Emotional evaluation of images: open patterns and unexplained facts (a review of the results of a questionnaire survey of 2282 people)

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1.Introduction

The invention of the algorithm that determines the pleasantness of image, video and sound from the point of view of most people happened in 2012-2013. Work on the creation of software and verification of the algorithm took place in 2018-2019. Due to limited funding, software was created to determine the attractiveness of images only, without video and sound. The USPTO recognized the invention and issued a patent on April 27, 2021 with the number 10991082. The direction of research on the attractiveness of video and sound remains open and is awaiting funding.

The study of people's emotions when observing images has been carried out since November 2018. to April 2019 Various methods were used: to assess the pleasantness; evaluate the nuisance; choose the three most pleasant / unpleasant; rate each image on a five-point scale according to the degree of pleasantness. Residents of different countries, different regions of the same country, of different sex and age were interviewed. The respondents were offered various types of images: landscapes, portraits, abstract compositions.

The respondents were required to rate the images on a pleasant-to-unpleasant scale. A person is able to easily and quickly choose, for example, the three most pleasant or most unpleasant pictures out of 9 or 13 proposed. A person can also easily and quickly rate 10 or 12 images on a five-point scale according to the degree of their pleasantness. How does this happen? What principles are laid down in the mechanism of this process, which takes place in the “eye-brain” system? And not only in the "eye-brain" system. The feeling of pleasantness is created through the production of appropriate hormones. This means that the endocrine system is also involved in this process. The eye-brain-hormone system is able to easily and quickly do something that is beyond the power of any of the most powerful computers. How does this happen? Why are these images more popular with a significant proportion of people? Yes, there are differences between people, but they turn out to be not so great in emotional assessments of images. This means that there is a certain single mechanism that the modern level of science does not know.

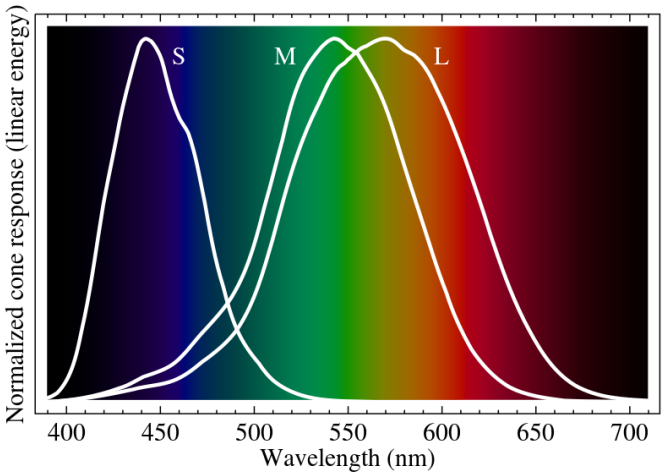
To try to answer these questions, a model of the eye-brain-hormone system was created. Studies have been conducted to compare the results of this model with the estimates of real people. If the model acts in the same way as real people, then it can be assumed that the mechanism inherent in the model also works in the "eye-brain-hormones" system of real people. Then it will reveal another secret in the knowledge of the greatest miracle - man.

To achieve the objectives of the study, two hypotheses were formulated at the initial stage:

1. The presence of the same type of reaction among a significant proportion of respondents.
2. How much the law of normal distribution manifests itself (does not manifest itself) in the perception of images.

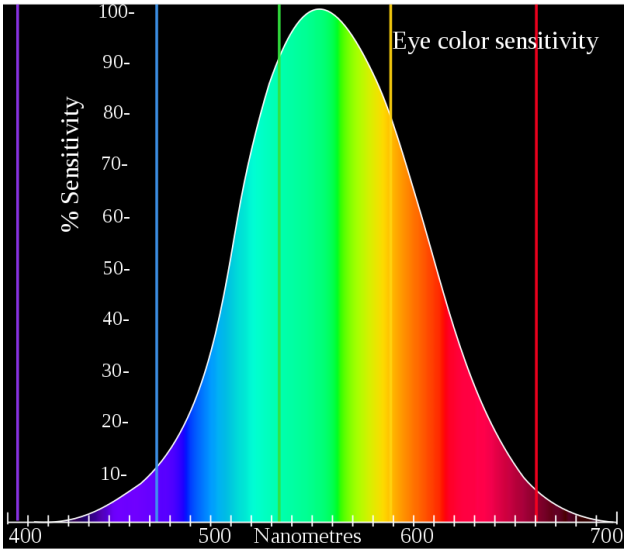
If everything is more or less clear with the first hypothesis, then the second hypothesis requires a comment.

