

Problems of the System Approach to the Study of Psychophysiology of Aesthetic Emotions Concerning an Architecture

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Abstract— The forming in architectural creativity is the process of generation of architectural forms, the morphogenesis of "structural information". The search for principles, methods, and regularities of the forming process, i.e., the semiotic basis of the theory should be carried out as the search for cognitive principles and objective psychophysiological foundation for creation and perception of the spatial environment by humans. This paper is aimed to reveal the essence of the interrelation between psychophysiology and geometric semantics of architectural form as a lingosemyotic structure. This interrelation represents the affective and reflexogenic basis of the spatial imagination and the corresponding dominant activity of the neural network. It turns out to be the basis of the theoretical concept of the study of psychophysiology of aesthetic emotions in the perception of form. The main subject of the paper is discussion of proper theoretical base for revealing the directions of experimental work providing objective results in neuroscience and for developing the architecture education methods. A list of necessary experiments on personal emotional reactions on architecture objects is proposed.

Keywords - architecture; structural information, cognitive; spatial imagination; neural network; emotional perception; experimental aesthetics.

I. INTRODUCTION

Neuropsychology of perception of the architectural form and artificial spatial environments by humans is an actual scientific problem. The study of it has become a special subject of the American Academy of Neuroscience for Architecture. There is a whole direction of "healing architecture" in European projects for healthcare. While studying the influence of three-dimensional visual stimuli on the brain, Russian and European scientists may potentially need a multidisciplinary study of the processes related to cognition and perception.

The paper is organized as follows. Section II differentiates streams of aesthetic rating and cognition of recognizable pattern vs archetype of perception [1]-[5]. Section III presents theoretical basis for the separation psychophysiologicaly conditioned modes of spatial imagination according to Duran [6] and some visual geometric representations of those modes [7]-[9]. In Section IV, it is given a brief comparison of the concepts discussed by Duran [6] and Ukhtomsky [10]. In Section V, it is proposed a list of necessary experiments. The conclusion outlines future effects and unresolved problems of investigating the connection between formal characteristics

of an architectural form as a visual stimulus and psychophysiological responses.

II. COGNITION OF RECOGNIZABLE PATTERN VS PERCEPTION OF ARCHETYPE

From the variety of conceptions [2], we see that cognitive and perception processes (see Table 1) are the interaction of two informative horizons, i.e., the language of concepts and the visual language representing a three-dimensional lattice for sliding the composite design. The experimental aesthetics of Fechner (Table 1) discerns associative and direct factors of the aesthetic impact of the form, similar to the concept of Shapoval [3] (see Fig. 1).

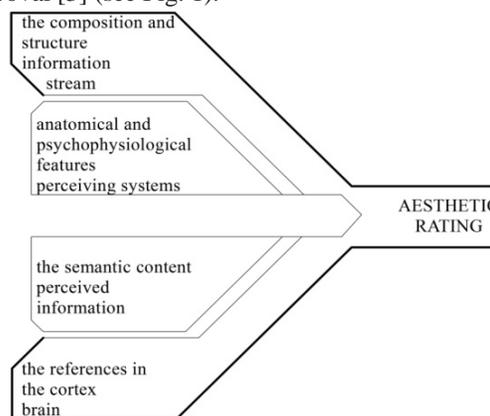


Figure 1. Two streams of aesthetic evaluation.

There is a wide connection between the streams of aesthetic impact and combinatoric levels of architectural form. The structure of architectural form is a kind of two-level grammatics (see Table 1).

