================= GENERAL STUDIES =================

Etiological Analysis as an Approach to the Detection of Association Networks in the Case of a Shortage of External Information

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Abstract—An approach to the enhancement of mental alertness in order to extract implicit knowledge and convert it into new information is considered. The approach is based on multifaceted analysis of certain objects, situations, problems, ideas, or confusions that appear to be important for a person or a legal entity. The distinctive feature of the approach is the formulation of a large number of "relevant" statements at the initial stage. Each of these statements is used to construct (1) a set of "factors," or statements that express the causes, the pretexts, and the conditions (including starting and boundary conditions) and (2) a set of "effects," or statements that present the consequences, the results, the conclusions, novel requirements and/or suggestions concerning the conditions of implementation, etc. Each factor and effect is subsequently considered as a statement that requires analysis of the same type as the primary statements. The procedure is repeated until the factors and effects that were detected become limited by factors that are not amenable to further analysis or effects that can be regarded as boundary effects relatively to all other effects. The analytical procedure has been validated and is used to solve diverse tasks of pedagogics, to resolve conflicts, and to conduct research.

INTRODUCTION

Problematic situations that cause a person to stop and direct attention (even momentarily) to a powerful emotion, a task set, a difficulty in decision making, a hazard, surprise, a misunderstanding, fear, a suspicion, uneasiness due to a certain situation, some unexpected change, etc., can occur during various human activities. These situations are associated with a certain halt, a break in activity, or confusion. Phenomenologically, this situation promotes the manifestation of the orienting reflex (after I.P. Pavlov [1]) or, speaking more broadly, orienting activity (with the distinct features of these processes in humans taken into account) [2, 3]. The distinctive features of orienting activities include the halting or deceleration of outward activity, changes in a broad spectrum of physiological parameters (the development of inhibition processes, reorganization of the activity of analyzers, redistribution of the use of different types of memory, construction of an image of the situation and a program of the required actions, and

others). This type of activity is associated with an acute information deficit and an increased intensity of activities directed towards the acquisition of information. The deficit of **external** information is often mentioned with regard to human activities, notwithstanding the declarations of the abundance of information on the internet, mass media, libraries, and archives. Both the traditional (text sources, especially published texts, advice from experts, bibliographic synopses, personal communication, and other types) and the modern means of searching for information are used. The tasks of automatized and automatic processing of a text that emerge upon the search for information imply the analysis of non-explicate components of the process of understanding with the aim to elucidate the semantics of the tasks. The components mentioned above can be subdivided into non-explicit meanings included in a text and the implicit knowledge that the participants of the communication process possess. The latter type of knowledge refers to the knowledge possessed both by

the recipient and the author (since the author possesses an implicit concept of the recipient's thesaurus).

Non-explicit meanings and knowledge contain a considerable amount of implicit information that can turn out to be very important for a specific person in the case of a certain personality type, formal status, personal interest, etc. All these factors define a person's willingness to analyze a phenomenon that has attracted attention, as well as the person's opinion on whether the analysis of this phenomenon is acceptable. This situation requires: (1) conscious retention of the phenomenon that has attracted attention (that has become the center of attention) in the mind (the construction of an intentional object as defined in Husserl's phenomenology [4]), (2) the initiation and continuation of cognitive activity [5] concerning the phenomenon and the resulting detection of noemata (the content of thoughts) that characterize the intentional object that serve as an attention focus, and (3) the information seeking that would relieve tension, shed light on the situation, and lead towards a way out (a solution). Information seeking is performed using both external sources and an individual's own reserves of knowledge, and the formulation of a solution terminates the individual cycle of orienting activity. The search for external information involves reference works, databases, and encyclopedias; there is a vast body of literature dedicated to the procedures for working with these sources. Importantly, the information derived from these sources can be adequate and/or relevant for a person's needs, but it is very difficult to make this information pertinent, that is, adapted to the person's individual requirements. The information seeking and associations in the body of an individual's personal knowledge accumulated by the brain requires effort in order to achieve this knowledge. This type of search is a distinct cognitive task that has remained largely overlooked; the present article addresses approaches to tackle this task. Importantly, an internal search of *this* type (based on introspection) is always pertinent and the respective approach to work can be qualified as an ***intrapersonal information seeking***.

