HARTLEY AND LKLB-PROCESS MEASURES: USE IN PSYCHOLOGICAL AND EDUCATIONAL TESTING

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МЕРЫ ХАРТЛИ И ЛКЛБ-ПРОЦЕССА: ИСПОЛЬЗОВАНИЕ В ПСИХОЛОГИЧЕСКОМ И ОБРАЗОВАТЕЛЬНОМ ТЕСТИРОВАНИИ

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Keywords

Hartley measure; LKLB-process measure; decision making; psychology; intuition; rational decision; intuitive decision; psychological testing; educational testing; new method.

Abstract

The problems of social analytics and decision-making on the management of complex information and economic structures are increasingly determined by human factors. The difficulty in regulating and recognizing information is determined by the unpredictability of the effects of new technologies on the psychophysical characteristics of man as an element of society. Therefore, of particular relevance is study of existing approaches and development of new approaches to testing and drawing up a psychological profile for socio-technical systems. The authors described the use of the Hartley information measure and the LKLB process in psychological and educational testing. The diagram of socio-technical system concept model and a description of its main elements are presented. One type of socio-technical systems are man-machine systems. Authors put forward the hypothesis that every socio-technical system has a psychological profile associated with the cognitive abilities and psychological compatibility of participants in the system. This profile influences the decision-making process of the subject in the human-machine system. The algorithm for conducting an experimental investigation of the hypothesis on the human-machine system example was developed. The authors presented and explained the graphical results of the experiment for four man-machine systems. The study confirmed that every socio-technical system in solving the problem of decision-making has its psychological and educational profile. The psychological compatibility of the moderator and the slave (tested, for example, the learner) affected this profile, in addition, there is a «non-commutativity» of the results of the slave and the leader. In practice, you can use the psychological and educational profile in forecasting the results of decision-making in the socio-technical system, in the identification of the infringer of information security, in developing a model and interpreting the behavior of the human subject-machine system.

Ключевые слова

Мера Хартли, мера ЛКЛБ-процесса, принятие решения, психология, интуиция, рациональное решение, интуитивное решение, психологическое тестирование, образовательное тестирование, новый метод.

Abstract

Проблемы социальной аналитики и принятия решений по управлению сложными информационными и экономическими структурами все чаще обуславливаются человеческими факторами. Сложность в регулировании и распознавании информации определяется непредсказуемостью воздействий новых технологий на психофизические особенности человека как элемента социума. Поэтому особую актуальность приобретает исследование существующих и разработка новых подходов к тестированию и составлению психологического профиля для социотехнических систем. В статье дано описание использования информационной меры Хартли и ЛКЛБ-процесса в психологическом и образовательном тестировании. Представлена схема концептуальной модели социотехнической системы и ее описаны основные элементы. Показано, что одним из видов социотехнических систем являются человеко-машинные системы. Выдвинута

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гипотеза, что каждая социотехническая система имеет свой психологический профиль, тесно связанный с когнитивными способностями и психологической совместимостью участников системы и оказывающий влияние на процесс принятия решений в ней. Разработан алгоритм проведения экспериментального исследования выдвинутой гипотезы на примере человеко-машинной системы. Приведены графические результаты эксперимента для четырех человеко-машинных систем. Результаты проведенного исследования подтвердили, что каждая социотехническая система при решении задачи принятия решений имеет свой психологический и образовательный профиль, на который влияет психологическая совместимость ведущего (модератора) и ведомого (тестируемого, например, обучающегося) человека, кроме того имеет место «некоммутативность» результатов ведомого и ведущего. На практике, предложенный подход к тестированию может быть использован при прогнозировании результатов принятия решений в социотехнической системе и интерпретации поведения субъектов.

