Ternary codes in psychology, culture, and art: Information roots

Vladimir Petrov & Lidia Mazhul
State Institute for Art Studies
5 Kozitsky per., Moscow 103009, Russia
E-mail: vmpetr@yandex.ru

Abstract

A set of six models dealing both with spatial and temporal aspects of perception, forms an entity with tightly coordinated links. Though the models proceed from different concepts (optimization of the structure of the memory, minimal resource expense when information processing, maximal reliability of the identification of objects' properties, etc.), they unanimously come to the preference of triplicity, or ternary codes in various fields of social and cultural life. This result is supported by numerous empirical data relating to different kinds of phenomena, including works of art.

Informational approach in cultural studies now puts forth [1-3], and investigations establishing *links* between different branches within this approach must be rather promising. The present paper is devoted to some of such links, connecting properties of human *memory*, *information processing*, and the phenomenon of the *threshold* of perception. (Of course, these fields are viewed within the framework of the informational approach.) As a result, we shall come to some *general regularities* of human behavior, culture, etc., the most interesting of them being related to the structure of works of art.

Advantageous 'spatial' structures: many-sided arguments in favor of triplicity

We should consider the most *universal and widespread procedures* of the information processing, which can be important for the problem in question. We shall start from the processes of human orientation in the environment, containing certain objects and events. Two preliminary notes should be made here.

First, the models described in this Section, deal with the properties both of objects and events, the information received being stored using certain *symbols* in the memory device. As it was shown earlier [4], exactly this form of the information keeping is much more advantageous than its keeping in the form of images ("gestalts"): it becomes possible to spend many times less resource, i.e., energy of the neuron net. [In fact, when using "gestalts," our first step of the memory which possesses rather limited volume of 8 units (see below), is capable of keeping only 8 images, whereas when using binary symbols, the same memory can keep information relating to $2^8 = 256$ objects or events.]

Second, it is proposed that the primary information ("raw data") is *structured* in such a manner that would provide maximal effectiveness of the usage of the information kept, under the condition of the limited number of symbols which are involved in the information processing. That is why these symbols are not "free," independent of each other, but they are grouped in certain clusters named "*parameters*." [Really, of course, a set of 10 symbols used without any structuring, is capable of designating 10^{10} objects or events (as it takes place in telephone nets), but true choice in such a variability is very complicated; but what is the most important, in such situations it is impossible to work with statistical links between objects' properties; hence, the orientation in such "boundless sea" of symbols becomes senseless.]

Taking into account these two considerations, let us turn to four partial models of universal processes inherent in keeping information relating to the environmental objects and events.

A. In the framework of the simplest model dealing strictly with the *encoding* (see, e.g., [5], a certain 'resource' of W symbols is considered to be fixed. These symbols can be divided into *equal groups* (each group may be regarded as a scale of a certain parameter). Let us suppose that each group

consists of x symbols (gradations of the parameter). Hence, the number of groups is W/x, and the given set of symbols permits to describe the number of different objects

$$y = (x)^{W/x}.$$

If to consider this expression as the function of the variable x which is capable of possessing arbitrary positive values (both whole numbers and fractional ones), we may find its optimal magnitude responding to maximal value of y: $dy/dx = 0$ when

$$x = e = 2.718\ldots$$

In other words, optimal is such a description which contains parameters each of them consisting of 2.718… gradations. However, the number of gradations should be integer (whole number). Hence, the best classifications are those ones which consist mostly of ternary parameters ($x = 3$), though maybe sometimes binary parameters ($x = 2$) can be also used.

B. In another model which is 'genuine informational,' the same conclusion about the optimality of ternary classifications was also obtained [2, pp. 19-20]. Here the '*response*' of a certain system (e.g., a man) is considered, this response being characterized by n independent components of a vector ('degrees of freedom'), each component again having x gradations of equal probabilities. The resource expenses (the nature of the resource may be various, e.g., the efforts needed to keep the information about each gradation of each parameter) are supposed to be proportional to the number of gradations:

$$r = a\,x,$$

a being the constant. Let the total resource expense be restricted by the value

$$R = a\,x\,n.$$

Then we may proceed from the information contained in one degree of freedom: $I(m)$. The maximal total information I for the total resource expense R, was shown to be equal

$$I = (\ln xR) / a\,x,$$

so it is possible to find an optimal value of x when $dI/dx = 0$. This value is

$$x = e = 2.718\ldots$$

Again we came to the same result: preference of ternary or binary parameters.