The laws of perception of visual images by the human eye are expressed by functions very similar to the bell-shaped Gaussian normal distribution curve.



Normalized response spectra of human cones, to monochromatic spectral stimuli, with wavelength given in nanometers.

(Source: https://en.wikipedia.org/wiki/Color_vision)



Photopic relative brightness sensitivity of the human visual system as a function of wavelength (luminosity function)

(Source: https://en.wikipedia.org/wiki/Color_vision)

The opponent's theory of visual perception suggests “that the visual system interprets color in an antagonistic way: red vs. green, blue vs. yellow, black vs. white. " (https://en.wikipedia.org/wiki/Color_vision)

The Nobel Prize winners Hubel and Wiesel have experimentally proved the mechanism of perception by the eye of the ratio of primary colors and brightness:

«These specialized "color cells" often have receptive fields that can compute local cone ratios. Such "double-opponent" cells were initially described in the goldfish retina by Nigel Daw; their existence in primates was suggested by David H. Hubel and Torsten Wiesel and subsequently proven by Bevil Conway. As Margaret Livingstone and David Hubel showed, double opponent cells are clustered within localized regions of V1 called blobs, and are thought to come in two flavors, red–green and blue–yellow. Red–green cells compare the relative amounts of red–green in one part of a scene with the amount of red–green in an adjacent part of the scene, responding best to local color contrast (red next to green). Modeling studies have shown that double-opponent cells are ideal candidates for the neural machinery of color constancy explained by Edwin H. Land in his retinex theory»

(https://en.wikipedia.org/wiki/Color_vision#cite)

The ratio between black and white reflects the characteristic of lightness (lightness, value) in the LAB, HSV color models of digital images. The ratios of red-green and blue-yellow reflect characteristics A and B (LAB color model); H and S (HSV and HSL color models).

The law of normal distribution methodologically approaches the opponent's theory of visual perception: its essence lies in the distribution of a variety of phenomena on a scale of some characteristic between two opposite poles. In this regard, on the basis of the normal distribution law, artificial intelligence was created in the form of a software algorithm (hereinafter referred to as the Algorithm), which imitates the human emotional assessment of any

image. The algorithm solves a complex problem that at first glance seems contradictory and unsolvable. On the one hand, each image is unique; it is very difficult to find a universal approach for evaluating different images with different characteristics and types. On the other hand, humans are capable of evaluating and comparing all kinds of images, sounds or videos using various criteria such as, but not limited to, acceptability, agreeability, and desirability. Moreover, humans are capable of performing this process very quickly. The algorithm automates the complex mechanism behind this process.

The algorithm based on the law of normal distribution was applied in several ways both to one image characteristic and to a combination of characteristics: L, A, B, S. A combination of several methods or several characteristics will be called the aggregated optimality coefficient. Application in one way to one characteristic is called a simple optimality coefficient.

In the case when a higher value of the optimality coefficient means a more pleasant image in the assessment of most people, such a correlation is called positive.

Otherwise, when a higher value of the optimality coefficient means a less pleasant image in the opinion of most people, such a correlation is called negative.

2.Description of the results of the questionnaire survey and verification of the Algorithm

In all surveys, the type of device for viewing and evaluating images: smartphone, tablet, laptop, computer. The number of images for evaluation ranged from 9 to 13.

2.1. Survey "Landscapes 13".

Period: the survey was conducted over 3 weeks from mid-November to December 7, 2018.

Number of respondents: 37 people.

Composition of respondents: more than 90%: residents of St. Petersburg, age from 40 to 80, higher education, Russians. Women 21, men 16.

Question to respondents: "Choose the three most unpleasant images."

Image type: The images were landscapes with a body of water (sea or lake).
Correlation type with aggregated optimality coefficient: positive.

The results of testing the 1st hypothesis about the presence of a large group with the same type of preferences: 23 people chose one picture among the three most unpleasant. 23/37 = 0.62.

62% have the SAME opinion about this picture! This is a colossal confirmation of the first hypothesis with a startling unambiguous result. Moreover, 29 people chose at least one of

the three pictures that eventually received the largest number of votes, dividing the first three places by trouble. And this is already 78%!

The results of testing the 2nd hypothesis about the presence of a correlation between subjective emotional preferences and the aggregated optimality coefficient calculated by the Algorithm: the correlation coefficient between the respondents' assessments and the Algorithm was 25%.