Introduction

The development of software and the ubiquitous use of human-computer automated systems for managing key business processes are inextricably linked with the constant processing of large data sets and issuance of management decisions based on them. The decision-making process can be formalized through fuzzy logic [1] and often requires the participation of the decision maker (DM). The type of decision taken depends on the intuition of the decision-maker, experience, knowledge and qualifications, as well as limited in time and resources, which in turn affects the probability of making erroneous decisions [2]. Recognition of information and making decisions on its basis plays a key role in psychology, psychology of education, psychophysiology, psychophysics, intuition studies [3], living intellect [4], in the theory and practice of quantum informatics, quantum logic, quantum, biological and neuro- computing [5 ± 10], in the study of the "quantum" properties of the brain [11], quantum intelligence, quantum sociophysics, quantum learning with reinforcement [12-18]. The works of recent years increasingly show the correctness of A.N. Kolmogorov, R.Hartley, K.Shannon and other researchers who drew attention to some limitations of the "classical" theory of information, which leads, among other things, to the current problems of the uncomplementarity of social and computer-technical networks, as well as CCD paradoxes and problems of information security [19].

In this paper, a sociotechnical human-machine system based on the principle of "Man-Man-Machine" was chosen as the object of research. The study topic is the process of human decision making in a given socio-technical system. The scientific novelty of the work consists in analyzing the psychological profile of the human machine system with the help of the LKLB-process (information anomaly) according to the Hartley-Shannon-Church-Turing model [20].

Goal of research

The aim of the work is to demonstrate the possibilities of a new testing method for determining the psychological and educational profile of a person, based on the recently discovered LCLB process [20] and its comparison with the Hartley model.

The main goal of the work is demonstration of a new testing method for determining the psychological and educational profile of a person, based on the recently discovered LCLB process [20] and its comparison with the Hartley model. To achieve this goal, a research hypothesis was formulated that each socio-technical system has its own psychological profile, closely related to the cognitive abilities and psychological compatibility of participants in the system and influencing the decision-making process in it. To test the research hypothesis, the following tasks were solved:

1. Identification of structural elements of the socio-technical system;
2. Determination of the measure of the amount of information in the socio-technical system;
3. Setting the task for the socio-technical system "Human-Human Machine (Pseudo-random number generator-GPRS)" and the definition of the conditions for experimental research;
4. Comparison of the results of solving the problem posed to the socio-technical system "Man-Man-Machine" with the Hartley model.

A certain psychological and educational profile, in practice, can be used in forecasting the results of decision making in the socio-technical system, as well as in the identification of the infringer of information security (IB) [21], in developing his model and interpreting the behavior [22, 23].

Materials and methods of research

As the main research methods in the performance of the work we used: the method of description, system analysis, analogy and generalization, elements of information theory and decision-making. And also the results of the investigation of the information anomaly (called the LCLB process) and the competition (in the higher nervous activity of a person) of processes occurring according to the Hartley-Shannon-Church-Turing model with quantum-like processes arising under special conditions [25]. When checking the research hypothesis, the socio-technical system "Human-Human Machine (Pseudorandom Number Generator-GPRS)" was analyzed, data on the decisions made by the person (element of the system) obtained in the experiments described by the authors in [20, 25].

Theoretical analysis

Developing the views on socio-technical systems, their functions and structure takes its origins from the studies of E. Trist and K. Bamforth of the Tavistock Institute [26] and D. Helridzhel [27], according to which the socio-technical system is a set of continuously interacting with each other and the surrounding (means of automation, storage and transmission of data and technological processes.) and social elements (the human factor - operators, decision-makers) (see Figure 1). Consequently, any human-machine system can be classified as a socio-technical system.
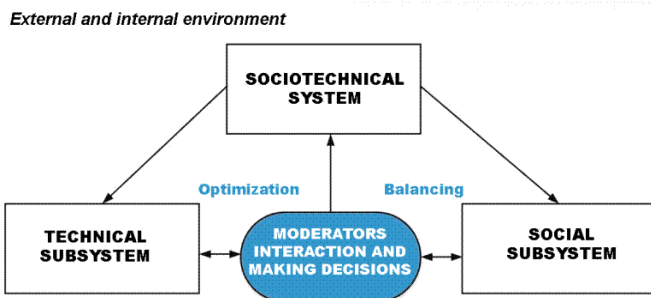
Fig. 1. Conceptual model of the socio-technical system
Рис. 1. Концептуальная модель социотехнической системы

In terms of managing and decision-making - it is a set of interrelated elements whose behavior and knowledge contribute to the characteristics of the whole system as a whole. The more information each component of the system has, the less uncertainty in its solutions.

