Function of art" may sound too mechanical without further qualification.

2.1 Zeki and neuroaesthetics

Let us start with same historical data. Zeki is a professor of neuroaesthetics at the University College London. In the center of his interest stands the visual brain of primates, mainly humans. Since 1994, Zeki has focused more closely on the neural basis of aesthetic feelings with special emphasis on art and artistic work. He perceives his study in neuroaesthetics as "a theory of art that has solid biological foundations" [20, p. 1].

Zeki earned his reputation in neurobiology by a successful research of the brain, with emphasis on the visual cortex in humans. He discovered and localized several parts of the visual brain responsible for processing different attributes of visual information[5] and showed that these parts of the visual brain are both processing and perceiving – contrary to earlier assumptions. He refuted the thesis that a colour is perceived by the brain solely based on its physical attributes (such as wavelength) when he discovered neurons in monkeys which react only to a specific colour, see also [9]. Furthermore, he showed that different attributes of visual information are forwarded for processing selectively with different speed. All these results together suggested that seeing is a much more complex process than previously thought.

The exploration of the visual brain and new results made possible by new imaging methods led Zeki to questions concerning the aesthetical quality of the information observed and its effects on the processing of that information in the human brain. He concentrated on a deeper study of neural mechanisms of higher cognitive judgments (aesthetic as well as moral, [11] and [19]). He currently focuses on neural correlates of different mental states including love, beauty, and hate (see the latest [10]).

His research and work has been widely discussed in the field of cognitive science; see for example the conference "Neuroesthetics: When Art and the Brain Collide" held in the year 2009 by the university IULM in Milan and the journal Situated Aesthetics [12] or the conference "Making worlds, Fare mondi – Neuroscience and Art in Dialogue" in Venice 2009 held by the Association of Neuroesthetics – video available on youtube [15].

Works linking aesthetics and the visual brain function started to appear by the end of the 90s – making it a relatively recent phenomenon. See for instance [20], or the Volume 6 of the Journal of Consciousness Studies [7] (with the subtitle "Art and the Brain") which includes contributions by several researchers ([16], [4], and [8]). The notion of neuroaesthetics gained its formal acceptance only in 2002. The Institute of Neuroesthetics, based in the Laboratory of Neurobiology (Vislab) at University College London, and in Berkeley, California, created by Zeki, is the current center of this research. The motto of the Institute is succinctly summed up as follows [1]:

> "to further the study of the creative process as a manifestation of the functions and functioning of the brain; and to study the biological foundations of aesthetics."

[5] Functional specialization of the visual brain – for motion, colour, body language, etc.

Institute's work on neuroaesthetics is based on the following three suppositions [1]:[6]

- All visual art must obey the laws of the visual brain, whether in conception or in execution or in appreciation;
- Visual art has an overall function which is an extension of the function of the visual brain, to acquire knowledge;
- Artists are, in a sense, neurologists who study the capacities of the visual brain with techniques that are unique to them.

These theses elicited strong reactions. We first review the fundamentals behind these theses in Section 2.2, and discuss the wider responses in Section 3.3.

2.2 Theory of seeing

Below, we summarize the basics of the recent advances related to the nature of seeing. This is of course a vast area far exceeding the scope of this article. We give only a short outline of a few aspects related to our aesthetical studies.

Seeing as a process

Visual stimuli processing action is the quickest one of all the stimuli processing actions, and arguably the most effective. For capacity restrictions, it is impossible for a human brain to gather and process all the information seen, and thus the information getting to the visual brain for processing needs to be pre-processed. The eye is not a passive receiver of the visual information, just passing it further. It filters the visual information (it registers the changes in the intensity or wavelength of the light) and while it focuses on a specific part of our surroundings, it "chooses" the part of the seen that will be given more "memory space" and thus will be processed later in more detail and more precisely.

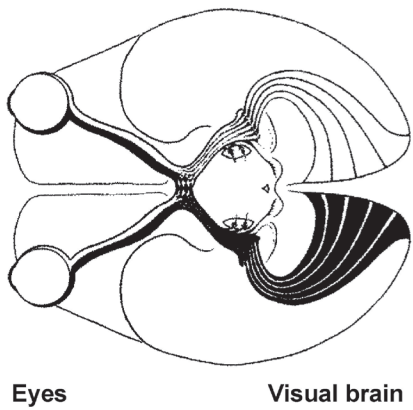

Figure 1: The fiber connection between eyes and the visual brain.