TABLE I. COMBINATORIC LEVELS OF ARCHITECTURAL FORM

Researcher	Combinatorial level of architectural form	
	Signs, symbols, Pattern associations	formal geometric (archetypes) and Abstract associations
Fechner [1]	associative factor	formal factor
Jenks [4]	signifier	signifying
Alexxander[5]	pattern language	-
general	recognizable types of forming	geometry archetypes

Primary geometrical elements give abstract associations because of connection with genetic archetypes of artificial perception. The problems of genetic archetypes (primary instruments of forming the architectural object), rhythm, meter, space, metaphor, etc. equally (if not more) belong to the problem area of architecture, which is usually defined as the theory of architecture. The rhythm archetype has no clear foundation in the theory of architecture: there is a lack of general theory of composition at the formal and subject levels [1]. The fundamental archetypes of architectural forming are determined as geometrical manifestations of revealed anthropological structures of the imagination [6]. This implies the reflexes based on archetypal groups of the spatial-imagination basic patterns [6]. Stable morphological artifacts of the architecture could be called "ARCHItypes" by analogy with recognizable types in other fields of culture. The neuropsychological studies of the archaeologist and anthropologist David Lewis Williams [7] are interesting in this regard. His experimental work shows that the motor skills of the modern subjects at drawing geometric primitives are completely analogous to the cave ones [7]: metric linear grid, ornamental concentric and rhythmic motives, spiral forms, etc (see Fig. 2).

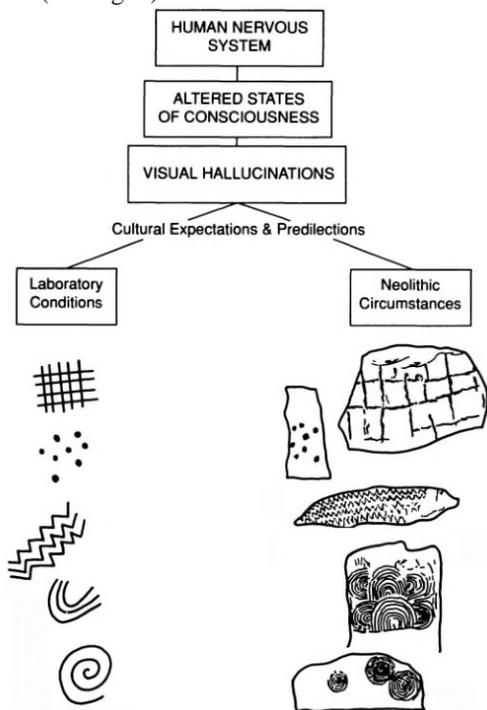


Figure 2. Comparison of the entoptic forms depicted under laboratory conditions (after Siegel 1977) and in Neolithic art [7].

All this is currently used by the formal contemporary art and architecture. That is why ARCHItypes should be considered as stable and typologically recognizable elements of architectural forms and composite structures composed of them, bearing certain symbolic meanings and correlated with the epoch and style. Archetypes are geometrized manifestations of the spatial-imagination modes having a reflexogenic nature, as it was shown in Williams's

experiments and Picasso drawings (see Fig. 2 and Fig. 3). Let us recall that the primary art examples are more ancient than languages and architecture for more than 40 800 years BC [8]. From this viewpoint, the imagination mechanisms for the mass, space, and metro-rhythmic ratio represent the "archetypes" of architectural form [1]. The primary elements of architecture and the rules for their connection are still the main problem in the theory of architectural composition, being not its specific subject.

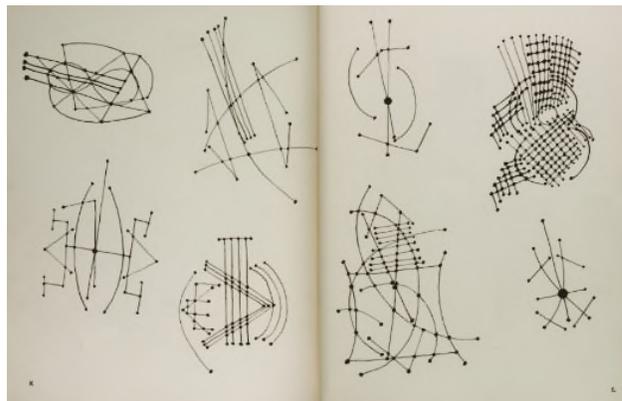


Figure 3. Drawings of Picasso (extracted from [9]).

Figure 3 represents the drawing of Picasso (1924) included in the illustrated edition "Unknown Masterpiece" [9].