In the information theory, the basic model in the form of the Hartley measure [24] is known, which is expressed by the following formula 1:

$$I = \log_2 N \qquad (1)$$

where N is the number of values, I is the amount of information (in bits). The measure allows you to determine how many questions (information bits) will be required to determine one of the possible values. Figure 2 shows a graphical representation of the classical Hartley model (direct line) for solving the situational problem of determining the number and the information anomaly found during the empirical tests (polyline).

This abnormal process ("LKLB process") was first detected and observed in certain cases (in the experiment with women). The "straight line" of the Hartley model is a "tectological boundary" (in the sense of A.A. Bogdanov). In order to explain the abnormality of the "polyline" behavior, I.V. Bashelkhanov, in [25], proposed a measure of information for sociophysical (sociotechnical) systems, expressed by formulas 2 and 3:

$$I - \sum_i I_{ci} + \sum_j I_{pj} = \log_2 N \qquad (2)$$

where I – the amount of information required to solve the problem,
$\sum_i I_{ci}$ – the sum of sources of counterproductive (c) information,
$\sum_j I_{pj}$ - the sum of sources of productive (p) information, N – the power of set of problem goals. Expressing the "two sums" through the power (formula 3) we get:

$$I = \log_2 \frac{\prod_i N_{ci}}{\prod_j N_{pj}} \times N \qquad (3)$$

where the numerator is the product of the powers of the sets of sources of counterproductive information, and the denominator is the product of the powers of the sets of sources of productive information.
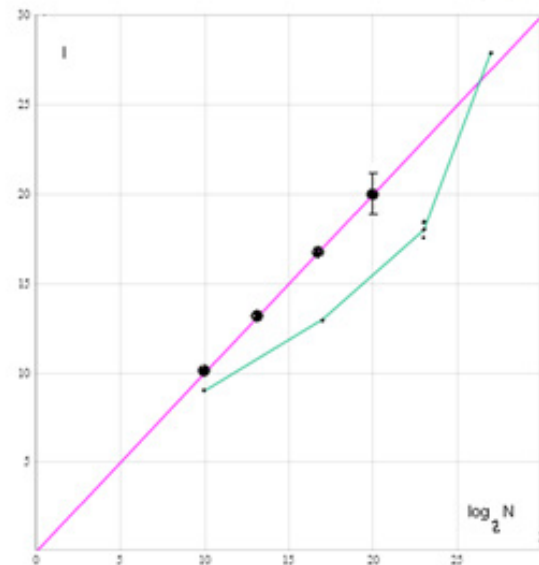

Fig. 2. Graphical representation of the information anomaly of the Hartley model. The "straight line" - the Hartley model ("circles" - data for determining the number of male men - Men), "polyline" through "points" ("LKLB process") - data on the number of females (Women: Nigina - Valeria). Characteristic absolute errors in solving the situational problem are also indicated.
Рис. 2. Графическое представление информационной аномалии модели Хартли. «Прямая линия» – модель Хартли («кружки» – данные по определению числа лицами мужского пола – Men), «Ломаная линия» через «точки» («ЛКЛБ-процесс») – данные по определению числа лицами женского пола (Women: Нигина-Валерия). Указаны также характерные абсолютные ошибки при решении ситуационной задачи.

