

AMBIGUITY IN ART

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Abstract. Non-linear theory proposed different models perception of ambiguous patterns, describing different aspects multi-stable behavior of the brain. This paper aims to review the phenomenon of ambiguity in art and to show that the mathematical models of the perception of ambiguous patterns should regard as one of the basis models of artistic perception. The following type of ambiguity in art will be considered. Visual ambiguity in painting, semantic (meaning) ambiguity in literature (for instance, ambiguity which V.Shklovsky called as "the man who is out of his proper place"), ambiguity in puns, jokes, anecdotes; mixed (visual and semantic) ambiguity in acting and sculpture. Complexity theory of the brain revealed that the human brain as a complex system is operating close to the point of instability and ambiguity in art must be regarded as important tool for supporting the brain near this critical point that gives human being possibilities for better adaptation.

NON-LINEAR MODELS PERCEPTION OF AMBIGUOUS PATTERNS

In perception psychology, multi-stable perception of ambiguous figures is often considered as a marginal curiosity. Nevertheless, this phenomenon is one of the most investigated in psychology. The first description of ambiguity was given by Necker in 1832. The most known examples of ambiguous figures are specially designed patterns such Necker' cube, "young girl-old lady" and so on. But visual and semantic ambiguity is very often connected also with that the available visual or semantic information is not sufficient by itself to provide the brain with its unique interpretation. The brain uses past experience, either its own or that of our ancestors to help interpret coming insufficient and therefore ambiguous information. Many patterns in our every day life, in a way, are ambiguous patterns, but using additional information, we usually resolve or avoid ambiguity [1]. Nikos Legothetis recently shown, that resolution of ambiguity is an essential part of consciousness job [2].

This paper aims to review and to familiarize with the present state the phenomenon ambiguity in art and to show that the mathematical models of the perception of ambiguous patterns should regard as the basic models of artistic perception. Ambiguous patterns are examples of two-state, bimodal systems in psychology. When we perceive ambiguous figure, like the fourth picture in the row on Figure 1, the perception switches between two interpretations, namely "man's face" or "kneeling girl" because it is impossible for the brain to recognize both interpretations simultaneously. Just like for any bifurcative state, it is impossible for ambiguous figure to predict what namely interpretation will appear first. G.Caglioti from Milan Politectic Institute firstly paid attention, that ambiguous figures are cognitive analogue of critical states in physics.

Various authors pointed out that perception of ambiguous figures possess non-linear properties, and that multistable perception could be modeled by catastrophe theory methods [3, 4, 5]

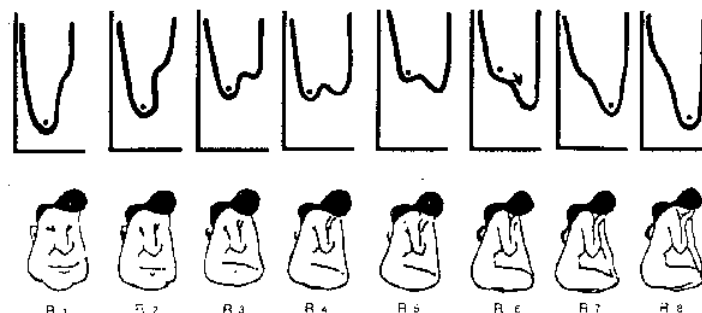


Figure 1. Ambiguous patterns are two-state systems. Their perception one can model by using elementary catastrophe "cusp"

The switch between two interpretations could be described by elementary catastrophe "cusp"

$$x^3 - bx - a = 0$$

where a and b are control parameters and x is the state variable. The first parameter a is called the *normal factor* and quantitatively describes the change in bias in the drawing in a "shape space" from a man's face to a woman's figure. Because this model may be used also for description of perception double meaning situations, it is reasonable to develop the idea of "shape space" on "meaning space" firstly introduced by Ch.Osgood [6].

The second parameter b is called the *splitting factor* or *bifurcation factor* and describes how much the amount of details is presented in the ambiguous figure.

The state variable x is presented as a scale from +10 ("looks a lot like a man's face") to -10 ("looks a lot like kneeling girl"). For this model we could formally represent potential

$$\text{function } V = \frac{1}{4}x^4 + b\frac{1}{2}x^2 + ax$$

which depicted on Figure 1, and consider catastrophic jump from one image to another as non-equilibrium phase transition. It is worth to note, that unlike to physical sciences, where potential function usually deduces from fundamental laws or standard theories, in mathematical models in psychology and others "soft sciences" potential function is hypothesized and really is considered as potential energetic function, which should be minimized. In this case it might be also considered as Lyapunov function in Hopfield's model of pattern recognition.