Conclusion: the first hypothesis is confirmed. The second hypothesis was not confirmed. The strength of the correlation with the Algorithm is in the zone of very weak (0-30%) correlation.

2.2. Survey "Landscapes 9".
Period: from January 1, 2019 until March 3, 2019
Number of respondents: 271 people.

Composition of respondents: Women - 57%, men - 43%. Residents of Russia - 68%, residents of North America - 32%. Age of the respondents: from 16 to 82 years.

Question to respondents: "Choose the three most pleasing images."

Image type: The images were landscapes with the sea, the beach, palm trees or their leaves, the sky with small clouds. The sea is calm, not at night. All images lack people and man-made objects (houses, buildings, etc.). The images were chosen with the intentional aim of bringing the meaning as close as possible so that the meaning of the image does not affect the emotional assessment of the person.

Scoring Method: Selecting an image meant adding one point to that image. It was not possible to select fewer or more than three images. All scores obtained by images were summed up for each image. Each image has a corresponding score. This sum of points, which is a numerical series, was compared with the corresponding value of the optimality coefficient calculated by the Algorithm.

Correlation type with aggregated optimality coefficient: positive.

The results of testing the 1st hypothesis about the presence of a large group with the same type of preferences: the three most pleasant images received 41% points. This result is significantly less than the same indicator (78%) of the first survey. But we consider it more significant, since in this set of images the influence of their meaning was practically excluded.

The results of testing the 2nd hypothesis about the presence of a correlation between subjective emotional preferences and the aggregated optimality coefficient calculated by the Algorithm: the strength of the correlation between the respondents' assessments and the Algorithm was 89% and fell into the strong zone (70-90%).

Conclusion: the correlation does not just exist, but is strong. Moreover, the correlation has practically reached the border beyond which it will be characterized as “very strong” (over 90%).

Let us consider in more detail the correlation of simple optimality coefficients for individual image characteristics: lightness and saturation: Lightness from the LAB color model and Saturation from the HSV color model. In terms of lightness, the correlation turned out to be 62%. According to the generally accepted rules of probabilistic statistics, a correlation of strength from 50% to 70% is characterized as an average degree. This means that with a stable average degree of correlation, the Algorithm predicts the brightness preferences of most people. A simple saturation optimality coefficient showed a weak correlation, namely 45% (which itself is close to the border of the average correlation strength). These results were quite predictable: lightness, brightness and saturation of color combinations should understandably affect the degree of pleasantness of the image.

However, in the course of research, an unexpected effect of negative correlation for characteristics A and B from the LAB color model was discovered. The correlation turned out to be weak. But surprisingly, 25% of the correlation for these two characteristics coincided in value literally up to 1 percent: -24.988% for A and -25.085% for B. This unexpected effect is of great importance from two different points of view. The fact is that characteristic A reflects the correlation between two colors: red and green. Characteristic B reflects the relationship between the other two colors: blue and yellow. In all recognized theories of color perception, these four colors are basic.

And the first of two unexpected conclusions from my research is that these four colors in images of landscapes are perceived by the human eye the more pleasant, the more pure they are. The absence of a positive correlation (both in lightness and saturation), the presence of a persistently negative correlation (albeit a weak strength) means that the purity of these four colors, to a certain moderate degree, affects the pleasantness of human perception.

The second unexpected important conclusion can be formulated as follows: the purity of these four colors in images of landscapes should be moderate and their moderation should be practically the same relative to each other, so that a person perceives them with positive emotion.

Now let's consider the aggregated optimality coefficients. The sum of the optimality coefficients for lightness and saturation, divided by the sum of the optimality coefficients for characteristics A and B (L + S) / (A + B), this fraction of the two sums gave a correlation of 85%! This result far and steadily exceeded the 70% border separating the average correlation from the strong one. The most effective variant of the aggregated optimality ratio achieved the result of 89%, which was indicated above.

2.3. Survey "Madonna Litta".
Period: from 03 April to 07 April 2019
Number of respondents: 1020 people.

Composition of respondents: to exclude the influence of gender differences in emotional assessments, only women were admitted to the survey; residents of Russian cities; age of the respondents: from 14 to 70 years.

Question to respondents: "Do you like this image?" The respondent saw the title of the questionnaire "Rate the pleasantness of different versions of the same image on a five-point scale."

Five answers were given under the image: 1-no; 2-not really; 3-neutral; 4 likes; 5-like it very much.