C. However, in principle, it is not obligatory to suppose all the scales (parameters) to be identical, possessing the same number of gradations. Sukhotin [6] considered the task of the most *economic 'non-motivated classification'* of a set of objects, using *arbitrary numbers* of gradations for different scales.

Think of a series of B objects described by a set of parameters (features, scales), each parameter consisting of several gradations. We shall use these parameters simply to *classify* objects – this is exactly what the aim of 'non-motivated classification' is (in contrast to 'motivated classifications' which are applied to distinguish between useful objects and non-useful ones). If we have $\beta(x)$ parameters with x gradations ('words'), then the number of possible classes is

$$y = \prod_{x} x^{\beta(x)},$$

symbol $\prod$ designating the operation of multiplying. [For instance, when classifying persons, we use one parameter with two gradations (gender: men or women) and two parameters with three gradations (age: young, middle, or old; education: non-educated, middle school, high school). Hence, the number of possible combinations $y = 2^1 \times 3^2 = 18$ classes.] How many gradations ('words') should we use to realize such a description? – Evidently, the number of such 'words'

$$W = \sum_{x} x\,\beta(x).$$

[In this example we should use $W = 2\times1 + 3\times2 = 8$ gradations, or 'words.']

The informational optimization in such case means nothing but *economy of the total number of 'words'* (gradations used) under quite evident condition – sufficient description of the given number of objects:

$$y \geq B,$$
$$W \rightarrow min.$$

The solution of this system of equations comes to rather non-trivial result: only those parameters should be used which possess

$$x = 2 \text{ or } x = 3,$$

i.e., only *binary or ternary parameters*. [In fact, the most economic way to describe the above 18 objects, is to use a set of one two-gradation parameters and two three-gradation parameters – we need only 8 'words,' whereas all other descriptions occur to be not so economic; e.g., when using 5 two-gradation parameters ($N = 2^5 = 32 > 18$) we need $2 \times 5 = 10$ 'words,' and taking 3 three-gradation parameters ($N = 3^3 = 27 > 18$) we need $3 \times 3 = 9$ 'words.'] Thus *ternary codes* turn out to be 'advantageous' elements of different systems of the information storage systems.

D. There exist some other theoretical arguments in favor of ternary codes – as rather advantageous for the information processing. Bearing these arguments in mind, we shall dwell upon the model of visual *perception of* objects' *color properties* in *changing illumination* – see, e.g., [4]. (In general, quite the same is the situation in any continuum, when it is necessary to simulate the perception of a certain property of objects, in the conditions of variable background.)

Here let us suppose that we have spectral photodetectors possessing *bell-like distribution of the response*: the peak value of the signal falls on a definite wavelength, whereas both at shorter wavelengths and longer ones, the signal is decreasing. (Such bell-like characteristic of the response is natural for any continuum to be perceived.) How to determine the color of the object perceived, e.g., whether the given apple is red or green? The only way to do this, is to compare the signal reflected from the object – with the signal from the background (e.g., from the sun or from another source of light). However, such a comparison may have ambiguous results: each photodetector with bell-like characteristic possesses two 'decreasing branches' of its spectral dependence, so that the percipient is not able to identify branches he/she is dealing with. Moreover, it is impossible to determine the color of the object, even when resorting to the help of two types of detectors, possessing differing peak wavelengths.