Actually, during the viewing of ambiguous figures, perception lapses into sequence of alternations, switching every few seconds between two or more visual interpretations.

Ditzinger and Haken offered an approach to the description of such oscillation under recognition of ambiguous figures [7]. Each pattern is described in this model as a vector in the space of quantitative parameters. There is a procedure for selecting non-correlated parameters, which enable to reduce an information volume. The most informative parameters are the order parameters (all they peculiarities occur near critical points, as in the case of order parameters near phase transition [7]).

Pattern recognition procedure is the following. First, pattern-prototypes are stored in the computer memory. Then, the pattern that should be recognized is inputted. The recognition dynamics is built in such a way, that its vector evolves in a parameter space to the most similar pattern stored in the computer memory.

The prototype patterns are encoded by V_{i_i} ($i = 1, \dots, M$). The components of every vector encode the features of the patterns. We can decompose each prototype pattern into their pixels and denote a pixel by its index j . To each pixel we attribute a gray (or a color) value v_j . The set of all gray values v_j forms a vector $V_{i_i} (v_1, v_2, \dots, v_N)$. It is assumed that all these vectors are linearly independent. A pattern to be recognized is encoded by a vector $Q(0)$ and is inputted in a computer memory at $t = 0$. A dynamic of pattern recognition is constructed so, that the initial vector $Q(t)$, is pulled into one of prototype patterns V_k with which it mostly coincides.

Recognized pattern is presented as the linear combination of prototype patterns

$$Q(t) = \sum_{j=1}^M d_i(t) V_i + \xi(t)$$

Where $d_i(t)$ is the order parameter, characterizing the degree to which a pattern is recognized, and $\xi(t)$ is a residual, uncorrelated with V_i (it is proved, that $\lim_{t \rightarrow \infty} |\xi(t)| = 0$).

The dynamic of pattern recognition is described as a gradient process in networks with only M neurons according to

$$\dot{d}_i(t) = \lambda d_i - (B + C) d_i \sum_{j \neq i}^M d_j^2 - C d_i^3,$$

$$\lambda_i > 0, B > 0, C > 0, d_i(0) = V_i' Q(0)$$

This system has only the attractors of the type $(0, 0, \dots, d_k \neq 0, \dots, 0)$. It can be shown that they must be either saddle points or nodes, but not limit circles (oscillations).



Figure 2. Image ambiguity: "young girl" – "old lady".

Ditzinger and Haken offered synergetic model of the perception of ambiguous patterns, describing dynamical features of such perception. It is based on the model of pattern recognition described above, and the model of the saturation of attention. The recognition of ambiguous patterns is reduced to inputting only two patterns-prototypes (e.g., "young girl" and "old lady") into computer memory with the order parameters d_1 and d_2 . In this case the dynamics of pattern recognition is described in the following way:

$$\dot{d}_1 = d_1(\lambda_1 - A d_1^2 - B d_2^2)$$

$$\dot{d}_2 = d_2(\lambda_2 - B d_1^2 - A d_2^2)$$

$$\dot{\lambda}_2 = g(1 - \lambda_2 - d_2^2)$$

$$\dot{\lambda}_1 = g(1 - \lambda_1 - d_1^2)$$

where the overdot means $\frac{d}{dt}$, λ_1 and λ_2 are time dependent attention parameters, and A , B , and g are constants. The last two equations describe the saturation of attention in the

perception of prototype patterns. As analysis shows, the oscillation of perception occurs when the appropriate relations between constants are satisfied [7]. The recognition of ambiguous patterns has very profound and various analogies with numerous artistic phenomena. This model perception of visual ambiguous patterns also could be applied on the case of meaning ambiguity, because meaning perception also includes such phenomena as saturation of attention and the concept of the order parameter [8].

VISUAL AMBIGUITY IN ART

Let us first consider specially designed visual ambiguity in art. Painting by Giuseppe Arcimboldo "*The Librarian*" is an example one of the first pattern of such type ambiguity in painting. At first sight we recognize face, but a closer look reveals just an arrangement of different books.