The search can be mediated by different procedures that an individual performs spontaneously or result from the use of a certain approach. Approaches of this type are usually considered within the context of heuristics [6].

The vast body of literature on heuristics allows the selection of the most convenient approach for a specific person and a specific task. Therefore, we refer the reader to the studies that are dedicated to these approaches [7−25] without attempting to list the entire set of approaches or to analyze the essence of each individual method.

However, the pertinent intrapersonal information seeking proper, which is referred to as etiological analysis below and is known as one of the universal cogni-

tive technologies [26], has not received focused attention within the framework of heuristics.

The etiological approach to thinking involves the analysis of circumstances under which certain objects or phenomena emerge and exist, as well as the stages of the existence of the objects or phenomena and the effect of various factors on the distinct features of these objects or phenomena. This approach is used in philosophy, physics, psychology, theory of management, geography, spatial analysis, biology, and theology. The research on mythology, cognition, and medicine are three fields for which the etiological concepts are currently essential.

The research on mythology revealed the universal character of myths concerning the emergence of the entire world (due to creation by a deity, the effects of natural elements, miracles, etc.) and a specific tribe (totem myths and etiological myths centered on creation), that is, all peoples of the world have been shown to have such myths. The need for etiological speculations turned out to be an essential part of human thinking. The replacement of the Biblical etiological mythology by the principle of historicism, which was proposed as a science-based concept in the 19th century (due to the expansion of scientific thinking to all spheres of life and the loss of faith in the etiological concepts of religion, such as the Biblical concepts of the origin of the world and the genealogy of prophets) is a very illustrative example in this regard. However, the crisis of historicism at the turn of the 20th century (the cause of the separation of comparative historical linguistics and linguistic typology, as well as the emergence of Nostratic concepts and the spread of anti-Darwinism, including the theory of nomogenesis) resulted in the emergence of tight limitations on etiological thinking (with a certain trend to refrain from statements on history within structuralism or Husserl's phenomenology). However, the limitations of the typological way of thinking eventually became apparent; therefore, postcritical historicism (postcritical etiology) emerged during the late 20th century and both a new meaning and new relevance were conferred to the etiological approach. Importantly, etiology combines historical, logical (cause-and-effect), rhetorical, legal, resource, and other components; thus, it is a universal approach to the analysis of the reality, including self-organization problems related to the evolution of the universe, the origin of the earth, the origin of life, the formation of specific shapes in crystals, geological objects, and organisms, and the development of states, societies, persons, enterprises, technologies, etc. The etiological analysis approach proposed in the present study for the activation of cognition is connected to all these directions of thought.

This approach developed by T.G. Petrov in 1980 has been used in various areas of human activity. The first detailed description of this approach as the ana-

lysis of networks of cause–effect associations with the fixation of the nodes of the network and the associations between the nodes was based on the materials of T.G. Petrov's personal archive [27]. The archive materials concerned the analysis of the organization of expeditions and expedition reporting at Leningrad State University and the use of information familiar to all employees of the organization, but not necessarily explicit. The material used to describe the cognitive approach under consideration is mostly of historical value, although it reflects the inflexible character of certain management practices in the educational institution (and possibly in other institutions as well).

THE ESSENCE OF THE METHOD OF COGNITION ACTIVATION

The preparatory stage

The preparatory stage. The use of the present method of mental activation implies the readiness to use this method at a suitable moment (when this type of analysis appears applicable to a specific problem), as well as the necessity of procuring certain consumables for the implementation of the procedure.