Only using *three types* of photodetectors, it becomes possible to determine the color of the perceived object. (For instance, the situation becomes clear, when the signal from the first type of detectors is low, from the second one large, and from the third one negligible.) It is namely because of the fact that three-detector scheme of spectral information processing is the most advantageous, such solution was used by the Nature in the process of the biological evolution, and it was realized in the case of some higher mammals, including human beings. [It is interesting to note that quite analogous scheme of color information processing, was realized in frog's eye: though it has only one type of spectral detectors, there are three types of adipose cells working as light filters; so practically three types of spectral detectors are formed.] Employing larger amount of detectors is ineffective as it requires extra resource expense. (Nevertheless, a four-type version was given a try in the process of the evolution, but finally rejected.)

So we have rather weighty and many-sided arguments in favor of triplicity, which occurred to be advantageous in various procedures of the information processing when orientation in the space of objects and events of the environment. Now let us turn to temporal aspect of this orientation.

Time and order: In search for the threshold of perception and non-accidental events

Here we shall consider two principal universal situations taking place when *changing signal* from objects perceived:

– identification of the very *fact of the change* in the signal;

– fixation of certain *regularities* in the changing signal.

Indeed, the first situation is the most important; besides, it is a basis for all subsequent informational processes. That is why we shall start exactly from the model for identification of changes, i.e., from the problem of the threshold of perception.

E. The *necessity of the threshold* (which should be inherent in reactions of every complex system) was deduced in the framework of the informational approach – as the result of the principle "All or Nothing" which increases the chance of the system's survival [1, pp. 116-122]. However, till now the *value of the threshold* remained unexplained, and especially the riddle of its *constancy for*

different stimuli continua. In fact, the value of the relative threshold of perception is the same for very different kinds of stimuli: intensity of light, loudness of sound, electric current, etc.; it is close to 12-15%. (About this phenomenon and its systemic determination see, e.g., [7, 8].) Meanwhile using the phenomenon of triplicity, it occurs possible to explain this riddle, beside in tight connection with the riddle of the volume of the first step of human memory (the so-called "Magic Number 7±2," see [9]). Really:

– as far as *fast speed* of functioning is the main criterion of the effectiveness for the first step of memory, the evolution chose the simplest and the most reliable way to form this step: to use three informational channels, each responding to transmission of the binary signal (e.g., 0 or 1); as a result, a 3-channel operative memory device is formed, with the total amount of cells $\boldsymbol{V = 2^3 = 8}$ (different combination of states);

– the relative *threshold of perception* is simply a result [9] of the functioning of such 8-state memory device: when all 8 units are occupied (by the information which keeps the intensity of the given stimulus), to empty one of them means to lessen the stimulus intensity to 1/8 of its magnitude, i.e., to 12.5%, and when only 7 states are occupied, to add one state means to increase the stimulus to 1/7 of its magnitude, i.e., to 14.3%; in other words, the threshold $\boldsymbol{S \approx 1/V}$ (it is exactly the phenomenon of relative threshold that will become the basis for our further consideration).

So, even in the light of this model, one can expect ternary structures domination anywhere. A giant number of such examples are presented in the monograph by Stepanov [10].

F. Finally, when speaking of certain *regularities* in changing signal, we should focus on the task which is the most universal in this field: fixation of the *repetition of signals*, their regular arising. [It was not without reason that even Russian formalists of the 1920's proclaimed the existence of only "two devices" in the functioning of art: repetition and delay, – though the last one is impossible without the former.] So the main "personages" of our consideration will be the *probabilities* of certain events. What is the most substantial for the *perception of the sequence* of certain events, is that it is accompanied by definite *emotions* of the recipient. Considering that we shall deal not with the events themselves, – but with their *probabilities*. [In other words, we shall disengage ourselves from specific nature of the events perceived.] It is exactly these probabilities that are the source of perceiver's *emotions* (and not the events themselves).

Here the heart of the matter is the search for *regularities* within the 'world of events': possible statistical *links* which can be *established* between certain events perceived, the links that are capable of generating *positive emotions*. We suppose that a perceiver is a '*hedonic subject*' (at least when he/she perceives the sequence of the events in question), with an inclination to *search for links*. Situations when such search takes place, can be rather various. Let us consider one of the most *typical situations* which can be outlined as follows.