III. DURAND'S COGNITION CONCEPT

A. Durand's concept about archetypes of spatial imagination

An interesting research of the archetype revealing in art structures has been performed by Durand (1921-2012) in the middle of the XXth century [6]. This research was based on the reflexology of Bekhterev, Jung's psychotherapy statistics, and the seminars "Eranos" (see [6] and refs. therein). The Durand's concept is completely compatible with the system-active approach [2] currently used in researches on the theory of architecture. It refers to the triad of the thinking and modalities as the base for the superstructure. This triad involves the imagination, the subject, and the object of imagination. Within the Durand's concept, this triad confronts the absolutely opposite (with respect to imagination) concept, i.e., "the time is death" [6]. An analysis of imagination modes leads to the inference that they are based on both, psychological as well as physiological mechanisms of perception and interpreting the physical laws and phenomena of the material world. From the viewpoint of Durand, anthropological structures of imagination, i.e., the process of forming appears to be essentially the result of the mode geometrization.

Since we are talking about very ancient archetypes of spatial imagination, only psychophysiological basis of Durand's concept is employed. It consists of three basic imagination modes. The first one is the postulated imagination mode corresponding to a social thinking [6]. The main psychophysiological mechanisms of the postulated

correspond to the instinct "toward the goal", the extrapolation instinct, etc. Spatial geometrization of postulated mode is based on biomechanical functions of the skeletal musculature and vestibular apparatus, and on the peculiarities of interaction with other individuals. In the triad of Vitruvius [11], the postulated corresponds to the "benefit", as well as to the "function" (see Fig. 4). The form depends on its purpose. This concept includes the aggregate of social meanings of the form and its ideology as indirect function providing the social certainty of the form.

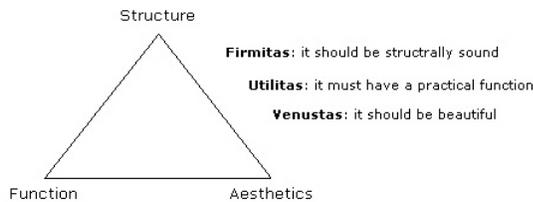


Figure 4. Vitruvian triad.

The scheme for geometrization of postulated imagination in architectural form becomes to be a structural frame for the dynamic and static axes. This mode is based on the geometrization of the uprightness instinct and the resistance to gravity (tectonics, in analogy to "gravitational forming"). Postulated basis underlies the parametric descriptions of the boundaries of objects and spaces, as a subject of social agreement. The same refers as well to movement representation in general, including the spatial element connection scheme, functional routes, etc.

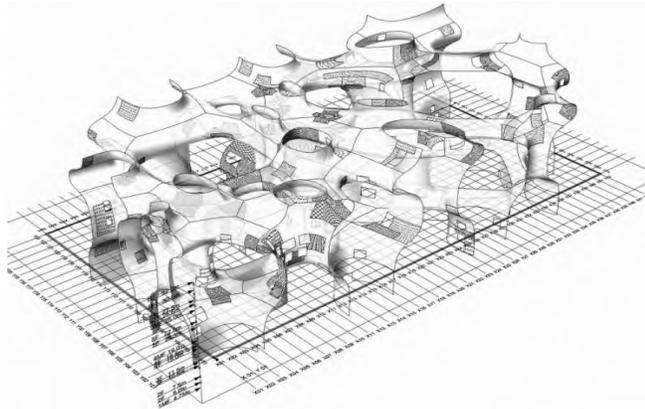


Figure 5. The Toyo Ito project of the National Taichung Theater [12].

The formal and semantic bases of the postulated mode of spatial imagination are linked with geometric metaphors of physical phenomena, such as configuration of force fields, momentums, trajectories, lines of forces, directions, points of force application, etc. Visual representation of these metaphors is very close to mathematical concepts in a symbolic graphic form used in natural sciences since Euclid's "Elements". So, postulated elements of the spatial imagination are inspired by anatomic proprioceptive signals (receptors in the muscles, tendons, joints) and corresponding excitation in the neuron ensemble. This statement could be

illustrated by the project of Toyo Ito [12] with the plan based on a math concept (Voronoi diagram, see Fig. 5).