The decision to apply the method implies familiarity with the method and understanding of the following key points: a) the use of this method to resolve complex problems is justified when the situation is actually of a grave character, b) thinking presents difficulties for many people [28], and c) the method presented in the study allows considerable facilitation of the process of thinking due to activation of the conscious processing and the retrieval of cryptic information from the subconscious sphere.

The preparation of consumables involves the accumulation of a stock of special cards (of the format A5–A6) divided into fields. The size of the cards depends on the degree of detail that is planned for the analysis (more detailed analysis requires larger cards).

The ***first stage*** involves the assignment of a name to an obstacle after recognition of this obstacle. These obstacles or attention foci (AFs – primary!) can be represented by attention-catching phenomena, objects, or events. Examples include, but are not limited to a natural phenomenon, an artifact, an idea, a new service, a case of a disease, manifestations of aggression, treason, or rudeness, the unusually low or high quality of a product (or products), the bankruptcy or success of an entrepreneur, a conflict in the social, personal, or work-related sphere, a statement made by a politician or a journalist, the nature of beauty or a font, a piece of news in the mass media, processing of an emotion, the meaning of a painting by Dali or the third symphony of Beethoven, a recollection, lie, or a dream. Importantly, precise definitions are not essential, since the essence of the situation will be realized at the later stages only; therefore several similar names can be assigned to the same obstacle. Each of these names

is recorded in a designated field of a card with a special lining, with one name or statement per card.

The objective of the ***second stage*** consists in the generation of the largest possible number of relevant statements qualified as secondary AFs. Various strategies, tactics, and techniques can be used to collect these statements.

As an example, one can decide to consider all well-established, well-founded and proven statements on a complicated situation. Such statements can be formulated using published sources, the internet, experts, persons of established authority, persons who occupy a higher position in a certain organization, etc. However, the entire work will largely consist of the arrangement of existing concepts in this case. The results of such work can turn out to be of considerable value and the comparison of the information retrieved and the basic knowledge can result in the formulation of novel statements, conclusions, and ideas (if the approach described above is used). However, one can use a different procedure and start with formulating one's own concept of the object of analysis. This concept can be different from the conventional (background) concepts. This activity may lead to the detection of completely novel aspects of the situation and views of the object of analysis. Importantly, the use of this cognitive technique by five to six people who lack specialized knowledge in a certain field can lead both to the detection of novel aspects of the problem and reconstruction of the content of the concepts used by specialists in the field. The complete heuristic potential of this activity can be harnessed if the work is organized according to the rules of brainstorming (the lack of criticism, disregard of the universal interdictions, such as the interdiction to consider a perpetual motion machine, and the avoidance of all actions that limit the manifestation of heuristic potential, such as acts of emotional aggression, demonstration of one's leader status, etc. [29]). It is important to free the human mind from all restrictions (related to professional status, accepted paradigms, social status, legal acts, etc.) to the greatest possible extent as these statements are formulated. As an example, statements that contradict fundamental laws can be proposed as well, since it is known from experience that the use of certain sophisticated technical solutions (such as the flight of an heavier than air aircraft due to the lifting power that emerges due to a specific configuration of a wing that is moving in a medium at an appropriate speed) can result in the apparent violation of such laws.

The necessity and possibility of starting work from the production of any statements related to a theme that is under consideration can be used as a heuristic approach to overcome the confusion of a person faced with a blank sheet of paper (or a blank computer screen) and the requirement to write a text related to a certain topic, whether it is an essay for school or some-

thing as important as a work report, a thesis, or a scientific work.

The formulation of new statements eventually comes to a halt, since the set of statements appears to cover the entire field of study. Experience shows that the formulation of 30 to 50 statements is sufficient for successful work[1].

The method is most valuable if multifaceted analysis of the situation is required, although certain restrictions can be imposed on the number and composition of the aspects under consideration when the nature of the task justifies such a solution. As an example, the analysis of research or engineering tasks can be preceded by arrangements concerning the decision to consider or disregard the costs of finding the solution; this can define the entire course of the subsequent etiological analysis.