Type of images: To carry out this stage of testing, a complex methodological problem was solved: how to completely eliminate the influence of meaning and at the same time the image should not be abstract, but meaningful? The answer was found: the creation of different lightness and saturation variants of the same image. The painting by Leonardo Da Vinci "Madonna Litta" was taken. This image has been modified in eight variations by changing the brightness. The respondents were asked to evaluate 9 options (1 original and 8 modified) of this image.

Scoring method: answer 3 (neutral) is taken as zero points; answer 4 adds 1 point; answer 5 - adds 2 points; answer 2 takes 1 point away; answer 1 subtracts 2 points. So, answers from one to 5 bring the following number of points to the image: -2; -one; 0; +1; +2. Thus, the scores were calculated for each image and summed up for all respondents (1020 people). Each image had a corresponding sum of points. This sum of points, which is a numerical series, was compared with the corresponding value of the optimality coefficient calculated by the Algorithm.

Correlation type with aggregated optimality coefficient: positive.

The purpose of this stage of testing is to test two hypotheses in the perception of portraits, that is, images of people.

Hypothesis 1, uniformity of assessments: the most pleasant image was chosen by 71% of the respondents (answered “like” or “like it very much”).

Hypothesis 2, correlation with the Algorithm: lightness correlation was + 52%; by saturation + 85%. According to the aggregated optimality coefficient, the correlation was the same 85%, which is characterized as "strong correlation".

According to characteristic A, the correlation, as well as for landscape images, turned out to be negative, although more significant: -53%. No correlation was found for characteristic B: + 3%.

Output. Both hypotheses are confirmed. The positive correlation for these two characteristics allows us to conclude that people perceive landscape and portrait images in the same way. The coincidence of the correlation for a simple coefficient of optimality for characteristics A and B was not confirmed. Perhaps it is here that one should look for the difference in the perception of landscapes and portraits.

2.4. The survey "Landscape 5-10".
Period: from March 23 to March 24, 2019
Number of respondents: 200 people.

Composition of respondents: to exclude the influence of gender differences in emotional assessments, only women were admitted to the survey; residents of Russian cities; age of respondents: from 14 to 72 years.

Question to respondents: "Do you like this image?" The respondent saw the title of the questionnaire "Rate the pleasantness of different versions of the same image on a five-point scale."

Five answers were given under the image: 1-no; 2-not really; 3-neutral; 4 likes; 5-like it very much.

Type of images: The most pleasant landscape from the "Landscapes 9" survey was taken (see above). This image has been altered in nine variations by changing the brightness. The change in brightness and lightness was made with a large amplitude: from too dark to too light. The respondents were asked to evaluate 10 options (1 original and 9 modified) of this image.

Scoring method: answer 3 (neutral) is taken as zero points; answer 4 adds 1 point; answer 5 - adds 2 points; answer 2 takes 1 point away; answer 1 subtracts 2 points. So, answers from one to 5 bring the following number of points to the image: -2; -one; 0; +1; +2. Thus, the scores were calculated for each image and summarized for all respondents. Each image has a corresponding score. This sum of points, which is a numerical series, was compared with the corresponding value of the optimality coefficient calculated by the Algorithm.

Correlation type with aggregated optimality coefficient: positive.

Hypothesis 1, uniformity of ratings: the most pleasant image was chosen by 88% of the respondents (answered "like" or "like very much").

Hypothesis 2, correlation with the Algorithm: lightness correlation was + 85%; saturation + 51%. According to the aggregated optimality coefficient, the correlation was 56%, which is characterized as “average correlation”.

According to characteristic A, the correlation of the simple optimality coefficient turned out to be positive: + 64%. According to characteristic B, the correlation is also positive: + 25%.

Output. Both hypotheses are confirmed. The fact of a negative correlation (established in the survey "Landscapes 9") of the optimality coefficient for characteristics A and B in the perception of landscapes was not confirmed. A new fact was discovered: when evaluating images with a large amplitude in terms of lightness, it is the lightness rather than saturation that begins to prevail. At the same time, a person's emotion is formed mainly according to the optimality algorithm according to the "lightness" characteristic. This allows us to put forward a third hypothesis - the hypothesis of the primacy of the influence of lightness on emotion in comparison with saturation. The hypothesis is formulated as follows: the optimality of the image in terms of lightness is primary, and the optimality of the image in terms of saturation is secondary in the emotional perception of a landscape image.

2.5. The survey "Landscape 4-10".
Period: from March 29 to March 30, 2019
Number of respondents: 80 people.

Composition of respondents: to exclude the influence of gender differences in emotional assessments, only women were admitted to the survey; residents of Russian cities; age of respondents: from 17 to 59 years.