We made a comparison of the results of the solution of the task posed to the socio-technical system "Man-Man-Machine" with the Hartley model. In the experiment, a random natural number was assigned (using the Machine and the first person who will be the moderator of the experiment), which the second person (the test person) had to determine by a sequence of questions assigned to the first person. Four models of the socio-technical system were compiled and used to perform the research (see Table 1).

The algorithm of the experiment included the following sequence of steps:
1. Selection of the socio-technical system;
2. Generation of PRNG of a random natural number;
3. Presenting the number to the moderator;
4. Determination of the value of the generated natural number by the test, using a sequence of questions.
5. Determination of the time value and amount of information spent to determine the correct value of the number.
6. Comparison of the obtained empirical data with the analytical model of Hartley.
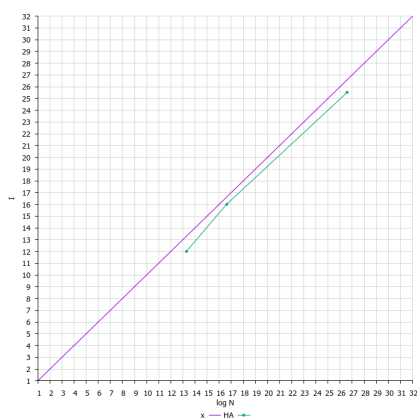
Table 1. Description of the experimental models of Man-Man-Machine

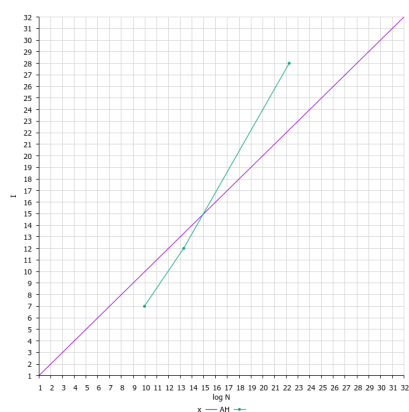Таблица 1. Описание экспериментальных моделей Человек-Человек -Машина

№	Sociological Model (Man-Man-Machine)	Description
1	Nigina-Aisa-pseudo-random number generator	Two social elements are women (a moderator tested: Nigina or Aisa) and a technical element: a pseudo-random number generator.
	Aisa-Nigina-pseudorandom number generator	
2	Aza-male-pseudorandom number generator	Two social elements are a man (moderator), a woman (tested: Isa) and a technical element: a pseudo-random number generator.
3	Aise-woman-generator of pseudorandom numbers	Two social elements - a woman (moderator), a woman (tested: Alexandra) and a technical element: a pseudo-random number generator (PRNG).

Experimental part

The results of this experimental study for each socio-technical system are shown in the graphical diagrams (Figures 3 - 5) where the logarithms N on the base 2 are plotted at the x-axis and the amount of information for obtaining the correct answer is plotted at the y-axis (the " straight line " Hartley model, "polyline" -experiment).

(а)

(б)

Fig. 3. The amount of information spent to determine the number of the Nigina-Isa-PRNG (a) system and the Aisa-Nigina- PRNG (b)

Рис. 3. Количество информации затраченное для определения числа системой Нигина-Айза-ГПСЧ (a) и системой Айза-Нигина-ГПСЧ (б)
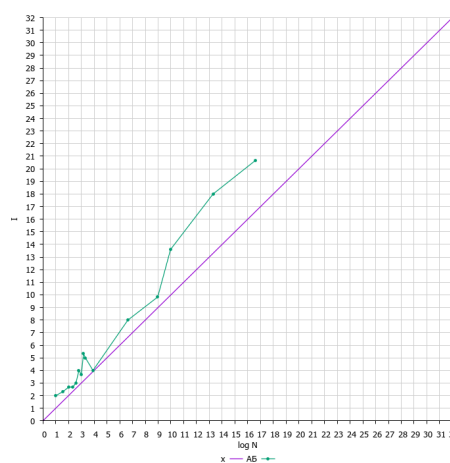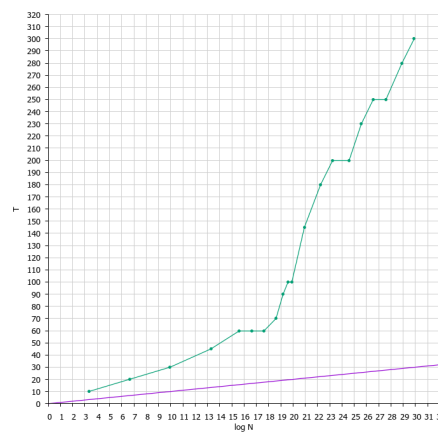