Implementation of the postulated imagination in the architectural form occurs mainly in the structure static and dynamic (tonic) axes, but also manifests itself in a gradient distribution of visual masses along these axes.

The digestive mode of imagination corresponds to the ontogenetic modality of thinking. The digestive mode is based on the physiological food instinct, i.e., the need for potential energy for building systems. This is similar to individual growth of a particular organism (the ontogenesis process). The digestive metaphor in the architecture could be associated with the mass. In the triad of Vitruvius «Utilitas, Firmitas, Venustas» [11], it actually corresponds to the «structure»; the same is the "strength". The digestive mode represents the constructive definiteness of the form. The basis of the mental representations of the "mass" is a material body or, in a broader sense, matter in a condensed state. Anatomically, the digestive mode is controlled by the interoceptive signals (from receptors of internal organs) to the Central Nervous System (CNS). Implementation of the digestive imagination mode is realized in the mass-to-space ratio in the architecture forms.

The copulative imagination mode should be interpreted more broadly as a regime of change, organizing rhythms, divisions, intervals, and fluctuations in the proportions of mass and space. Durand's copulative mode implies that an imagination is inherent to the human physiological processes of higher nervous activity, biophysics, phylogenetics, i.e., anthropogenic modality of thinking. The semantic subtext of rhythm is a manifestation of the most important property of life, i.e., the changes. The copulative mode highlights the difference between psychological states (joy, sorrow) as functional transition from one process to another one, from one mode to the next one, and affects the psychophysiology. General physical sense and the archetype of the copulative imagination mode is the wave, i.e., the oscillatory nature of the matter in general, including biological and physiological processes (the electrogenesis in CNS). In the triad of Vitruvius, the manifestation of copulative imagination mode is expressed by the term "Aesthetics"; aesthetic certainty of the form. Physiologically, this mode is based on the signals from exteroceptive receptors (cutaneous, visual, auditory, olfactory ones), subconscious internal perception of electrogenesis (alternating currents) of the brain and CNS, and low energy electromagnetic fields of the body cells.

The thesis "primary characteristic of architectural masterpiece is the space" [1] corresponds to the antithesis of the imagination triad as an objective source "the time is death". The time (under the relativity) and the death (biological or cultural memory termination) exist in the physical sense only where any substance is presented, i.e., the substance in a condensed state, or the biological life. The imagination modes control the space as objective (i.e., existing regardless of imagination) reality. An artistic extreme metaphor "time as death" is opposite to the notion of "mass" as emptiness or vacuum, i.e., the something that is opposite to the human beings.

A single natural-scientific source of discoveries and "white spots" of the theory of composition is called by the term "physiomimetics". It was introduced by Soar and Andreen [13] for modeling the spatial structures for buildings by analogy with the molecular lattices. But this

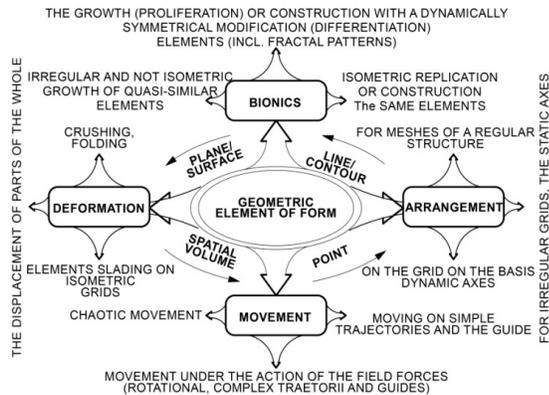


Figure 6. Interrelation and integration between phisiomimetical methods and the principles of architecture forming.

term reflects the core of all methodological techniques of architectural forming, in line with the fundamental and applied physics (in math models), not only bionics (Fig.6).