There exists a certain *'lattice' of events* which are more or less *regular*. Example of such regular lattice is the sequence of dawns: they come every day, with a strict (or almost strict) 24-hour periodicity, so dawns are the 'knots' of this lattice. In turn, on the basis of this 'primary' periodicity, another kind of cycles (i.e., another lattice, which may be named 'secondary') may occur, for instance, Sundays: they form 7-day periodicity. Such regularly coming events forming the *secondary lattice*, may be rather important both for the *personality* or the entire *system of culture*: sometimes on their basis various customs appear, as well as some prejudices. For instance, during the First World War the following strange regularity was observed by soldiers: when they got a light from somebody's cigarette, each third act might become fatal. (This regularity seems to be mystical, but its explanation is simple: during the first flash, a sniper found his aim, during the second flash he corrected his back-sight, and at the third one he made a shot, which could be mortal!)

(The situation of the "superposition" of one periodical structure on another, seems to be very "sharp" for perception, hence it might become rather influential for the formation of appropriate universal informational procedures. Really, exactly those situations are experienced with intensive emotions [1, 2], where we have some elements of regularities ('hints' on them), combined with certain ambiguity concerning their existence.)

How to establish such *secondary periodicity* built on the basis of the primary one, i.e., the periodicity working within the lattice of primary events? And first of all, *how many secondary events*

should be at the disposal of the subject (observer of these events), so that he/she could realize their periodicity? Two secondary events? or maybe three? or four? – This task can be easily solved.

Indeed, let the probability to meet the given secondary event in a certain position within the lattice (in the given 'knot') be p_k; for instance, if $p_k = .2$, then *statistically* this secondary event can be met in one knot out of every five ones. For example, a person plays roulette every day; one day he/she wins a large sum, then after four 'waste' days, he again wins a large sum, and so on. Hence, sooner or later he/she may conclude that these happy secondary events are subdued to cyclic regularity, with the period of 5 knots (i.e., the secondary events are not accidental).

But when exactly (i.e., at which occurrence) one can realize the periodicity mentioned? when he/she starts to *perceive the regularity*? – This question seems to be very important, as the very regularities introduce certain *order* in human's life, and they provide his/her due behavior during interaction with the environment. Moreover, in the case of *works of art*, the *search for regularities* is one of the main perceptual procedures; it is accompanied by *positive emotion* when the regularity is found.

Evidently, an event is considered regular when the person sees that the *probability of accidental occurrence* of the secondary event *at this knot* is negligible, i.e., it is less than the relative *threshold of perception*. Hence, the formula for the probability to meet the event in question, n times in 'due' positions (relating to strict secondary periodicity), equals

$$p_{(n)} = (p_k)^n \le S,$$

S being the above mentioned relative threshold of perception.

Now we should take into account that the relative threshold of perception $S \approx .15$ (see the above consideration), and the value n should be *integer*. So, for the most widespread situation when $p_k = .5$, we have

$$n \ge 3.$$

Really, if $n = 2$ (i.e., the event was met only two times in due positions), then $p_{(2)} = .25$. So, the *probability of accidental occurrence* of such situation is *not small* (it exceeds the above relative threshold) and is perceived as 'usual,' more or less habitual. But when $n = 3$, the probability $p_{(3)} = .125$, and this event should be felt as not accidental, i.e., evidencing in favor of the *regularity* present: periodical behavior of secondary events. Of course, further, when $n = 4$ (and $p_{(4)} = .0625$) or more, this regularity is confirmed, becoming more and more reliable, and even boring, hence generating *negative emotions*. However, namely the moment of the *first discovery* of the regularity is the most striking for the person, as well as for resulting *positive emotion*. Moreover, exactly this positive emotion determines the perception of the entire sequence of the events.