[6] The motivation of these suppositions will be more apparent after reading Sections 2.2 and 3.

To understand the visual information processing it is necessary to realize that the image a human brain creates is not a mere copy of reality. Seeing and understanding are two inseparable processes. Due to the preprocessing of visual information, the eye is called "the seeing eye". The rules for the pre-processing stage performed by the eye are still not known in detail; we do know that some part of this pre-processing stage is performed by the eye itself (an eye was originally a part of the brain and evolved from it). The retina in the eye has a specific part called fovea, which is used for capturing details. The part of the seen stimulating fovea is allocated a much bigger part in the brain compared to the whole image observed by all retina.

The picture of reality in the brain is thus not an image similar to a photograph, it is more like a dynamic, evolving, and constantly changing map placing emphasis on specific parts of the view field.

The visual brain and its functional specialization

From the eye's retina, the visual percepts proceed to the primary visual brain. The visual brain or visual cortex is a part of cerebral cortex processing visual stimuli, and its located in both hemispheres. By results of Zeki, visual cortex consists of parts with different specializations which are used for processing different attributes of the visual information.

The functional specialization of the visual brain parts is still under study, yet we do know the basics. The primary visual cortex denoted as V1 is the earliest cortical visual area, the only one prepared for functioning at birth. V1 is specialized for processing information about changes in movement of objects and is associated with pattern recognition. This part also processes stimuli from fovea and hence a large portion of the primary visual brain is associated with a comparatively small part of the retina processing information originating in a small part of the visual field.

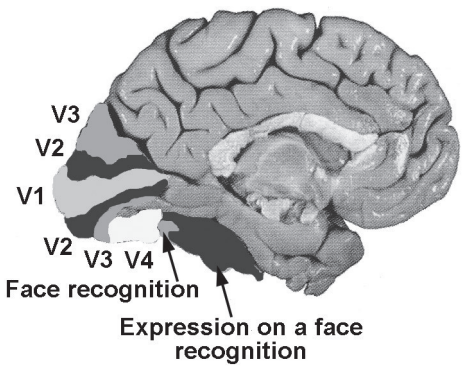

Figure 2: Parts V1 – V4 of the visual brain.

The functions of the pre-striate cortex, denoted as V2, are very similar to the primary visual cortex. Cells in this part react to orientation, colour and spatial frequency. The information en route from the primary visual area to other areas passes through V2. The

third visual brain denoted as V3 processes the global motion. The cells specialized on lines of different gradients are associated with the biggest part of the visual field. The V4 part processes colour, and cells in this part are associated with a relatively large portion of the receptive field. V4 reacts, in addition to colour, to orientation, spatial frequency, and to simple geometric shapes.

V5 specializes on motion. This is the only part of the visual brain with a direct connection with the eye (apart from the primary visual cortex). This means that the center for processing motion may receive data using two distinct paths – through V1 and directly from the eye. The direct path enables faster reaction times to movement. The reasons are most probably evolutionary as a quick reaction to movement might have been crucial for survival. V5 is also the center responsible for some eye movements.

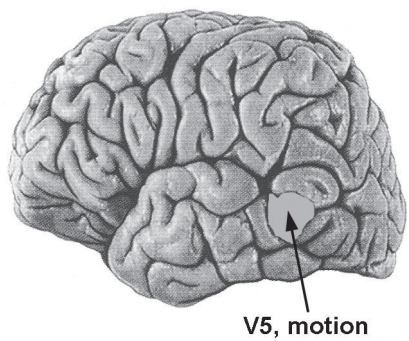

Figure 3: The V5 part of the visual brain.

Zeki in his book [22] specifies – in addition to form, color and movement – further functional specializations of the visual brain; these are linked to special attributes of the visual stimuli: light, body language, face and facial expression, and even the depth of the reality seen. The latter is of particular interest to our setting and is in accordance with the research of Sakata [17], [18]. Sakata claims that monkeys (whose system of seeing is similar to that of humans) have special neurons that combine visual hints about the depth of the visual field (like shades) and linear perspectives.