Figure 3. Giuseppe Arcimboldo "*The Librarian*"

The most famous example of ambiguity in painting is, of course, *Mona Lisa* by Leonardo. In *The Story of Art* Ernest Gombrich said:

"Even in photographs of the picture we experience this strange effect, but in front of the original in the Paris Louvre it is almost uncanny. Sometimes she seems to mock at us, and then again we seem to catch something like sadness in her smile."

"This is Leonardo's famous invention the Italians call "*sfumato*" - the blurred outline and mellowed colors that allow one form to merge with another and always leave something to our imagination. If we now turn to the "*Mona Lisa*", we may understand something of its mysterious effect. We see that Leonardo has used the means of his "*sfumato*" with the utmost deliberation. Everyone who has ever tried to draw or scribble a face knows that what we call its expression rests mainly in two features: the corners of the mouth, and the corners of the eyes. Now it is precisely these parts which Leonardo has left deliberately indistinct, but letting them merge into a soft shadow. That is why we are never quite certain in which mood *Mona Lisa* is really looking at us. Her expression always seems just elude us" [9, p.228].

The ambiguity of *Mona Lisa*'s smile one can compare with ambiguous images like "young girl - old lady". The oscillation in the perception of that painting can be described by Ditzinger-Haken's model.

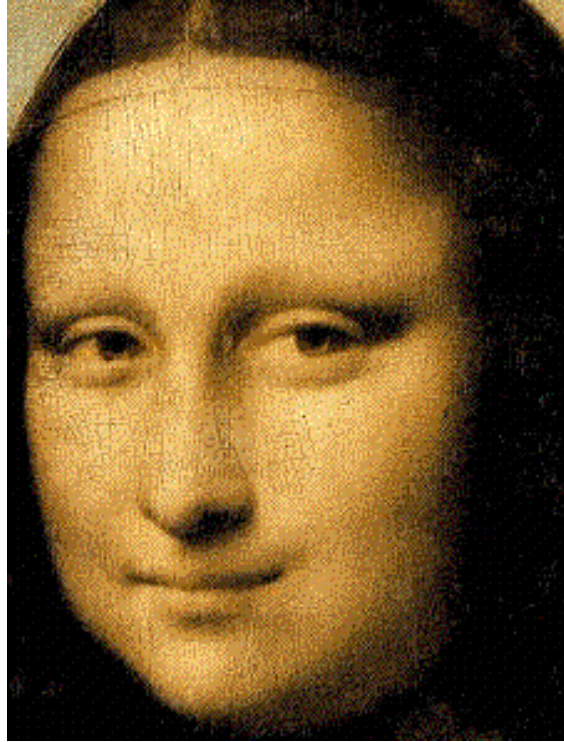


Figure 4. Ambiguity of *Mona Lisa*'s smile.

Figure 5 gives an example other kind of visual ambiguity, when the human face is designed from different figures. This is the painting *Disappearing Bust of Voltaire* by Salvador Dali.

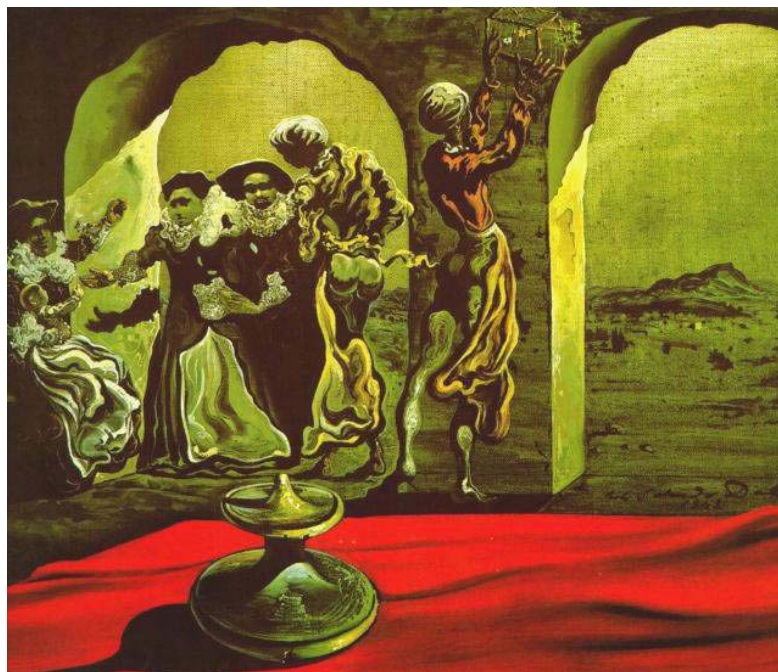


Figure 5. Ambiguity of Voltaire bust in Salvador Dali's painting *Disappearing Bust of Voltaire*

SEMANTIC AMBIGUITY OF VISUAL SCENES

Let us consider the following painting by J.Vermeer [11].