Naturally, this moment (of resulting positive emotion) depends on the value p_k: in order the second appearance of secondary event to be the indicator of a periodical regularity, the value of p_k should be less than $\sqrt{S} \approx .39$. And of course, secondary events possessing lesser values of p_k, being repeated two times in due positions (knots of the primary lattice), are perceived as 'accidentally quite unbelievable'! Example of such low-probable event was presented earlier: a large sum won by a person playing roulette. (Apropos, when dealing with the perception of devices of art, the value $\sqrt{S} \approx .39$ responds to the 'threshold of realizing,' i.e., reflexive understanding of deliberate, intentional usage of any device – see [11].)

Nevertheless, the most widespread situation responds to the above mentioned version: $p_k = .5$, i.e., the case of a binary choice – the given secondary event should either be met at this place, or not, with equal probabilities of both versions. Such version is typical at least when the first repetition of the secondary event, i.e., when $n = 2$, because of unknown a-priori probability of the event considered. (The subject proceeds – though implicitly – from the concept of maximal likelihood.) And at the second repetition ($n = 3$) the sequence of events becomes perceived as evidently quite regular, because $p_{(3)} = .125 < S$. So again we see *ternary structures* as those ones which are 'dictated' by *expectations* inherent in the perceptual procedures.

(Meanwhile, it seems reasonable to consider the situation of not so strict, but 'soft' periodicity: when the secondary event falls not exactly on 'due' knot, but maybe on the previous knot or next one, i.e., on one out of these three knots. In such a case, the probability to meet occasionally the given secondary event at its due place or near it, equals for the second 'soft' meeting $p_{(2)} = 1 - (1 - p_k)^3$ which for $p_k = .5$ responds to $p_{(2)} = .875$, and for the third 'soft' meeting $p_{(3)} = .875^2 = .766$, and so on. Only if p_k is rather small, such 'soft' periodicity can be felt more or less soon, e.g., if $p_k = .2$, then

$p_{(2)} = .488$, $p_{(3)} = .238$, and only $p_{(4)} = .116 < S$. In other words, in such soft case the periodicity is felt only after the fourth meeting with the secondary event observed. Probably such are situations in the sphere of folk tokens dealing with weather, which were investigated by Kharuto [12].)

From partial psychological and cultural regularities – to general ones

The above considerations permit not only to establish links between different branches of the informational approach (or between different models obtained in the framework of this approach), but also to come to some rather non-trivial conclusions concerning various psychological and cultural regularities, even having gnosiological sounding. However, first of all, it is desirable to outline the *borderlines* of the phenomenon in question: the triplicity – should it be met everywhere, in all spheres and all situations? – Of course, not!

When considering the roots of this phenomenon, we proceeded from considerations which possessed quite definite *specificity*: in all cases we did not deal with the "content" of objects (or events) perceived, their *own features*. Really, the non-motivated classification is determined not to single out objects which are useful for the subject, – but simply to keep information about various objects. As well, the three-detector procedure of determining spectral characteristics of objects, does not concern any "usefulness" of objects perceived. Finally, the lattice of "secondary" events was considered without any connection with the nature of these events. If we wished to take into account the "content" (own properties) of objects or events discussed, the *triplicity* may turn out to be *disadvantageous*. For instance, positive emotion which accompanies the detecting of the regularity (periodicity), is treated as being caused exactly by the regularity detected, – but not by those events themselves. (So if these events themselves are sad, accompanying emotion would be negative, and the phenomenon of triplicity should not take place.) That is why in some specific situations the behavior of the subject (as well as the behavior of any informational system, including the system of culture) will not be subdued to the principle of triplicity.

But much more interesting are situations giving *maximal chances* to this principle. Appropriate conditions take place primarily in the sphere of *art*, where the *disinterested perception* plays an important role. For some adjacent fields, more or less similar situations are typical.