Question to respondents: "Do you like this image?" The respondent saw the title of the questionnaire "Rate the pleasantness of different versions of the same image on a five-point scale."

Five answers were given under the image: 1-no; 2-not really; 3-neutral; 4 likes; 5-like it very much.

Type of images: One of the nicest landscapes from the Landscapes 9 survey (see above) was taken. This image has been altered in nine variations by changing the brightness. The amplitude of the change in brightness and lightness has been significantly reduced compared to the set of images from the previous survey. A slight spread in lightness and brightness was made. The respondents were asked to evaluate 10 options (1 original and 9 modified) of this image.

Scoring method: answer 3 (neutral) is taken as zero points; answer 4 adds 1 point; answer 5 - adds 2 points; answer 2 takes 1 point away; answer 1 subtracts 2 points. So, answers from one to 5 bring the following number of points to the image: -2; -one; 0; +1; +2. Thus, the scores were calculated for each image and summarized for all respondents. Each image has a corresponding score. This sum of points, which is a numerical series, was compared with the corresponding value of the optimality coefficient calculated by the Algorithm.

Correlation type with aggregated optimality coefficient: positive.

Hypothesis 1, uniformity of assessments: the most pleasant image was chosen by 80% of the respondents (answered “like” or “like very much”).

Hypothesis 2, correlation with the Algorithm: lightness correlation was + 17%; saturation + 54%. According to the aggregated optimality coefficient, the correlation was 83%, which is characterized as "strong correlation".

Hypothesis 3, primacy of lightness: with a reduction in the amplitude of lightness in the set of images proposed for evaluation, the optimality in terms of lightness loses its importance, while the optimality in terms of saturation becomes much more important. The hypothesis is confirmed.

According to characteristic A, the correlation of the simple optimality coefficient turned out to be positive: + 84%. According to characteristic B, the correlation is also positive: + 73%.

Output. Three hypotheses have been confirmed. The fact of a negative correlation (established in the survey "Landscapes 9") of the optimality coefficient for characteristics A and B in the perception of landscapes was not confirmed.

2.6. Survey "Kandinsky 12".
Period: from March 15 to April 02, 2019
Number of respondents: 611 people.

Composition of respondents: women 67%, men 33%. Age from 13 to 76 years old. All respondents are residents of Russian cities.

Question to respondents: "Do you like this image?" The respondent saw the title of the questionnaire "Rate on a five-point scale the pleasantness of 12 works of the great Russian artist

of the 20th century." Despite the fact that this title deliberately set the person up for a benevolent assessment of the images, the vast majority of the works received an overall negative assessment. This confirms the results of numerous other studies about the unpopularity of abstract painting among most people. Most people prefer realistic images

(Here you can refer to the results of the most famous project "The Most Wanted Paintings on the Web", supported by the Chase Manhattan Bank: http://awp.diaart.org/km/index.html).

The average score for the image was minus 201.5 (-201.5). Only 2 images out of 12 entered the positive zone, the most pleasant image received a total rating of only 46 points. While the most unpleasant image got minus 406 points (-406).

Five answers were given under the image: 1-no; 2-not really; 3-neutral; 4 likes; 5-like it very much.

Type of images: from the works of Kandinsky, I chose those compositions that had nothing to do with realism, the most abstract combinations of shapes and color spots.

Scoring method: answer 3 (neutral) is taken as zero points; answer 4 adds 1 point; answer 5 - adds 2 points; answer 2 takes 1 point away; answer 1 subtracts 2 points. So, answers from one to 5 bring the following number of points to the image: -2; -one; 0; +1; +2. Thus, the scores were calculated for each image and summarized for all respondents. Each image has a corresponding score. This sum of points, which is a numerical series, was compared with the corresponding value of the optimality coefficient calculated by the Algorithm.

Correlation type with aggregated optimality coefficient: negative.

Hypothesis 1, uniformity of ratings: the most pleasant image was chosen by 42% of the respondents (answered "like" or "like very much").

Hypothesis 2, correlation with the Algorithm: lightness correlation was -72%; saturation -84%. According to the aggregate optimality coefficient, the correlation was -73%, which is characterized as “strong correlation”.

Hypothesis 3, primacy of lightness: when evaluating different images, perception correlates with the optimality in terms of lightness and saturation in approximately the same way. The hypothesis has not been confirmed.

According to characteristic A, the correlation of the simple optimality coefficient turned out to be negative: -86%. According to characteristic B, the correlation is also negative: -69%.