Figure 6. Jan Vermeer. *Girl with a Pearl Earring*

Many art historians consider this portrait as a masterpiece of ambiguity, because it offers huge amount of meaning interpretations. Her face is simultaneously somewhat sad and joyful, erotical and distant, submissive and yet dominant.

There is a humorous book called “Captions Courageous” by B.Reisner and H.Capplow attempting reinterpretation of famous masterpieces in painting – with more or less wit [12]. This possibility to create new interpretations for famous paintings which are perceived as comic is connected with insufficient information [1].



Figure 7. Complex visual scenes usually allow different meaning interpretations. This famous painting "*Birth of Venus*" by S.Botticelli may be headlined as "Slip into this, it's a raid"(from the book "*Captions Courageous*" by B.Reisner and H.Kapplow [12]).

SEMANTIC AMBIGUITY IN PLOT DEVELOPMENT AND IN COMIC SITUATIONS

A significant type of ambiguity in art means the possible existence in artwork (most often in position of main hero) of two different states, one of them may be hidden until a certain time. A commonplace example of this form of instability exists in numerous book and movie plots in which a spy or Secret Service agent is hiding his identity while maneuvering about in hostile camp. At any moment, he may be unmasked, and the agent's task is to extend his secret identity as long as possible.

In well-known American movie "ROBOCOP" the main character is simultaneously a robot, incarnating an idea pitiless and perfect machine of revenge, and a human being, capable on deep and tender feelings.

Another, less-banal example, ambiguity of social nature - what V.B.Shklovsky describes as "the man who is out of his proper place" - is also widely presented in art [13]. According to Victor Shklovsky, "...The novels of olden times were based on the incidental falling out of a man from his society. By almost fatal position of an illegal birth or a loss of documents has been motivated an introduction of a hero into the world which has been a destiny of millions. But a hero has been rescued from that world with the help of recovered documents. A hero of old novel - is the one who is not in his proper place, a hero of one society finding himself in an absolutely different society." [13]. "The History of Tom Jones, a Foundling" by Henry Fielding, is an example of such a novel. The main character Hlestakov in the play by N.Gogol "Inspector General" obviously one may also describe using this kind of ambiguity.

In Apuleius's "Golden Ass" the main character is, of course, out of his proper place because the ass in reality is a man. The plots of such tales like "The Ugly Duckling" by H. Andersen and "The Beauty and the Beast" also are of the same type of ambiguity, sustained over the entire period of the plot.

In the majority of the novels by Agatha Kristy we deal with semantic ambiguity, as almost any character of these novels could appear as the murderer. This state of semantic ambiguity is skillfully supported by the author down to an outcome of the plot: "You know that I never deceive. I simply speak something such, that it is possible to interpret double" -once confessed A.Kristy.

Without ambiguity of natural languages, the existence of poetry is impossible. According to A.N.Kolmogorov, entropy of language H contains two terms: meaning capacity h_1 - capability to transmit some meaning information in a text of appropriate length, and flexibility of language h_2 - a possibility to transmit the same meaning by different means [14]. Namely h_2 is a source of poetic information, and the ambiguity of language is one of the causes of it's flexibility. Languages of science usually have $h_2 = 0$, they exclude ambiguity, and cannot be used as a material for poetry. Rhythms, rhymes, lexical and stylistic norms of poetry will put some restrictions on a text. Measuring that part of the ability to carry information spent on those restrictions (denoted as β), A.N.Kolmogorov formulated the law, according to which poetry is possible: if $\beta < h_2$. If the language has $\beta \geq h_2$, than poetry is impossible. We know that the brain resolves a visual ambiguity by means of oscillation. A semantic ambiguity (the ambiguity of meaning) is a result of ambiguous words or whole sentence. Semantic ambiguity, wide spread in comic situations, also resolves by oscillations.

Ambiguity of humor is often a clash of different meanings. It involves double or multiple meanings, sounds, or gestures, which are taken in the wrong way, or in incongruous ways.