One of the most impressive empirical findings dealing with the phenomenon of triplicity, relates to the *number of colors* dominating each national school of painting [13, 14]. Among various regularities characterizing color properties of painting (which have been deduced in the framework of the information approach), one should be mentioned in connection with the problem discussed. In each national culture, a set of *three "main colors"* (color triad) should dominate all cultural life, revealing themselves first of all in the system of painting. Spectral characteristics of these "main colors" are determined by geographical specificity of appropriate cultural region (primarily by the character of the sunlight typical for this region). Thus, for French and Italian painting such a triad consists of yellow, orange, and dark blue colors, in Spain these three colors are white, red, and black, and in Russian painting white, red, and green. These theoretical predictions were corroborated by empirical investigation concerning 822 paintings of the 15^{th} – 20^{th} centuries, belonging to French, Italian, Spanish, and Russian culture: each school revealed inclination to using exactly the above three colors.

Among other numerous evidences of the preferred triplicity (see also [10]), we may find *three main personages* in fairy tales, various prosaic works (e.g., three musketeers), etc., *ternary structures* in *religion* (trinity), *philosophy*, *linguistics*, and other fields. For instance, in *anthropology* we see *three "main colors"* in primitive cultures: red, white, and black, – being symbols of three main substances of human beings (blood, sperm, and faeces, respectively). Many other examples can be used to corroborate the principle of triplicity in various kinds of art [10]. So maybe it was not without reason great English poet Robert Browning wrote:

Then a mile of warm sea-scented beach;
Three fields to cross till a farm appears…
(Robert Browning, Meeting at night)

In future, it seems prospective to consider the phenomenon of *musical melody* in the light of this principle. In fact, the listener is constantly waiting for a certain regularity to be discovered, i.e., the repetition of definite features of sounds. (The number of such features should also be not more than

three, because of the limited 8-state volume of the above mentioned first step of our memory, let these features be, for instance, the tonality, the loudness, and so on.) For works of the so-called 'light music' (e.g., jazz) dealing with orderings which are functioning at short distances (involving the first step of the memory or the second one, responding to time intervals up to 3 seconds), the composer may use only one kind of repetition to be expected. But for works of 'serious' music (e.g., symphonies) which deal with larger spaces (up to several hours, responding to the functioning of the third step of memory – having an unlimited volume), the total number of the features used can be much more, as far as they may function at different levels: one set of features at the level of instant sounding, another set linking certain perceptual 'blocks,' other sets providing repetition on more and more high levels (scales).

As well, prospective may be the application of the approach derived, to some problems of *poetical structures*. Here rather important role should be played by the *three-mechanism* model of the *language processes*. (Appropriate model contains such mechanisms as associative, grammatical, and correlational, and all the richness of our mental world is provided due to the interactions of these three mechanisms – see, e.g., [2, 9].) The phenomenon of *rhyme*, together with its possible (in future) borders, can be considered in the light of 'pleasure' received due to certain phoneme repetition (which is governed by the triplicity). The very existence of the *free verse*, together with the criteria of its distinction from 'classical' verse, can be also considered proceeding from the principle of the triplicity (and maybe also three-parametric structure).

But the realm of the phenomenon considered is not limited by the sphere of arts: due to rather universal (non-specific) character of this phenomenon, it is capable of penetrating many other spheres, especially those ones which are based on *unconscious processes*. For instance, the *three-dimensional semantic space* which is inherent in most perceptual processes (namely such space is usually fixed in experiments using semantic differential techniques, starting from Osgood et al. [15]), is one of the consequences of the principle of the triplicity. Moreover, the *three-dimensionality of* our *perceptual space* (in which we live) can be hopefully ascribed to the same principle: we wish to receive positive emotions when perceiving various objects and/or events, hence, it is desirable to plunge them in the three-dimensional space. At least, both 'spatial' and 'temporal' motives are constantly "pushing" us to such worldview.

So maybe in general, we are living in a very *strange world*, determined mainly by our desire to receive *positive emotions*, under conditions of quite definite properties of our memory and appropriate informational processes? In turn, our positive emotions caused by the processes of establishing the regularities, are tightly connected with the very our *survival*! [Really, to survive, it is necessary to establish links inherent to the environment.] Hence, to survive, we should be constantly in *search for regularities*, and the triplicity is one of our mighty means in this process. Possibly here are the roots of many features of our world, including its three-dimensionality?

And going further, maybe this is exactly where we can find the key to the famous '*antropial principle*,' i.e., the riddle of the very existence of the world in which we live?

