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Modeling of Individual`s «State» in Pandemic

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***Abstract*—Mental health and physiological condition of a person, his social success are defined by his ability to adapt to a rapidly changing world. The purpose of the article presented is to illustrate the models, which can influence on the state of an individual in a pandemic. The scientific analysis of the problem reveals that the main tools to define the state of an individual appear to be conceptual models and mathematic statistics. For research, we use some elements of system analysis, cognitive approach and theory of fuzzy sets. To achieve the purpose we have solved the following tasks. In 2020, the survey of students and teachers of the university was conducted to obtain primary data in order to build the models of 'adaptation' and of the degree of 'changing the world picture' of an individual during the pandemic. The influencing factors are revealed, the cause-and-effect relationships between them are indicated, a cognitive model of the 'state' of an individual during the pandemic is built, and its simplicial analysis is also carried out. Pareto diagrams are built to identify the factors that make the main contribution to changing the picture of the world and adaptation of people in a pandemic. The results of the research are used to support managerial decision-making.**

***Keywords*—system, state, system pattern, cognitive model, simplicial analysis, fuzzy sets, pandemic**

I. Introduction

Person's positive attitude towards life is related to his abilities to adapt to a dynamic environment. The development of various types of self-regulation helps an individual to adapt to emerging social changes. The review of scientific reports on the problem shows that the main investigation tool is conceptual modelling and mathematic statistics. We study the state of an individual in a pandemic using system analysis, cognitive approach and theory of fuzzy sets.

The term 'state' in system analysis characterizes a section/replica of the system, a stop in its development. The state is defined through input and output signals or through macro parameters of the system. [1]. In the psychological aspect of biological systems, the concept of 'state' is understood as the 'state of the personality' or mental health of a person, or as the individual's 'functional status'.

Many researchers are working to develop different models of a person's state. A model of the 'emotional state' of an individual is proposed based on the interaction of two processes: the scope of emotions and the continuing ability to be active. The 'state' of the individual in this case is characterized by decrease in controllability. The authors consider the conditions for achieving the 'state' of emotional stability. These include conditions for increasing the reflexivity of the individual and transferring the motor skills, which are reflexively restated under emotional stress, to the background [2]. The author of this article examines the patterns of behavior of students in a pandemic. It is recorded that the technical aspects of distance learning technologies do not cause any difficulties for students. However, students have to put more effort into mastering the studied materials. Sociological research has shown that 20% of students, from the whole number of respondents, mark the 'state' of a high level of ill-being or disadvantage, 9% of students demonstrate the 'state' of sensible emotional discomfort that arises as a result of digital inequality and socialization abuse or failure [3]. Several models of 'stressful states' of individuals in the absence of employment are proposed. They include a 'state of shock', a 'state of conformation' to the situation, a 'state of destructive change' and a 'state of reconciliation' with the current situation. In conditions of unemployment, the individual develops a general 'dysfunctional state'. The elimination of such conditions requires the help of social services in finding a new job or obtaining new special or professional skills [4]. The cognitive models of the 'state' of an individual with the extremist ideology and a neutral position on extremism have been developed in the course of research. The study shows that a set of preventive measures has a positive impact on the 'state' of an individual with an extremist ideology. The factor 'hyperdependence' also significantly affects the general 'state' of an individual with a neutral position on extremism as well. This factor presupposes that the individual is ready at all costs to defend the principles that he perceives as 'sacred' [5].

Foreign researchers M. Soga, M. J. Evans, D. T. C. Cox, and K. J. Gaston describe the states of individuals during the COVID-19 pandemic. They marked the deterioration of mental health among the population of European countries, that is, the states of anxiety, depression, stress disorders, etc. There was increase in physical activity, contacts with nature and the interest in moving from big cities to rural areas. The COVID-19 pandemic is seen as a global natural experiment in human-nature interactions. This experiment provides understanding of these processes, dynamics of their interactions and the search for the best strategies for managing them [6]. The aim of this study was to determine mental health outcomes during pandemic induced lockdowns. We surveyed n = 9,565 people from 78 countries. Outcomes assessed were stress, depression, affect, and wellbeing. Results indicated that on average about 10% of the sample was languishing from low levels of mental health and about 50% had only moderate mental health. These results suggest that on whole, respondents were moderately mentally healthy at the time of a population-wide lockdown. The highest level of mental health difficulties were found in approximately 10% of the population [7]. The study results indicate that Chinese people were affected due to lockdown measures. It is suggested that ER intervention reduces the negative psychological impacts for improving quality of life. Chinese people can function one's sentiments in their social environment effectively for quality of life [8]. The pandemic has provided us with unique opportunities to witness human nature as it unfolds, from changes in patterns of reproduction, shifting social norms, and curiosities of cognition that can warp our recognition of threat. This paper is a call to action in science—both in the application of existing knowledge about viral and human nature and also as an opportunity to make discoveries that would not be possible except when a global social experiment is underway [9]. A total of a sample size of 52,462 . A pooled mean of 18.57 was found for fear of COVID-19. The mean of fear of COVID-19 was higher in women than in men (20.67 vs. 18.21). The highest and lowest means of fear of COVID-19 had been found in Asia (18.36) and Australia (17.43) based on continent, and in hospital staff (19.51) and college students (17.95) based on target population, respectively. According to the results of meta-regression analysis, there was no significant association between the mean of fear of COVID-19 and sample size and participants' age. The mean of fear of COVID-19 was high around the world; therefore, it seems necessary to pay more attention to the negative effects of the COVID-19 pandemic on mental health [10].