Additional requirements can be imposed, for example, on the character of the statements that are formulated, on their sequence, or on their composition. As an example, if the statements can be evaluated as positive or negative, one can make an attempt to alternate them (zebra heuristics), to discriminate between different universal aspects of the description, or to alternate between the formulation of statements related to the substrate, structure, energetics, programs, functions, and objectives (values) [30]; the discussion of issues related to the functioning of an organization can involve the discussion of technologies, finance, human resources, time consumption, quality, etc. Alternation of this type can provide a multifaceted character of the analysis and the balance between the contributions of different aspects to a specific study.

The multifaceted character of an analysis (when required) can be achieved using certain specialized procedures as well. As an example, certain frames or structures used for the representation of data in the area related to a certain object can be considered [31, 32] and all slots of these frames can be recorded. The further work is organized in order to include all slots in the analysis and to generate comparable numbers of statements related to each slot. The simplest frame of this type is represented by a set of questions answered independently and one at a time by the participants of a party game about writing funny stories with such slots as: who is he? who is she? where? when? what were they doing? what did he say? what did she say? what was the outcome? The latter frame is a temporal frame or a scenario that can be addressed in temporal categories and used to analyze causal relationships.

The *third stage* involves the analysis of *factors* and *effects,* that is, the processes, objects, or phenomena that affect each of the statements pertaining to the primary and secondary AFs or depend on them, respectively. These associations and influences can be extremely diverse: they can be represented by causes and effects, pretexts and events that occur, preceding and subsequent states, conditions and results, concomitant conditions, starting and finishing points of the analysis of the situation, requirements that arise upon the implementation of the action, events and emotions caused by these events, wishes and actions, etc. These factors and effects serve as tertiary AFs. The broadest possible cognitive freedom is important at this stage as well: in other words, a certain issue may *seem* a cause or an effect, the beginning or the end, etc., but even seemingly fundamental issues are worth recording. The evaluation of the issues can be corrected at later stages of the process, whereas the most important objective of this stage consists in the formulation of the maximal possible number of statements concerning the issues that affect the primary and secondary statements or depend on them. This stage of work involves the formulation of new statements (that correspond to quaternary AFs) and the issues that affect them or are affected by them (quinary AFs; however, it is not worthwhile to discriminate between the quaternary, quinary, and higher-order AFs, on one hand, and tertiary AFs, on the other hand). The number of these AFs can range from tens to hundreds, depending on complexity of the problem, the level of detail selected for the analysis, the resources available, and other circumstances; however, the number is limited by the time that is available, the interest in the problem, satisfaction with the level of understanding, and similar factors.

The *fourth stage* involves the analysis of every factor-statement and every effect-statement (that is, secondary and tertiary statements) in a way analogous to that used for the analysis of primary statements. Several iterations of the process can be performed when required by the specific content of the area under investigation and the level of detail selected for the analysis (the generation of secondary, tertiary, and higher-order AFs can actually be considered the respective iteration of the process being discussed). Notably, this work can be performed either by an individual or by a group, and the group can either be composed of individuals who work together at the same time and place or of unrelated individuals who return to the intermediate results of the analysis several times. The latter situation can emerge, for example, upon the monitoring of modifications of a technological process, since emerging ideas, including the most impressive ones, are not always implemented immediately after being formulated and can be easily forgotten after a period of routine work, especially in case of pressure to achieve a positive result rapidly. As evident from the above, the nature of cognitive processes is essentially non-individual and these processes and can be implemented both by an individual or a group, either gathered at a single site or distributed over space and time;