Modularity of seeing

The discovery that there are different parts of the visual brain specializing in processing different attributes of visual information has been one of the main scientific achievements of the recent years. Yet the exact nature of functional specialization of the visual brain still remains one of the big questions of neurobiology. There are other parts believed responsible for other specific attributes of visual stimuli, but the main unknown is how the resulting data are synthesized. Neurologists conjecture that there is no special center of the visual brain that synthesizes the resulting data from the specific visual brain parts.[7]

[7] Contrary to expectations, V1 as the primary center does not fulfill this function.

The specialized centers of the visual brain are known to be both receiving and transmitting and it is also known that they are mutually interconnected. It seems therefore reasonable to assume that they communicate with each other. Details of this process are as yet unknown and even the existence of such communication is presently conjectured only.

The separation of visual stimuli is known to be present already during the perceiving stage and occurs in the following order: colour, form, movement (the difference is approximately 60–80 ms). These were examined via the reaction speed to the change of single attributes and via the inability to see the change in other attributes.

Thus it seems that a human brain uses a modular system to process visual data. As we have mentioned above, it is assumed that specific centers communicate with each other without a centralized "unit" or center.

3. From the aesthetical point of view

Following the brief overview of the biological facts in Section 2, we discuss in this section the main theses of Zeki's work in neuroaesthetics and test it against other approaches.

3.1 Brain and art

During his work on the brain structure, Zeki became interested in the ways our brain sees, processes and evaluates art. Similarly to an analysis of evaluation processes in the brain connected with judgments in general, Zeki seeks to find out which neurological processes stand behind judgments such as "I like this picture". In his work, he formulated as a guiding principle the thesis we have quoted in Section 1 which draws parallels between the function of the visual brain and the function of art. To put this principle succinctly, he claims that art is created by brain, and must therefore obey its rules. The very fact that the process of seeing is an active and structured one implies that seeing cannot be equated with "taking a photograph" of reality – rather, the mental image of reality is a result of complex procedure governed by the rules of the visual brain. Artists cannot escape these rules entirely, they can just bend them a little, argument the image with their memories, feelings, etc., but cannot stand outside and above them.

Also, artists create their work for perception by other human beings. Thus, the work must be backwards decipherable, at least to a certain extent, by the visual brain. Just as brain captures an idea of a tree, for instance, based on all possible physical instances of trees, artists behave in principle in the same way – they try to render a tree in a way that everyone recognizes a tree in the drawing; artists thus attempt to capture the essentials of a notion, just as a rational reason does. Since the visual art is a product of human brain, Zeki concludes that to study aesthetics from the neurobiological point of view, the function of art has to be defined similarly to the function of the brain, that is

> "… to represent the constant, lasting, essential and enduring features of objects, surfaces, faces, situations, and so on, and thus allow us to acquire knowledge …" [22, pp. 9–10]

Any attempt to describe a judgment on aesthetical values, or any attempt to formulate rules on such judgments, must therefore be based on the ways brain processes visual art, and visual information in general (even if it does not contain an apparent aesthetically relevant component).

Perhaps this idealistic reduction of art to mere "logic of brain" produced the strongest reactions. There are other theories and the whole emerging area calls for a more balanced and structural approach.

3.2 Neural correlates of beauty

It was Kant who posed the following question: "What are the conditions implied by the existence of the phenomenon of the beauty and what are the presuppositions that give the validity to our aesthetic judgments?" In their work [11, p. 1699], Hideaki Kawabata and Semir Zeki set out to

> "… attempt to address the Kantian question experimentally by inquiring into whether there are specific neural conditions implied by the phenomenon of beauty and whether these are enabled by one or more brain structures."

Their research was a pioneering work in an area of experimental application of theoretical results of neurobiology with the focus on the assessment of the works of art as regards their aesthetical value. This contrasts with the previous works in this field which dealt with simple geometrical patterns rather than real artworks. Their exceptionally well-researched article invited a lot of reaction and followers.

We now know that in order to judge the aesthetical quality of a picture, the human brain uses the frontal part of the brain, called prefrontal cortex, which is usually connected with memory and higher decisions. The judgment about an aesthetical quality of a picture is thus assumed to be a standard decision-making process, taking place in the area of the human brain that usually deals with decisions using the visual-space memory. How much memory is used for these operations (how much and in what sense) remains unknown at present. One can assume that the evaluation of immediate perception is influenced by the visual-space memory available to an individual; this interaction with information stored in memory suggests an explanation for different aesthetics in different historical ages, and why it changes with geography and education. The use of prefrontal cortex (a center of higher cognitive functions, including distinguishing between right and wrong) suggests that aesthetical judgments are judgments in the strict sense of the word, much as moral judgments are. This opens aesthetical judgments to further empirical study within a well defined framework.