The purpose of the work is to develop various tools for the construction and analysis of the models illustrating the influence of significant factors of the living environment and psychological indicators on the change in the 'state' of the individual during the pandemic. The basic idea of modeling is to formalize the subjective view of the researcher about reality through developing new subjective images. To achieve that it is necessary to sort out a problem and to structure the information about it, then to conduct systematic and cognitive analysis based on the researcher's experience and intuition.

II. Construction of Models

A. Graphical Models Using Fuzzy Sets

To obtain primary data, the survey of students and teachers of the university was conducted in 2020 using a questionnaire developed at the Department of Labor Psychology of the Omsk State Technical University. The questionnaire determined the level of adaptation of a person and changes in his subjective picture of the world due to the COVID-19 pandemic. The questionnaire allows, as a whole and separately, assessing the person's feeling, his well-being, activity, emotional state, interpersonal relations, and perspective on life, spiritual values, protection and awareness during the pandemic. The indicator 'condition' reveals health problems, 'well-being' – comfort or discomfort in everyday life, etc.

Data processing procedure:

- sort primary data from minimum to maximum values;
- split the data range into equal interval;.
- counting the respondents answers as frequencies of occurrence of values for each interval;
- calculation of values with accumulation in intervals;
- divide the data with accumulation in each interval by the maximum value from the data range;
- arrangement of the obtained values on the coordinate plane and their connection by lines.

Figures 1 and 2 show the graphical models. The model of adaptation is on the left, and the model of the degree of change in the picture of the world is on the right. Models for men are indicated by a solid line, and for women – by a dotted line. Students' models are marked with a dotted line, and teachers' models are shown with a solid line. The building of models is carried out using theory of fuzzy sets.

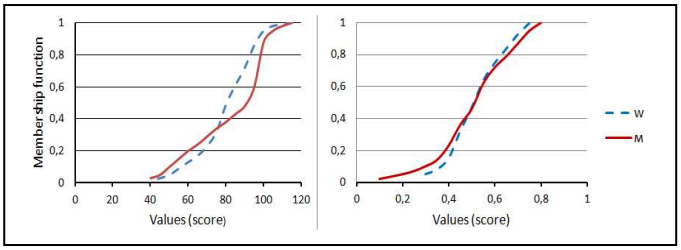

Fig. 1. Gender models 'adaptation' (left) and the degree of 'changing the world picture' (right)

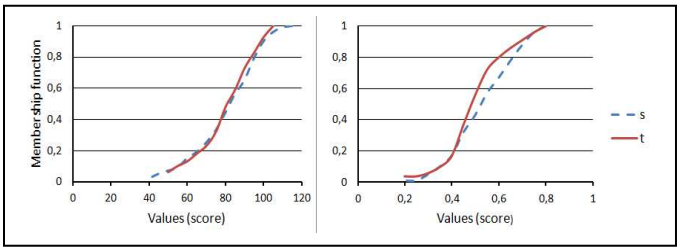

Fig. 2. Models 'adaptation' (left) and the degree of 'changing the world picture' (right) for two age groups

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Discussion. The values in Figure 1 are divided into two intervals at the point of intersection of the graphs. In the first interval of Figure 1 on the left and right, the degree of adaptation and change in the picture of the world for men is greater than for women. In the second interval they are greater for women than for men.

In Figure 2 on the left, the adaptation models for students and teachers are almost the same, differing in the range of values that is greater for students than for teachers. In Figure 2 on the right, the degree of changing the world picture for students is less in the interval [0.4; 0.7] than for teachers.