Output. Two hypotheses are confirmed, the third is not. The fact of negative correlation (established in the survey "Landscapes 9") of the optimality coefficient for characteristics A and B in the perception of landscapes is also confirmed in the emotional assessment of abstract images. There was no difference in this. Unless in the strength of such a negative correlation. Let us recall that in the Landscapes 9 survey, people's assessments correlated with simple optimality coefficients for characteristics A and B with a strength of 25%, and in this survey, according to Kandinsky, 86% and 69%. The difference is in the degree of correlation.

For all four coefficients of optimality of the Algorithm, calculated according to four characteristics (L, A, B, S), the correlation turned out to be a strong degree or close to it! In terms of lightness (L), the correlation between the optimality coefficient and total emotional assessments turned out to be -71%, for A - 86%, for B -69%, for S -84%.

Based on the combination of optimality coefficients, this stage of testing the algorithm allows us to state a qualitative breakthrough into the "VERY high degree of correlation" zone! A simple sum of four optimality coefficients for four characteristics (L + A + B + S) gave the result of 91% correlation with the respondents' estimates.

2.7. Survey "Kandinsky - In White2".
Period: from 07 April to 08 April 2019
Number of respondents: 100 people.

Composition of respondents: women only. Age from 18 to 74 years old. All respondents are residents of Russian cities.

Question to respondents: "Do you like this image?" The respondent saw the title of the questionnaire "Rate the pleasantness of different variants of one image (Kandinsky" In White2 ") on a five-point scale".

Five answers were given under the image: 1-no; 2-not really; 3-neutral; 4 likes; 5-like it very much.

Type of images: from the set of the previous survey, I chose the most pleasant composition according to the respondents. As the author called it - "In white II". The brightness and contrast were changed in 12 variants with a small amplitude. In total, respondents were asked to rate 13 almost identical images.

Scoring method: answer 3 (neutral) is taken as zero points; answer 4 adds 1 point; answer 5 - adds 2 points; answer 2 takes 1 point away; answer 1 subtracts 2 points. So, answers from one to 5 bring the following number of points to the image: -2; -one; 0; +1; +2. Thus, the scores were calculated for each image and summarized for all respondents. Each image has a corresponding score. This sum of points, which is a numerical series, was compared with the corresponding value of the optimality coefficient calculated by the Algorithm.

Correlation type with aggregated optimality coefficient: negative.

Hypothesis 1, uniformity of ratings: the most pleasant image was chosen by 42% of the respondents (answered "like" or "like very much").

Hypothesis 2, correlation with the Algorithm: lightness correlation was -90%; saturation - 98%. According to the aggregated optimality coefficient, the correlation was -39%, which is characterized as “weak correlation”.

Hypothesis 3, primacy of lightness: perception correlates with optimality in terms of lightness and saturation in approximately the same way. The hypothesis has not been confirmed.

According to characteristic A, the correlation of the simple optimality coefficient turned out to be negative: -93%. According to characteristic B, the correlation is also negative: -97%.

Output. Two hypotheses are confirmed, the third is not. The fact of a negative correlation of simple optimality coefficients with respondents' assessments for all four characteristics is confirmed.

In total, 2282 people took part in all polls.

3. The results obtained for all the polls allow us to formulate the main conclusions

1. Correlation with the optimality coefficients of the Algorithm for lightness and saturation, based on the law of normal distribution, in most cases exceeds 70% and qualifies as a strong degree. This applies to all types of images. This allows us to conclude that the mechanism of emotional evaluation of the image (the "eye-brain" system) operates on the principles of normal distribution: a certain relationship between the mean and extreme opposite values.

2. At this stage of research, two types of images with diametrically opposite correlation in lightness and saturation have been identified: landscape-portrait and abstract.

The most unexpected and inexplicable conclusion: all four simple coefficients of optimality have a negative correlation with the assessments of people when they perceive abstract images. Let me remind you that for landscape images, two of them always gave a positive correlation - in lightness and saturation. For abstract images, optimality in lightness (L) and saturation (S) negatively correlates with respondents' assessments. The full significance of the discovery of this effect has yet to be assessed by scientists. However, today it is already possible to state with confidence that the human brain evaluates the pleasantness of landscape and abstract images by two characteristics (lightness and saturation) in a strictly opposite way. Moreover, in each case, this reaction has a significant stable degree of correlation.

3. A stable effect on the correlation of the optimality coefficients for characteristics A and B was not found.