* * *

We hope further efforts to establish links between different branches of the informational approach can result not only in growing self-consistency of this approach, but also in various findings both of concrete character and rather general one.

Acknowledgements

The author wishes to express his gratitude to Leonid Dorfman, Alexander Kharuto, Alexander Levich, Colin Martindale, Sergey Chesnokov, Kseniya Sapozhnikova, Alexander Stepanov, and Roald Taimanov for fruitful discussions on the problems of the paper.

References

[1] G. A. Golitsyn, *Information and Creation: On the Path to 'Integral Culture.'* Moscow: Russky Mir, 1997 (in Russian).

[2] G. A. Golitsyn, & V. M. Petrov, *Information and Creation: Integrating the 'Two Cultures.'* Basel; Boston; Berlin: Birkhauser Verlag, 1995.

[3] V. M. Petrov, *The Information Approach to Human Sciences, Especially Aesthetics*. In: C. Martindale, P. Locher, & V. Petrov (Eds.), Evolutionary and Neurocognitive Approaches to Aesthetics, Creativity, and the Arts. Amityville, NY: Baywood Publishing Co., 2007. Pp. 129-148.

[4] G. A. Golitsyn, & V. M. Petrov, *Information and Biological Principles of Optimality: Harmony and Algebra of Living*. Moscow: KomKniga, 2005 (in Russian).

[5] S. V. Fomin, *Scales of Notations*. Moscow: Nauka (in Russian).

[6] B. V. Sukhotin, *Classification and Sense*. In: V. P. Grigoriev (Ed.), Problemy Strukturnoy Lingvistiki. 1981. Moscow: Nauka, 1983. Pp. 52-65 (in Russian).

[7] Yu. M. Zabrodin, & A. N. Lebedev, *Psychophysiology and Psychophysics*. Moscow: Nauka, 1977 (in Russian).

[8] L. A. Mazhul, & V. M. Petrov, *Logic of Finiteness: Intellectual Systems in the Information Era. 2. Limits to Diversity, Exactness, and Economy*. In: H. Hrachovec, A. Pichler, & J. Wang (Eds.), Philosophy of the Information Society (Papers of the 30th International Wittgenstein Symposium). Kirchberg am Wechsel: Austrian Ludwig Wittgenstein Society, 2007. Pp. 150-152.

[9] G. A. Golitsyn, & V. M. Petrov, *Information – Behavior – Language – Creativity*. Moscow: LKI Publishers, 2007 (in Russian).

[10] A. I. Stepanov, *The Number and Culture: The Rational Unconscious in the Language, Fiction, Science, Present Politics, Philosophy, History*. Moscow: Languages of Slavic Culture, 2004 (in Russian).

[11] V. M. Petrov, *Devices of Art: Optimal Frequency of Occurrence (Information Approach*). In: R. Tomassoni (Ed.), Pa Psicologia delle Arti Oggi. Milano: Franco Angeli, 2002. Pp. 43-48.

[12] A. V. Kharuto, *Year Cycles of Changing Air Temperature and Folk Calendar: A Statistical Comparison*. In: A. V. Kharuto & V. M. Petrov (Eds.), Information, Time, Creativity. International Conference 'New Methods in Studies of Artistic Creativity' and International Symposium 'Information Approach in Studies of Art and Culture.' Abstracts. Moscow: State Institute for Art Studies; P. I. Tchaikovsky Moscow State Conservatory, 2007. Pp. 88-93 (in Russian).

[13] V. S. Gribkov, & V. M. Petrov, *Color Elements in National Schools of Painting: A Statistical Investigation*. Empirical Studies of the Arts, vol. 14, No. 2, pp. 165-181, 1996.

[14] V. M. Petrov, *Quantitative Methods in Art Studies: A Handbook for Students*. Moscow: Academic Project, 2004 (in Russian).

[15] C. E. Osgood, G. J. Suci, & P. H. Tannenbaum, *The Measurement of Meaning*. Urbana, 1957.