B. Models Using a Cognitive Approach

The cognitive approach is used to investigate the problem. The development of the cognitive model begins with the formation of a problem field, which consists of a set of factors and connections between them [11]. The cognitive model is formalized as a weighted directed graph $G = (G, E) = (\{G_i, G_j\}, \{w_{ij}\})$, where G_i , G_j – vertexes – vertexes, w_{ij} – curve weights, $i, j=\overline{1,n}$ (Fig. 3). In our research, the factors of the problem field are divided into the target factor – the 'state' of the individual during the pandemic and the control factors: 'feeling', 'well-being', etc. Further, the cause-and-effect relationships between the factors are formed using the logical rule 'if A then B', where A is a set of causes, B is an effect.

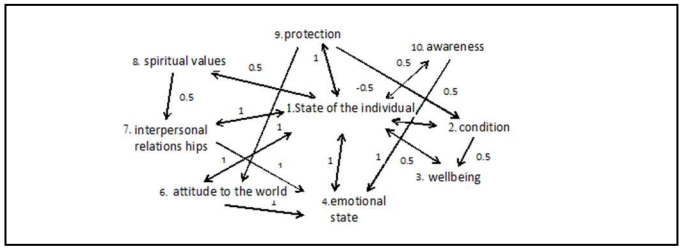

Fig. 3. Fragment of cognitive model of the 'state' of the individual in a pandemic

In the process of examination, the following judgments of experts are revealed: "If an individual's 'well-being' is better, then their 'state' during the pandemic is better." "If 'interpersonal relationships' are worse, then the 'state/condition' of the individual in a pandemic is worse," etc.

III. Simplicial Analysis

The simplicial analysis to identify implicit relationships between factors is performed using an incident matrix containing ten simplexes with different connectivity. The analysis of the $K_X(Y, R)$-complex begins with the greatest connectivity and ends with the connectivity of zero. The columns with the highest number of items are the first, second, fourth, and fifth columns, which contain nine units each. The greatest connectivity of the complex is $q=8$. At this level of connectivity, there are four components $\{x_1\}$, $\{x_2\}$, $\{x_4\}$, and $\{x_5\}$, which correspond to the factors 'state' of the individual, 'well-being', 'emotional state' and 'activity', unrelated to each other. Further, the level of connectivity is consistently reduced by one, the corresponding simplexes being detected, and the condition for their unification being checked.

A. The Results of q-analysis for the $K_X(Y, R)$-complex

$q=8$ $Q_8=4$ $\{x_1\}$ $\{x_2\}$ $\{x_4\}$ $\{x_5\}$
$q=7$ $Q_7=5$ $\{x_1\}$ $\{x_2\}$ $\{x_4\}$ $\{x_5\}$ $\{x_6\}$
$q=6$ $Q_6=6$ $\{x_1\}$ $\{x_2\}$ $\{x_4\}$ $\{x_5\}$ $\{x_6\}$ $\{x_7\}$
$q=5$ $Q_5=6$ $\{x_1\}$ $\{x_2\}$ $\{x_4\}$ $\{x_5\}$ $\{x_6\}$ $\{x_7\}$
$q=4$ $Q_4=6$ $\{x_1\}$ $\{x_2\}$ $\{x_5\ x_8\}$ $\{x_4\}$ $\{x_6\}$ $\{x_7\}$
$q=3$ $Q_3=6$ $\{x_1\}$ $\{x_2\}$ $\{x_5\ x_8\}$ $\{x_4\}$ $\{x_6\}$ $\{x_7\}$
$q=2$ $Q_2=6$ $\{x_1\}$ $\{x_2\}$ $\{x_5\ x_8\ x_3\}$ $\{x_4\}$ $\{x_6\}$ $\{x_7\}$
$q=1$ $Q_1=4$ $\{x_1\}$ $\{x_2\ x_4\ x_5\ x_8\ x_9\}$ $\{x_6\}$ $\{x_7\}$
$q=0$ $Q_0=1$ $\{all\}$

The view of the structural vector $Q_X=\{456\ldots641\}$ shows that the $K_X(Y, R)$-complex is strongly bound for small values of q, and it decays into incoherent components for others. At the level of connectivity $q=4$, the connected component $\{x_5\ x_8\}$ appears, indicating a latent relationship between the factors x_5 – 'activity' and x_8 – 'spiritual values'. The vertices of the orograph with the factors 'well-being', 'emotional state', 'activity', which correspond to the simplexes of the greatest dimension, are chosen as controlling in the study of the discussed problem.