For the purposes of their research, Kawabata and Zeki distinguish three aesthetical categories: beautiful, neutral and ugly. Contrary to their expectations, their research showed that there are only two brain patterns associated with these three categories. One for the neutral and one for the beautiful and ugly. However, the beautiful and ugly stimuli do differ in one aspect: even though processed in the same center, they are processed with a different intensity – the beautiful with a stronger one, the ugly with a weak one. This article initiated a deeper study of the processes in the human brain connected with the

visual information with special emphasis on its aesthetical components and comparisons between aesthetical and moral judgments (see for instance [19]).

3.3 A wider perspective

The study of aesthetics is sometimes assumed to be subsumed in the general study of the mind. Nowadays there are two general standpoints on this more general nature of aesthetics which are relevant for us: they are called internalism and externalism. The distinctions between these two standpoints are rather fuzzy, but the general idea is that the proponents of the internalism tend to explicate aesthetic judgments by means of an isolated individual while the esternalists claim that the external circumstances play an inherent role in this process. This is not the say that internalists deny the constructive role of the external world, but their notion of the mind is limited to the individual.

Recent advance in neuroscience seem to give new convincing arguments to those who claim that aesthetics resides with the subject. According to Ricardo Manzotti in the Preface to Situated Aesthetics [12], there are those who claim that the aesthetical experience "will one day be identified and dissected by either psychology or neuroscience" [12, p. 1]. Manzotti disagrees with this sentence being an externalist himself. When he quotes Semir Zeki, he chooses the following sentence: "there can be no satisfactory theory of aesthetics that is not neurobiological based" (cited in [12, p. 1] from [21, p. 52]). Very often (see the Conference proceedings [12]) sentences like these epitomise the main critique of Zeki's theories, namely that he mistakenly claims that aesthetics can be reduced to neurological processes. For instance, Lambros Malafouri claims

> "… I believe that the underlying 'internalist' assumptions in neuroaesthetics that one sees with the brain …, or that there might be inside our brains some universal neural signature of beauty …, are deeply misconceived." [12, p. 134]

> "… I categorically reject that such a 'neural correlate' can be seen itself as 'sufficient', or as having any 'ontological' priority or 'constitutive' role in the production of human aesthetic experience (including but not limited to beauty)." [12, p. 134]

In a more general framework, the notion of "Situated Aesthetics" is proposed as an alternative to the internalist's viewpoint. Centered around the externalist tenants it seeks to provide a framework for analyzing aesthetical experience as situated in the real world [12]. These approaches share the same benefits and drawbacks of the analogous theories of the mind. There are sometimes convoluted in the attempt of the full generality of exposition, yet often fail to provide a useful discourse for specifically aesthetical questions.

In our opinion, as illustrated by our discussion of Zeki's viewpoint above, much of the dispute with Zeki and other neuroscientists rests on a premise that they (Zeki and others) somehow reject any importance of the external circumstances of the aesthetical judgments. We believe that this is a misunderstanding as we view Zeki's theory as an attempt to say something meaningful about aesthetical experience from the neurobiology point of view without the ambition to provide a general framework.

4. Conclusion

The approaches and topics studied in [13], [14], and [5] are driven by the working assumption that one can objectify certain aspects of aesthetics, as considered relevant for the specific task at hand – in particular, we focus on the aesthetical component of visual information. This research extends the previous efforts, e.g. [3] and [2]. Neuroaesthetics can be considered as one of the ways to achieve this objectification for a certain non-trivial part of an aesthetical judgment. However, we do not claim that neuroaesthetics' view encompasses all relevant factors, neither that it answers the philosophical question about an aesthetical mind or beauty. Other approaches to structural aspects of aesthetics include the aesthetics processing [6], and the *hereditary thesis* introduced in [14], see also [2].

Our statement is that the visual information processing is inseparable from its aesthetical component, and therefore a working scientific theory of aesthetics is a step to a better understanding of visual perception in general. We believe that the neurophysiological component is a very important part of this phenomenon.

The alternatives to the neurophysiological standpoint are beyond the scope of this survey and will be taken up in the upcoming [6].

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