Here is D.D.Minayev's epigram:

"I am a new Byron" - you proclaim.
I can agree with you:
The British poet was lame
The rhymes of yours are also lame."

The method used in this epigram is connected with a comparison based on different distant meanings (Byron was the lame, and a vain poet was also a lame, but in his rhymes). The situation described in this epigram is common to a lot of semantically ambiguous comic situations, which contain two states. One state we should call a state with high social status. This position is honorable and sometimes brings profit. The second state we should call a state with low social status. Everybody avoids occupying it. In the aforesaid example, the state with the high social status ("a good poet") we connect with words "a new Byron". Another poet is trying to get this state. But the author of the epigram unexpectedly transfers a poet to the second state with a low social status. This state we connect with the words "the rhymes of yours are also lame". Such an unexpected leap is achieved by using the same word ("lame") for totally different states.

So, a feeling of comic is very often connected with sudden transition from a state of high social status to a state of low social status, or the other way round. Is it a single transition? Does it happen only once? Not, of course. It is a multistable perception of meaning. The rhythmical, repeating nature of laughter (ha-ha-ha, etc.) shows that such transitions are repeated. Evidently, a laughing person mentally oscillates every time from the state of high social status to the state of low social status and *vice versa*, by comparing them. As a result, the rhythmical laughter is generated by the nervous system.

Let us consider also the following anecdote about Sherlock Holmes and Dr. Watson

Sherlock Holmes and Dr. Watson are going camping. They pitch their tent under the stars and go to sleep. Sometime in the middle of the night Holmes wakes Watson up.

"Watson, looks up at the stars, and tell me what you deduce."

Watson says, "I see millions of stars, and if there are million of stars, and if even a few of those have planets, it's quite likely there are some planets like Earth, and if there are a few planets like Earth out there, there might also be life."

Holmes replied: "Watson, you idiot, somebody stole our tent".

We see that Watson and Holmes offered two different semantic interpretations of the same visual picture of star sky and if Watson gave namely one of possible interpretation of picture of star sky, Holmes paid attention on semantic context of this picture and connected it with their rest position.

The origin of the oscillatory character of laughter should be connected with the fundamental property of the distributed neuron set, i.e. as the oscillation occurring in the perception of ambiguous patterns. According to Ditzinger-Haken's model of recognizing of ambiguous patterns, stable limit cycles can be formed in systems of usual nonlinear differential equations for those variables, which describe the visual perception (e.g. attention). Evidently, this is the common characteristic of distributing neuron sets. That's why it is manifested not only in evolutionary low stages (the ancient visual-morphologic structure of nervous and psychological activity of a human being), but also in its latest stages as well (in the semantic-analytical structures of the left cerebral hemisphere).

Comic situations are very often connected with polysemantic, i.e. semantically ambiguous, situations. Another situation of perception of ambiguous patterns occurs in a parody of a famous person by some actor. On one hand, we can recognize the manners, gestures, style and voice of that famous person. On the other hand, we see quite a different person. The same method is used in literary and poetic parodies. Every time we are dealing with a bimodal, double-meaning situation. As a result, we have the oscillation of perception, and laughter is one of the external manifestations of this oscillation.

One can assume that in ambiguous comic situations oscillations occur between two semantic images. The phenomena of synchronization are typical for a self-organizing process in an active medium (and the nerve substance is an active medium). From that, we can conclude that the period of oscillation between semantic patterns coincides with the period of outward macroscopic oscillations, manifested as laughter with the duration of about 0.1 sec. This value is much smaller than the oscillation period, which occurs when recognizing ambiguous figures (1-5 sec.).

Why does laughter occur in the perception of double-meaning situations, and not in the visual perception of ambiguous patterns? We can explain this by essentially different periods of the

corresponding oscillations. In the visual perception this period is approximately equal to $t=10$ sec., and in the perception of the ambiguity of meaning - this period is about $t=0.1$ sec. That difference could be explained by the fact that a much smaller mass of nerve substance is involved in creating semantic patterns, compared with constructing visual patterns. This is because visual information is processed in the massive and ancient visual cortex, and semantic patterns are interpreted in compact Broca-Vernike zone in the left brain hemisphere. Anecdotes, jokes and sketches deliberately are created as short as possible (laconic), in order to reduce the time needed for the saturation of attention in the process of recognition.