B. The Results of q–analysis for the $K_Y(X, R)$-complex.

$q=7$ $Q_7=2$ $\{x_1\}\{x_9\}$
$q=6$ $Q_6=2$ $\{x_1\}\{x_2\ x_9\}$
$q=5$ $Q_5=2$ $\{x_1\}\{\ x_2\ x_9\ x_6\ x_7\}$
$q=4$ $Q_4=1$ $\{all\}$
$q=3$ $Q_3=1$ $\{all\}$
$q=2$ $Q_2=1$ $\{all\}$
$q=1$ $Q_1=1$ $\{all\}$
$q=0$ $Q_0=1$ $\{all\}$

The view of the structural vector $Q_Y=\{2221\ldots1\}$ shows that the $K_Y(X, R)$-complex is strongly bound for small values q, and for others it decays into incoherent components. At the connectivity level q=6, the first coherent component $\{x_2\ x_9\}$ appears, which illustrates the latent relationship between the factors 'well-being' and 'protection'. This conclusion shows that the stronger the mechanisms of psychological 'protection', the greater the risk of involving an individual in conflict situations. The vertex of the orograph with the 'protection' factor, which corresponds to the simplex of the greatest dimension, is chosen as the controlling in the study of the discussed problem.

IV. Use of a System Pattern

Observations show that the functioning of any technical, social, biological systems is subject to systemic laws and the laws operating in nature and society [12]. For example, a system pattern of 20%/80% shows how much effort (cause) is needed to implement the final result (effect). To illustrate the system pattern, we use the tool called Pareto diagram. Using Microsoft Excel, this tool allows you to identify the quantitative cause-and-effect relationships. A survey of students and teachers show that 59 people (39%) call 'emotional state' as the reason for the individual adaptation to

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the conditions of the pandemic, 48 people (32%) – the factor of 'protection', 21 people (14%) – 'awareness', etc. (Fig. 4).

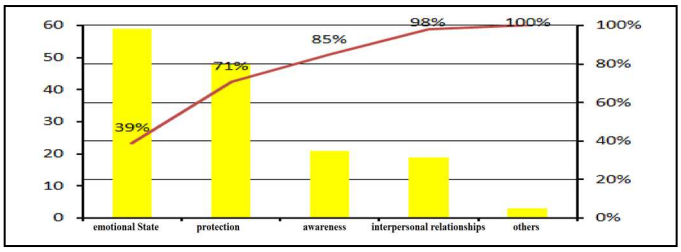

Fig. 4. Pareto diagram ~20% of causes affecting the adaptation of individuals

Figure 4 shows Pareto diagram revealing that approximately 80% of the people indicate 20% of the causes (emotional state, protection, awareness). These causes have a significant impact on their 'state' of adaptation to the pandemic. The survey of students and teachers show that 67 people (45%) name the factor 'awareness', 53 (36%) – 'condition', etc. (Fig. 5).

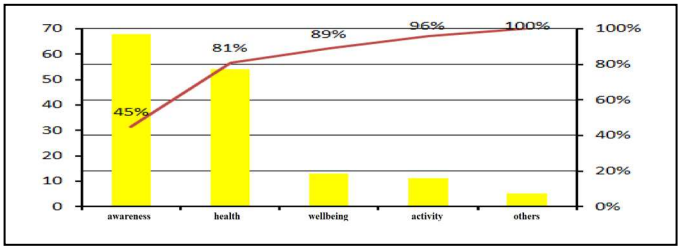

Fig. 5. Pareto diagram ~20% of the reasons affecting the change in the picture of the world of individuals

Figure 5 shows Pareto diagram indicating that almost 80% of the respondents mark 20% of the reasons (awareness and condition) that have a significant impact on their 'state' to change the picture of the world during the pandemic.

CONCLUSION

A world with a pandemic seems unfavorable for mental health of people, to sustain a normal life. The threat of infection generates anxiety, reduces activity and social interaction. The simplicial analysis of the cognitive model reveals a significant factor of 'condition', which causes the changes that occur in the subjective sphere of the individual due to the COVID-19 pandemic. The new environment created by the pandemic provides an opportunity to reassess the meaning of life and set the life priorities based on the current situation.

The integration of different disciplines to study of the problem of the 'state' of the individual in changing environmental conditions allows the researcher to structure knowledge about the problem from subjective views as well as to systematize and transform information into a form that provides its rational organization to support managerial decision-making.

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