Fig. 4. The amount of information spent in determining the number of the Aisa-Men-PRNG system

Рис. 4. Количество информации, затраченное при определении числа системой Айза-Men-ГПСЧ

(a)

Fig. 5. The amount of information (a) and the time in seconds (b) spent for determining the number of the Alexander-Women- PRNG system

Рис. 5. Количество информации (a) и время в секундах (б) затраченное для определения числа системой Александра-Women-ГПСЧ
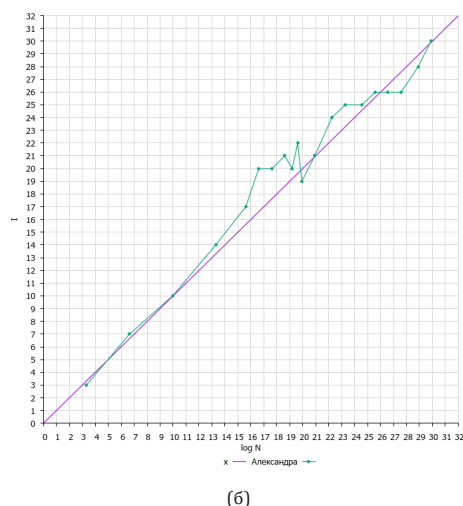
(б)

Fig. 5. The amount of information (a) and the time in seconds (b) spent for determining
the number of the Alexander-Women- PRNG system
Рис. 5. Количество информации (а) и время в секундах (б) затраченное для
определения числа системой Александра-Women-ГПСЧ

When proposing his formula, R. Hartley stressed that he completely excludes psychological factors. On our graphs-schemes, we clearly observe the factors excluded by Hartley. The actions of the latter are sufficiently stable and non-trivial so as not to be a "statistical noise", etc. When comparing the data obtained experimentally with the Hartley measure, it can be concluded that only in some cases the model of the socio-technical system "Man-Man-Machine" is approximated to analytical values when making a decision, which indicates competition (in higher human nervous activity) which occur according to the Hartley-Shannon-Church-Turing model with quantum-like processes arising under special conditions. The males in all the studied cases of solving situational problems acted rationally, within the limits of absolute error, according to the Hartley model. The females acted rationally (in certain intervals of the determined numbers) and intuitively (according to Vasilyeva I.V., the results are below the conditional "direct Hartley" -if there are sources of productive information). In addition, in a significant number of cases, the behavior of the tested person reflects the dominance of sources of counterproductive information in the solution of the situational problem under conditions such as stresses (results above the conditional "direct Hartley") - the detection of which is extremely important for ensuring security, identifying psychological and educational compatibility, etc. in man-machine systems.

Conclusion

From the study carried out by the authors it follows that each human-machine system has its own psychological and educational profile allowing one to detect the cognitive and educational abilities of the moderator, the slave (a person tested to identify the psychological and educational profile). Psychological compatibility of the leader (moderator) and the slave (tested, for example, learning) person. The data of our studies show that there is a "noncommutativity" of the results of the slave and the leader in the socio-technical system. The "confusion" of the states of the slave and the leader is manifested in rare cases - in cases of psychological and other compatibility. Thus, in this paper, a new, simple enough method of psychological and educational testing based on the LKLB process is proposed.

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