B. Durand's concept and Anokhin's "cognitom"

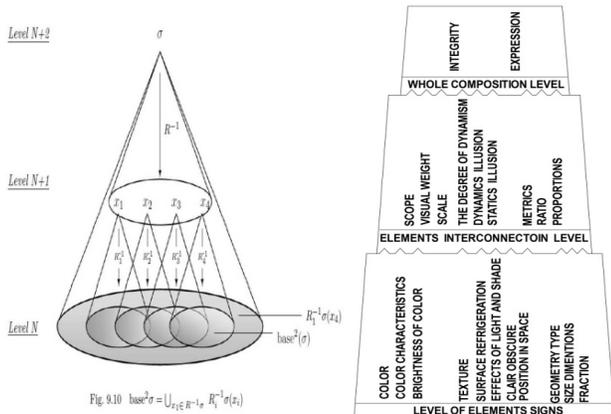


Figure 7. Comparison of the "cognitom" formalization according to Anokhin [11] and the hierarchy of formal composition properties.

Architectural forms represent the systemic encoded visual "information" in stereo-metric elements of the form/space, reflecting the multidimensional data from the highest physiological functions. At the same time, the functions work as filters and are included into the conversion mechanisms (see Figs. 6, 7, 8). The triad of imagination (according to Durand: imagining-imagination-fantastic) is a three-step statement, which corresponds to the graphs structure of "cognitom", i.e. a hypennetwork brain model proposed by Anokhin [14]. Similar interconnection exist between the "cognitom" formalization of the architecture of mind and the hierarchy of formal

composition properties [15] (see Fig. 6). The highest level usually represents typical patterns, compositions (ARCHItypes), the lowest collects primary visual elements (extraction stimulus and archetypes), the middle one includes instruments of interconnection of elements (intraception archetypes).

IV. DURAND'S CONCEPT AND UKHTOMSKY'S DOMINANCE

Interesting results come from the consideration of architecture history as the homological sets of various forms. The architectural form itself becomes a derivative of the four spatial operators, which are geometrical representations of abstract psychophysiological associations (see Fig. 9). The system of higher mental functions is controlled by a dynamic dominance. According to Ukhtomsky [10], the principle of dominance is applicable to the strategies of visual perception, which were studied by Arnheim [14]. The dominance might serve as the most determining factor integrating feelings in the process of visual perception into the whole picture-«gestalt». The linguistic approach [5] to architecture is unable to explain, how a suite of primary geometric elements transform into the «enigmatic signifier» [4]. The way of transmission of multidimensional data of elements into the symbolic form of architecture is the actual problem of the architectural theory.

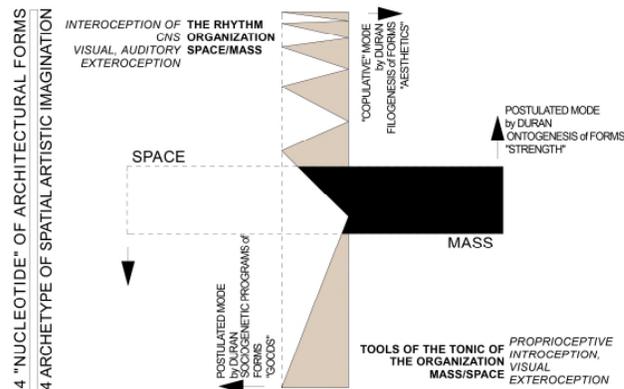


Figure 8. Four «nucleotides» of architecture form have complementary pairs crossing each other.

Any architectural form can be represented as a vector field model. The model's complexity depends on the forming paradigm. The change of paradigms is connected with revolutions of scientific knowledge, which implies that the science changes the ideology of art [16]. Consideration of the archetypical imagination modes in the light of physiology and the hypothesis on bi-similar basis of spatial imagination (see Fig. 1, Table 1) leads to a natural-science concept of the geometrical imagination. This implies that there is mutual reflection of the conscious- (ARCHItypes) and subconscious-level (archetypes) regularities, phenomena, principles of matter organization in living and nonliving nature (see Fig. 6). This concept explains the hypothesis of supra-modality of visual art and music according to Korsakova-Kreyn [17].

The dominance is also controlled by the experiences and beliefs, as well as by the physiology. According to Maslow [18], the pyramid of self-censorship reflects the "upward" sequence of dominances from the lowest to the highest level. Durand repeated Ukhtomsky regarding the concept of an art.

