THE HUMAN FACTORS INFLUENCE ON PROCESS OF PATTERN RECOGNITION (THEORY QUESTION)

Vladimir PRISNIAKOV*, Ludmila PRISNIAKOVA**

*Institute of Geothecnical Mechanics Nat. Ac. Sc. of Ukraine
**Institute Psychology of Ac. Pedag. Sc. of Ukraine,
49050, Kazakova #4, kv.30, Dnipropetrovsk,Ukraine
<kprisn@a-teleport.com>

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ABSTRACT

The aim of our report is to show the possibility of mathematical modeling of pattern recognition as information processing in human memory Mathematical model of information processing in human memory for description some actions of the image interpreter has been used. The starting-point is a equation of processing of information by human memory .It connects a magnitude of information in memory with time and the rate of information inputting into memory., The dependencies on stimulus brightness and the received sensation, the description of darkness and light adaptation; the relationship between the threshold sensitivity and stimulus magnitude, the dependence of the choice response time and probability appearance of signal has been obtained, on the theoretical solution of this equation... The obtained solution describes the experimental data with brightness as stimulus well. The solution of the initial equation for threshold values connected with human sensor systems sensitivity. The resulting formula describes its influence of degree of brightness, the size of the test-object, the degree of contrast between the irritant and background. In the special case that the operator has alternative stimulus the choice response time is added by latent period of the simplest response and the choice response time respective. The given formula connects this time with a probability appearance of signal. The theoretical predictions have been checked. Theory works well for mathematical modeling real situation and extends possibility study on function of image interpreter.

1. INTRODUCTION

The pattern recognition, determination of their shapes, dimensions, location by their photographic or visible images are depended on the activity of image interpreter. He has obtained the information, has processed hers, has remembered hers and has level with image in his memory. Visibility (or probability of detection) is depended on the brightness of background and object in him, on level of visual adaptation, on stay in field of vision. Improvement of activity of image interpreter is determined by possibility of its mathematical description.

2. THE MATHEMATICAL MODEL

Process of pattern recognition is defined as the processing of information by human memory in relation to the *equation* (Prisniakov, Prisniakova, 1990)*:*

$$dI/dt = \overset{\bullet}{R} - (I - j)/T \quad (1)$$

We obtained, on the theoretical solution of this equation,

$$I = \dot{\mathsf{j}} + \dot{R}\,T + (I_0 - \mathsf{j} - \dot{R}\,T)\,exp(-t/\mathsf{j}) \quad (2)$$

the dependencies on stimulus brightness and the received sensation, the description of darkness and light adaptation; the relationship between the threshold sensitivity and stimulus magnitude, the dependence of the choice response time and probability appearance of signal.

3. THE ADAPTATION

If we interpret the changing sensitivity of receptors during ***adaptation*** like the fading of information in memory, we can describe the process of adaptation by using a formula for information retention in memory. We derived this formula from a differential equation (1) (or equation (2) under $\dot{R}=0$) describing the conservation of the flow of information ((Prisniakov, Prisniakova, 1988)

$$\overline{I} = \mathsf{`j} + (1 - \mathsf{`j})\,exp(-t/T) \quad (3)$$

where $I = I/I_0$ is relative sensitivity of the receptor; I is current value of information about stimulus intensity; I_0 is the initial value of information about the intensity of the stimulus; $\overline{\mathsf{j}} = \mathsf{j}/I_0$; j is the minimum value of the amount of information retained in human memory after a sufficiently long period of time; (it is acquired by memory through life experience and by genetic endowment; a consequence of both nature and nurture). Let me show you how this theory of loss information predicts all adaptation data for light and darkness adaptation. Different experimental conditions alter the values of the parameters T (a memory information processing time constant, determined experimentally) and $\overline{\mathsf{j}}$. Let us examine the application of equation (3) in more detail and investigate the effect of various parameter values for T and $\overline{\mathsf{j}}$. Comparison of analysis of theoretical and experimental data shows that as luminance, B_d, increases, both the time constant of the process of light adaption, T, and the parameter j decrease. Computations of the experimentally derived values of T and j made it possible to plot relations between $T(B_d)$ and $\mathsf{`j}(B_d)$ which can be approximated in the range of values of B_d by the following functions:

$$T = 3 - (1/3)\,ln(B_d),\ \mathsf{`j} = b_1 + b_2\,ln(B_d),$$

where $b_1 = 0.25;\ b_2 = -0.04.$

The curvature of the lines characterizing the relation between light sensitivity and darkness adaptation depends on a number of factors. For example, the degree of luminance during the preliminary exposure of the eyes to light, on the section of the retina to which the test stimulus is applied, on the area of this projection, etc. Besides, it is necessary to take into account the difference of the adaptational capacities of the cones and rods. It has already been hypothesized, as mentioned as the result of the initial luminance of the light perceived by the eyes. One can use formula (3) for predicting the process of adaptation to darkness. The comparison of the predictions against numerous experimental data shows that the process of darkness adaptation can be computed precisely enough from formula (3) under an average value of T; the values of T and $\mathsf{`j}$ for cones and rods being different. For example, the comparison of Piper's experimental data against the predicted results based on formula (3) shows a satisfactory fit. It is worthwhile nothing that when $t=10$ min the experimental data show a discontinuity which corresponds to the time lag between

adaptation periods of cones and rods. Both sections are approximated very well but for different values for the rods and cones.