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[1] The use of different constructs of the same type (spaces saturated with information, numerical taxonomy, and others) involves the formulation of 40–60 statements of this type prior to the analysis, and thus the order of magnitude of the number of statements is the same in both cases
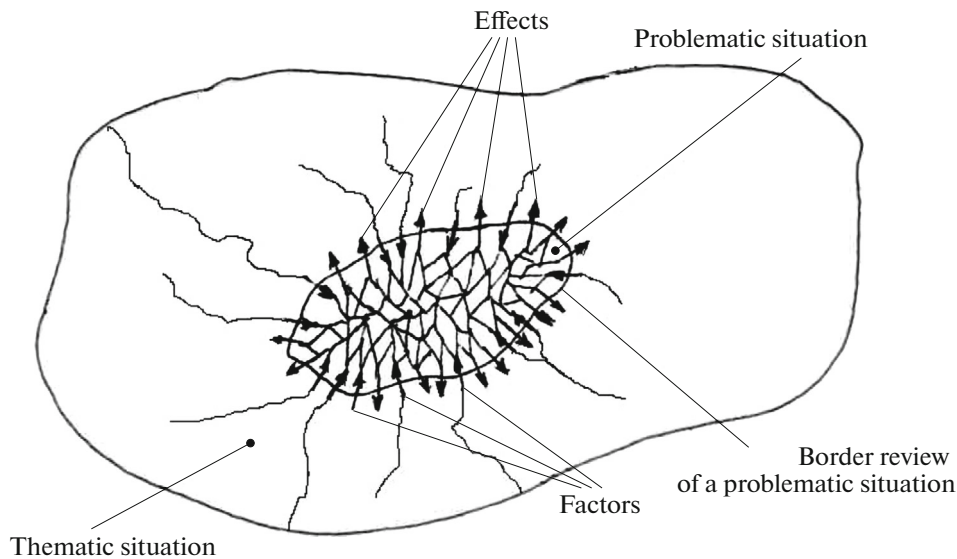
Fig. 1. The scheme of the relationships between groups of statement.

compare with [30]). The fourth stage ends when the new statements that are qualified as relevant do not continue to emerge or when the material identified appears sufficient for the analysis of the situation.

The *fifth stage* involves the testing of all associations identified, supplementation of the connection network by the associations that were skipped, and (when necessary) the introduction of novel statements and identification of the associations between these statements and all other statements.

The *sixth stage* consist in the analysis of the previously constructed network of statements. A scheme of the relationship between the groups of statements introduced below is shown in Fig.1.

One should start with the detection of statements that do not depend on any factor that is being considered, but influence certain phenomena. These statements concern the basic concepts that are assigned an absolute character within the process of analysis; they are subdivided into the initial factors, the boundary factors, the starting conditions, etc.

These include:

Limitations related to the structure of:
 • the world (laws of nature, resources, borders...),
 • intentional objects,
 • the human body,
 • the human cognitive sphere,
 • culture (norms of behavior, legal acts, ideals...).

Priorities (degree of relevance) determined by:
 • conflicts,
 • beliefs,
 • threats.

The character of the data:
 • sources,
 • availability,
 • reliability,
 • quality,
and others.

The next step consists in the detection of statements that do not influence anything within the area under consideration, but can be regarded as the conclusions derived from the analysis and thus qualified as *terminal effects*.

This group of statements includes:

questions that remain unanswered,

conclusions,

ideas that appear novel in the situation under consideration,

qualifiers used for the categorization of the situation under consideration,

explanations,

expected effects,

disproofs,

suggestions, including those on the extension of the research programs,

warnings,

formulation of the problems to be solved at the next level,

innovation projects,

formulation of the specifications of failures,

formulation of new restrictions, etc. (compare with the group E of cognitive techniques that provide for the transition to the more advanced spiritual states through understanding [10]).

The factors and effects listed above do not necessarily have permanent and universal significance for an individual case of etiological analysis. The lists of factors and effects are not exhaustive and they were only presented here in order to attract attention to the diversity of impulses, boundaries, pretexts, and conditions that serve as starting points and stumbling points of the movement towards the "primal boundaries" of the causes of the problem, on one hand, and the consequences, results, and conclusions that terminate the work (in some cases, only for the time being), on the other hand.