Three functional modes of imagination, i.e., digestive, copulative, and postulated ones, could be called as the mass mode; the metro-rhythmic mode; and the tonic-axis mode of the architectural structure. The concept "the time is death" transforms into the mode of space-time. The proof of interrelation between the dominance principle and the geometry forming could be provided by representation of the ontological categories of architecture (i.e., function, design,

style, etc.) as a set of connected parameters. Ancient Egyptian architecture describes the mass prevalence. The Gothic and Baroque architecture actualizes the vertical elements (prevalence of the postulated mode). The analysis of actual for each style set of formal parameters gives the sequence of imagination modes in the history of architecture, which is equal to the structure of pyramid of self-censorship according to Maslow (see Fig. 9).

The projection of this concept onto the forming process gives an understanding of the form scale as a consequence of interaction of copulative and digestive imagination modes (see Figs. 8, 9). The archetypes and manifestations of the anthropomorphic scale vs socio scale (Neolithic community had about 30-40 people) emerged in the Neolithic period.

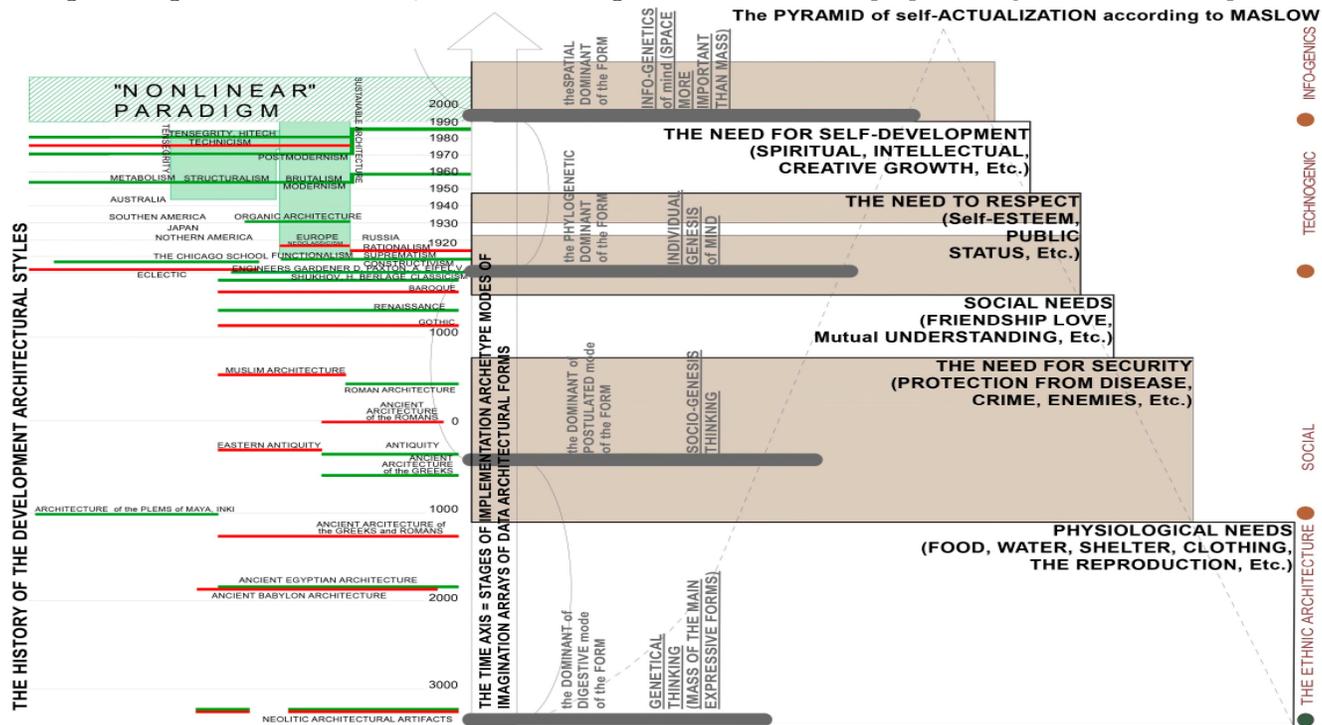


Figure 9. Comparison Preliminary graphical analysis of the actualization of imagination modes in the history of architecture.

