

COMPLEXITY THEORY OF ART

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Yevin, I. (2000a) *What is Art from Physics Standpoint?*, [in Russian], Moscow: Voentechizdat, 144 pp.

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Abstract: *It will be shown that great many artworks, including well-known masterpieces, exist near critical points or at critical point itself and the main objective of art is to control these instabilities. Recent experiments revealed that music tends to lower the degree of chaos in brain waves. One may suggest that any musical score might be considered as a program of controlling chaos in the brain. Mathematical models of perception of ambiguous patterns and ambiguity in art are also discussed. Phase transitions and critical slowing down in artworks will be described using Hopfield's model of associative memory and catastrophe theory concepts. Attractor network model of Western music tonality cognition is proposed. Inverse U-shape relation between arousal potential and hedonic value of artworks is explained by using Ginzburg-Landau model of phase transition.*

1 INSTABILITY IN THE BRAIN AND ART

Theory of complex system and synergetics show that brain is acting close to instability points and therefore exhibits the main features of self-organization: non-equilibrium phase transition, critical slowing down, oscillating behavior (Bak, 1996, Haken, 1996, Kelso, 1995). The main objective of this paper is to show, that great many artworks,

including well-known masterpieces, also exist near critical points or at critical point itself and we can find in art any features of self-organizing systems near unstable point.

1.1 Control of instability in art

Different notions of instability, borrowed from natural sciences, could be applied to different artworks and different kinds of art: Lyapunov instability in choreography and circus, Nash instability in entertaining genres (detectives, adventures), unstable (frustrated) interpersonal relations in plays by W. Shakespeare, etc. Most of these kinds of arts might be considered as an ability to stabilize appropriate unstable states (Yevin, 2000a, Yevin, 2001).

Investigations of human EEGs have shown that these signals are deterministic chaotic processes with relatively small number of degree of freedom (no more than 10), which depend on the functional state of the brain (awaking, sleep, and epilepsy; Haken, 1996, Kelso, 1995).

In the late 1980s, Hubler and his co-workers carried out a series of studies concerning control of deterministic chaotic systems (Hubler and Lusher, 1989). It turned out, that carefully chosen tiny perturbation could stabilize any of unstable periodic orbits making up a strange attractor.

N. Birbaumer and others (1996) revealed that music tends to lower the degree of chaos in brain waves in that the dimensional complexity is reduced (see also Patel and Balaban, 2000). For some epilepsy patients music triggers their seizures. One can suggest that any musical score might be considered as a program of controlling chaos in the brain.

1.2. Ambiguity and art

Phenomenon ambiguity is the consequence of the profound analogy between pattern recognition and pattern formation in open systems far from equilibrium, discovered by H. Haken (1979).

N. Legenstein (1999) recently has shown that resolution of ambiguous pattern is an essential part of the function of the brain, because every pattern, in a way, are ambiguous (in semantic sense, for instance; also see Kruse, 1995).

Mathematical models of perception of ambiguous patterns which describe oscillating behavior is applied to perception ambiguity in art (ambiguity of smile in Leonardo da

Vinci's *Mona Lisa*, ambiguity of double meaning comic situations) are described by means catastrophe theory methods and synergetic model of perception (Yevin, 2000).

2 MODEL OF ASSOCIATIVE MEMORY AND STRUCTURE OF ARTWORKS

Hopfield's model of associative memory and catastrophe theory concepts are used to describe some structural features of artworks. The structure of many artworks is bimodal in itself, that is can be depicted as Hopfield's potential function with two minimis. For instance, acting involves an ability to create the second phase, a "role phase" where the first one is a physiological and psychological nature of the actor. Sculpture art involves an ability to depict representatives of living nature (humans or animals) from materials of inanimate nature (wood, stone, bronze, etc.).

The presence of bimodality in art makes possible the existence of various types of phase transitions. The plots of some artworks are based on the idea of animated statue, where the phase transition "inanimate-animated" takes place (opera *Don Giovanni* by Mozart, poems *Copper Horseman* and *Stone Guest* by Pushkin). Just as like bimodality of sculptural art begets plots about animated statue, bimodality of actor art gives a possibility to use a phase transition called "character invasion" for plot development (Neuringer, 1995, Yevin, 1997).

The main character of the movie *A Double Life* is an actor who plays the role of Othello for so long time that it begins to affect to his psychic activity, making him more and more jealous of his beloved and, like the stage character, he strangles her and then kills himself.

Structure of Western music tonality also one can understand by using Hopfield's neural network model of associative memory. Tonality is a hierarchy of pitch-class. If only one pitch-class is stressed more than others in a piece of music, the music is said to be tonal. If all pitch-classes are treated as equally important, the music is said to be atonal. Almost all familiar melodies are built around a central tone toward which the other tones gravitate and on which the melody usually ends.

Three stable steps of tonality: tonic, mediant and dominant are keynotes or attractors of neural network. Others steps of tonality: subdominant, submediant, ascending parenthesis sound, descending parenthesis sound play the role of recognizable patterns, gravitating to some or other keynote.