The statements that cannot be regarded as initial factors and terminal effects (that is, the respective cards) are included into non-ascending rankings of the numbers of factors and effects. As a result, the statements related to the core aspects of the situation are found at the first positions of the ratings that are obtained. These statements can be related or unrelated prior to the convergence on terminal effects; however, they constitute the most relevant part of the representation of the situation that is being considered; therefore, they deserve the most attention upon the construction of the first generalized image of the situation.

The statements that follow the statements of the highest rank (with regard to the factors, the effects, and the sums thereof) reflect the less-important aspects of the situation. However, these aspects are still of considerable significance and it is unacceptable to ignore them upon sufficiently detailed analysis.

Several other types of statements can be specified, in addition to those mentioned above. As an example, the statements connected to a small number of factors and to non-singular effects can be regarded as postulates related to the basic statements (as a first approximation). In contrast, the statements that give rise to a small number of effects and are related to a large number of factors are close to the final effects.

The subsequent stage consists in the identification of statements associated with identical or similar sets of factors and effects. These statements can be regarded as synonymous or identical and a certain universal or invariant definition can be formulated for them and used to replace the initial definitions. This allows the reduction of the number of cards (statements) that are analyzed. Matching of the statements is completely justified at this stage of the analysis, since it makes the structure that is identified more amenable for contemplation; however, matching performed at the earlier stages would be unreasonable, since it would impose a semiotic filter on the heuristic process.

Boundaries of the first type (factors) are related to the influence of external conditions on the situation, whereas the boundaries of the second type (effects) are related to the influence of the internal features of the situation on the environment in which the situation takes place. In other words, boundaries can be contemplated both from inside the situation and from the outside. The observer located at the boundary can look either "into" the situation under consideration (this is the objective of the approach described in the present study), or "outwards," or onto the environment of the situation (this is an example of the implementation of the environmental approach to the situation [33]). From a logic viewpoint, this is related to the special status of boundaries [34, 35] considered as instances of the violation of the law of the excluded middle.

The processing of the material according to the procedure described above can serve as the basis of the further substantial analysis, or the starting point for the construction of a new network of statements and the detection of associations between these statements, that is, a new iteration of the purely etiological analysis. As for the substantial analysis of the material, it is important that certain instances of reduction of the number of factors and effects result in a more illustrative demonstration of the associations that are involved; therefore, demonstration of the fragments of the unified graph itself can be of didactic significance for the representation of the results of the study. A compact representation of this type serves as an information filter that allows the elimination of synonymous and insignificant statements that act as "noise" within the body of information.

It is very important to pay attention to the diversity of the associations that are detected at the next stages of the process: one can classify the associations according to qualitative features (temporal, spatial, whole-to-part, causal...), directionality (enhancement or attenuation of effects), the level of power, and other features. Arrows and other graphical symbols of different types can be used if the classification is relatively simple. The classification of a large number of different types of associations can involve the introduction of formal characteristics called "color patterns" (for example, 31subordinative associations occur in the "Meaning ⇔ Text" model of formal grammar developed by I.A. Mel'chuk [36]).

Generally, the possibility of the introduction of different types of global markup into the network (both the sentence network and the association network) is an important issue. As an example, the sentences and associations can be labeled according to reliability or soundness, or according to their notoriety or novelty, or according to their foundations (published sources, the author's own results, consequences of general principles, etc.). The analysis of the network can also involve the classification of statements according to the foundations thereof (a priori assumptions, mythologemes, empirical data, etc.). This type of markup reveals the diversity of information that reflects the problem situation.

The work performed according to this method provides a multifaceted view of the situation; importantly, some of the revealed aspects may be completely unexpected. These circumstances should be taken into

4 No. AF	1 Statement−noema (AF fixation)		
5 No.No.	2 Factors	3 Effects	6 No.No.
i	Factor-1	Effect-1	m
p	Factor-2	Effect-2	k
...	...	...	...
l	Factor-n	Effect-q	v

Fig. 2. The structure of a heuristic card (Petrov's version).