V. CONSEQUENCES FOR FUTURE EXPERIMENTS

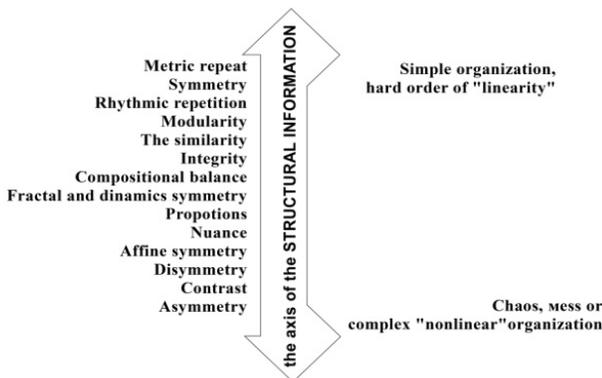


Figure 10. Structural information from the forming processes.

So, the architecture form appears at the intersection of four imagination modes (see Fig. 8), namely the material of architecture (mass/space), composition tools (and the metro-rhythmic frames of axes). They could be treated as "operators" of the three-dimensional form related to "structural information" (see Fig. 10) and semantic features. Analysis of the form as a set of parameters of archetype modes opened the way for researching dominances of emotional perception (Fig.7). It is reasonable to combine the tracking of physiological processes (the frequency of respiration, palpitation, EEG parameters, etc.) with purely cognitive tasks associated with individual perception and spatial thinking of the subjects. This includes the following groups of studies with the fixation of the physiological systems work and the objects of the subject's concentration:

1. Experiments on the mental rotation of figures (spatial and impossible) without changing the proportions. In this

case, the analysis of the results should take into account the different character of the silhouette, the discrete or specific configuration of the forms.

Experiments on the mental rotation of figures (spatial and impossible) with changed the proportions, color, texture, etc.

2. Testing the physiological changes when displaying video with different scenarios of perception of the same architectural form, as well as groups of architectural forms of different styles, groups of architectural objects that are topologically equivalent (homologous series of architectural forms).

3. Video rotation of models of architectural forms with the study of fixation of attention on their structure, comparison of little changes of the similar structures.

4. The study of the role of the part, the relationship between details and the whole, a group of experiments on the perception of generalized models of known architectural objects.

5. Perception of monotonous visual media and architectural fields (short and long surfaces, facades).

6. Cognitive tasks before and after the experiment.

7. The comparison of the perception of artificial three-dimensional objects with the perception of natural prototypes.

It is necessary also to account for the possibility of cognitive dissonance and other stress factors in the subjects' reaction, comparison of results for different age and other categories of subjects. For diagnostics of the physiological reactions, not so expensive equipment is needed, such as fMRI, the thermal imager, ECG, EEG, and the eye-tracker (to account for the attention-fixing points of the testing subjects).

VI. CONCLUSIONS

It is necessary to mark that a structure of an architectural form can be taken as a system of psychophysiologicaly encoded visual stimulus information. The systemic relationship between psychophysiological concepts and the theory of formal composition promises an effective experimental study. The list of experimental study proposed in this paper is not completed because it should be supplemented by wide graphic and video series of visual stimuli. A convincing chain of relations between the formal characteristics of the architectural form as visual stimuli and neural responses is not complete. However, the developed theoretical base guarantees not only the right direction of the experimental strategy, but also its reliability. The main aim of this study is to find clear interrelations between the geometry of architectural form and the way of emotional perception. The second aim is to establish an interrelation between emotional reactions and phisiomimetic patterns of forming to reveal possible new ways in architecture forming. The third goal is to clarify possible new directions in architectural education, namely — methods, strategies, necessary new disciplines, etc. However, the greatest difficulty of the forthcoming work will be precisely the analysis of the experimental data.

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