We can depict exactly in Hopfield's potential function only distances between minimis, but not depths of these minimis. It is reasonable to suggest that the minimis depth of tonal energetic function is extremely personal for human beings and reflects a musical

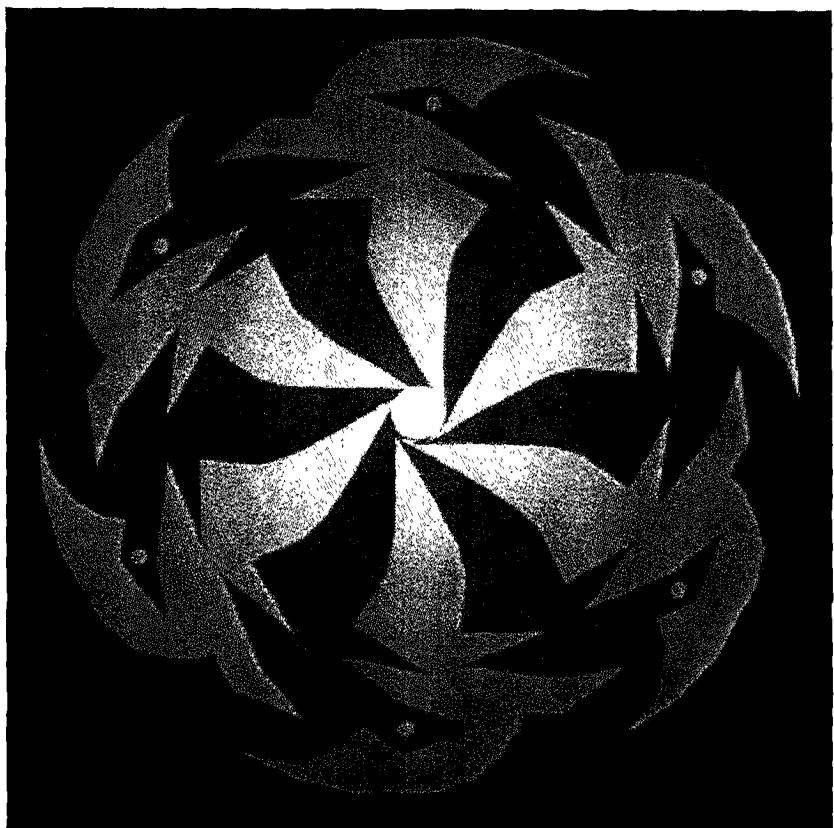
abilities (giftedness) of a person. The more a person has a gift for music, the more depth of valleys has appropriate energetic function. A person who is devoid of music ability has energetic function with shallow valleys (Yevin, 2001).

3 THE WUNDT CURVE

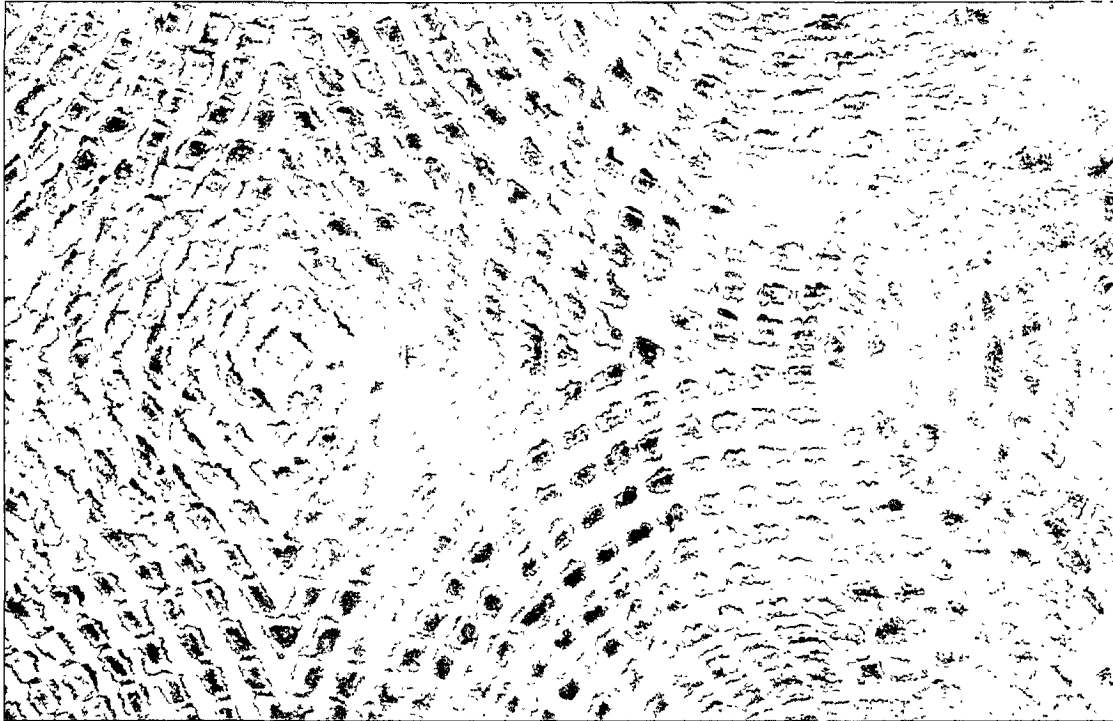
The relationship between “arousal potential” of artworks and “hedonic value” well known as Wundt curve (which looks like inverse U) is explained from the theory of criticality standpoint, more exactly, the theory of second order phase transition. The “arousal potential” in this model is the order parameter and “hedonic value” plays the role of control parameter (like temperature in Ginzburg-Landau model of phase transition).

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Symmetry