MIXED AMBIGUITY

Ambiguity of sculpture

We have considered visual ambiguity in painting (see also [11]) and semantic ambiguity in jokes, anecdotes and puns. Let us consider mixed (visual and semantic) ambiguity, taking an example from sculpture art. Sculpture involves an ability to depict representatives of living nature (most often humans and animals) from materials of inanimate nature (wood, stone, bronze, etc).

In creativity of different sculptures one can observe a prevalence of one of these phases with respect to another. In Michelangelo's works we see triumph of alive and even spiritual under inert matter of stone. E.Gombrich wrote in book "The Story of Art": "While in *"The Creation of Adam"* Michelangelo had depicted the moment when life entered the beautiful body of a vigorous youth, he, now, in the *"Dying Slave"*, chose the moment when life was just fading, and the body was giving way to the laws of dead matter. There is unspeakable beauty in this last moment of final relaxation and release from the struggle of life - this gesture of lassitude and resignation. It is difficult to think of this work as being statue of cold and lifeless stone..."

It is interesting to note, that ambiguity of sculpture art influences on literature, because the plots of some works of arts in literature are based on the idea of animated statue - that is, the transition "inanimate-animated" (such as opera "Don Giovanni" by Mozart, "Copper Horseman", "Stone Guest" by A.Pushkin and, of course, in ancient legend about sculptor Pygmalion).

Ambiguity of dolls

In the essay "Dolls in system of culture" Yu.Lotman marks ambiguous (as well sculpture) nature of this cultural phenomenon closely connected to ancient opposition alive and dead, spiritual and mechanical. At the same time, as against a sculpture, the doll demands not contemplation but play. It serves as a certain stimulator provoking creativity [15].

Ambiguity of acting

Like any human being, an actor has in his everyday life some set of rather stable physiological and psychological personal properties: sex, appearance, timbre of voice, gait, temper, and so on. The acting involves ability to create a second phase, a "role" phase, different from the original physiological and psychological nature of the actor. In other words, a bimodal "actor-role" state created may be compared with ambiguous patterns, for instance, the pattern where we see in turn "young girl" or "old lady". One may say that in this case young girl will "play the role" of old lady and *vice versa*.

In acting, one can observe the existence of two polar types of actors:

1. An actor as a bright, brilliant individuality, eccentric person with the original appearance, and so on (Alain Delon, Arnold Schwarzenegger). It is rather easy to make a parody of such actors;
2. An actor with prominent outstanding abilities for transformation and reincarnation (Laurence Olivier, Alec Guinness). In that case, it is very difficult to make a parody.

Yu.Lotman note, that in the cinema more, than at the theatre the spectator sees not only role, but also actor [15, p.658]. Observing play of the famous actor we alternately focus our

attention or on guise (image) of actor familiar to us on other movies, or on peculiarities of a role, which the actor plays. Such oscillation of attention is the reason, that with the reference to acting we use a word "play".

In the case of acting the prototypes are, for instance, "Laurence Olivier" (the image of actor) and "Othello" (the image of character). Therefore, according to the common law of perception of ambiguous patterns, the oscillation of our attention takes place, and we see in turn either an actor or his role.

Just as like bimodal nature of sculpture art begets plots about animated statue, bimodality of actor art gives a possibility to use a phase transition called "character invasion" for plot development [16].

The main hero of the film "A Double Life" 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. In the film "Jesus of Montreal" the actor playing the role of Jesus Christ becomes transformed into a Christ-like figure [16].

As a rule, all bimodal metastable states in the end of movies turn into stable, onemodal states as a result of bifurcation.

CONCLUSION

In ordinary speech, and especially in scientific communication, in general we try to avoid ambiguity. By contrast, in humor, one of the aims is to create ambiguous situations to provoke laughing. And in art as a whole ambiguity is an indispensable, necessary part.

"...art is supposed to have multiple meanings. It is self-defeating to increase one aspect of meaning. The more a single meaning dominates a work, the less it is a work of art. Something that has one and only one meaning – no matter how interesting or important that meaning is – is no longer a work of art" [17, p.46].

Understanding ambiguous nature of art gives an ability to formulate problem computer simulation of artistic creativity as computer making of ambiguous images and meanings (for instance, by means of genetic algorithms) [18].

Synergetics and the theory of complexity revealed that the human brain operate near unstable point, because only near criticality the human brain could create new forms of behavior. Ambiguity in art is an important tool maintaining the brain near this unstable, critical point.

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