The analysis of the effect of duration, τ_0, of preadaption exposure to luminance, on the shape of the adaptation curve that is on the values of T and $\bar\varphi$ yield the formulas

$$T = a_1 \sqrt[4]{t_0} \;\; ; \;\; \bar\varphi = a_2\, ln(2+t_0/t_0)+a_3$$

If dark adaptation follows a period of long adaptation to a certain color, the numerical values of T and $\bar\varphi$ change. In this case the calculated predictions fit the experimental data better under an assumption of linear changes in the variables

$$T = T_0 + \theta t$$

In this case the solution of the equation for the retention of information in sensory memory yields:

$$\bar I = \bar\varphi + (1-\bar\varphi)(1+\theta t/T_0)\, exp(-1/\theta) \quad (4)$$

We can also analyze other effects such as:

--- **the dynamics of the magnitude of preadaptation on the shape** of the adaptation curves; computations from (3) yielded the average values of variables T and $\bar\varphi$ which satisfactorily fit the experimental data (under the same value of pre-exposure brightness $I_0 = 30\ mlb$: nominator is retinal cones, denominator is rod cells) – see Table 1.

Table 1

$I_0 = 30\ mlb$	4700	447	44	4
T, min	2.2/2.8	1.3/2	1.8	1.5
$\bar\varphi$	$0.11/4.710^{-4}$	0.01	0.01	0.1

---- **the effect of luminance of different colors** on the adaptation curve; results of computations of experimental data (from formula (3) are in Table 2.

Table 2.

Colour	T, min	$\bar\varphi$
Violet	1.35	0.022
Yellow	1.3	0.063
Red	0.91	0.094
White	1.35	0.034

----- **the effect of adaptation to light** on subsequent darkness adaptation is mainly reflected in the values of $\bar\varphi$, ; while the values of T_0 and θ change insignificantly.

4.THE BRIGHTNESS AS STIMULUS

The problem of the relation between magnitudes of sensation and stimulus is solved in the general form for the first time. The solution the differential equation (1) gave the general Psychophysical Law:

$$\overline{I} = (1+p)/(1-exp(-pR))/p \quad (5)$$

This exponential curve describes the experimental data with brightness as stimulus well.

5.THE HUMAN SENSOR SYSTEM SENSITIVITY

Difference in brightness implies the existance of not only absolute but discrimination thresholds as well. Brightness range of light varies from the absolute lightness threshold (10^{-5} -- 10^{-6} cd/m^2) to the very high values (up to 10^6 cd/m^2). Visual sensations of the observer may be described in terms of the absolute brightness of a stimulus and the relative brightness of light stimuli which can vary.

Solving equation for threshold values we have the formula for the Weber's fraction

$$DR_0/I = ln(1+p)/(1+p)(1-exp(-pR/\text{j})), \quad (6)$$

where DR_0 is the sensory discrimination threshold.

This formula opens new possibilities of the analytical assessment of the processes, connected with human sensor systems sensitivity.

The analysis of our computations showed that the influence of difference factors can be estimated both qualitatively and quatitatively with the help of equation (6). This influence is reflected, first of all, in the values of j, p, $\dot{R}T$. The analysis of the experimental data obtained showed that j, p, $\dot{R}T$ values depend upon the light wave lenght l. The corresponding relations between j and $\dot{R}T$ variables and l are

$$j = j_1 exp(\text{q}t), \dot{R}T = a + bl,$$

where j_1 =6.6 10^{-8} unit, q= 0.025 1/s; a=32un; b= -0.03 1/nm.
This formula is obtained by approximation of the computations based on experimental data.

6.THE TIME OF PATTERN RECOGNITION

In the special case that the operator has alternative stimulus the choice response time is added by latent period of the simplest response and the choice response time respective. Solving Eq. (1) we have the formula

$$`t_p = 1 + ln[1+p(1/W-1)]/ln(1+p) \quad (7)`$$

The theoretical predictions have been checked. This theory works well for mathematical modeling real situation and extends possibility study on function of image interpreter.

CONCLUSION

The work shows the prospects of mathematical description of process of pattern recognition by man as information processing in human memory. Theoretical formulas predicts the adaptation processes for light and darkness adaptation; they can also analyze the dynamics of the magnitude of preadaptation on the shape of the adaptation curves; the effect of luminance of different colors on the adaptation curve; the effect of adaptation to light on subsequent darkness adaptation; theoretical

relations describe the influence of degree of brightness, the size of the test-object, the degree of contrast between the irritant and background.

Nomenclature

$\grave{I} = I/\text{j}$;

I – the amount of information;

I_0 is the initial value of information about the intensity of the stimulus.

$p = \text{j}/\dot{R}\,\text{T}$;

$\dot{R}$ – the rate of information imputing into memory;

DR_0 is the sensory discrimination threshold;

W – probability appearance of signal;

j -the amount of information retained by memory after sufficiently long period of time;

t- time;

$\grave{t}_p = t_p/t*$;

t* -latent period of the simplest response;

T is memory information processing time constant, determined experimentally.

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