7	Solution temperature at the front of the oxidation zone of a sulfide deposit		
19, [9]	The depth of the front of the oxidation zone (up to 400 m)	Oversaturation for malachite (the driving force of crystallization)	1, 18
[9]	Seasonal oscillations of temperature that are less pronounced in the deeper layers (at middle latitudes, the effect is significant up to the depth of 40−60 m)	The content of dissolved oxygen in groundwater that arrives at the front of the oxidation zone	8
20, 21	The inflow of water and oxygen into the oxidation zone	Oxidation of copper sulfides by oxygen dissolved in water	9

Fig. 3. An example of a filled heuristic card according to Petrov (the number of a reference in a list of publications used for the analysis is shown in square brackets).

account, for example, upon the discussion of situations that are similar to those related to the legal persecution of experts for deriving conclusions qualified as secret information from data that are available from open sources (in fact, economic espionage is primarily based on open sources). Another example is the emergence of insurmountable contradictions between the law on the open character of ecological data and the law on national security (for example, analysis of the composition of waste water from any restricted access facility can be used to reveal the type of work that is performed, the number and composition of staff, certain information on health, etc. [37]).

The working approach described here can be implemented in different ways adapted to the specific needs of certain categories of users.

VERSIONS OF THE APPLICATION OF ETIOLOGICAL ANALYSIS

Petrov's version

The cards used in this version (which are called "heuristic cards") include a number of fields shown in Fig. 2.

The statements that concern any (!) relevant features and details of the situation under consideration, in other words, the AFs that pertain to the analysis of the situation or the object of interest, are recorded in field 1. The factors detected in the course of the analysis are located in the column 2, and the effects are located in the column 3. Field 4 contains the number of the attention focus (the number can be assigned according to the order of the detection of attention foci, for example). Columns 5 and 6 adjacent to the above-mentioned columns of factors and effects contain the numbers of cards that act as factors (on the left) and effects (on the right), respectively.

An example of a filled card used during the analysis of the characteristic pattern formation in natural malachite is shown in Fig. 3 [38].

The collection of a sufficiently large set of cards with statements of this type is followed by recording of the associations between the noemata by means of construction of a synoptic table that consists a numbered set of attention foci arranged according to the order of detection.

Factor No.No.	No.No. AF	Attention foci (AF)	Effect No.No.
7, 13, 23	1	Oversaturation with malachite	4
4, 12	2	Intensity of cleavage of malachite crystals	3
2	3	Seed thickness in malachite crystals	5, 6
1	4	The rate of linear growth of malachite crystals	2
3	5	Large crystals of malachite (dark-colored)	29
3	6	Small crystals of malachite (light-colored)	29
19, 20, 21	7	Solution temperature at the front of the oxidation zone	1, 8, 9
....	8	....	......

Fig. 4. A fragment of a filled synoptic table.

19, 20, 21	7	Solution temperature at the front of the oxidation zone of a sulfide deposit	1, 8, 9

Fig. 5. The filling of a simplified version of a heuristic card according to Chebanov.

An example of a fragment of a filled synoptic table used to analyze the problem presented above is shown in Fig. 4

The situation is addressed using the analysis of the above-mentioned table (Fig. 4). Notably, the addition of attention foci into the synoptic table can take much less time than the detection of connections between the foci. This situation can be considered normal in the case of the analysis of a technological process that is being improved or the exploration of a new area of research; in these cases the table serves as a tool for documentation and preservation of the emerging ideas in the area under investigation and for more detailed analysis of these ideas; it motivates one to implement these ideas.

The version according to Chebanov

This version is a somewhat simplified modification of the original one. An example of the filling of a simplified version of a heuristic card according to Chebanov is shown in Fig. 5. The example is the same as that was used to illustrate Petrov's version.

Clearly, this approach is simplified, since only the numbers (rather than the names of the factors and effects) are listed. This approach relies on the use of a larger volume of operational memory, but the time

spent to write and read the names of the factors and effects is reduced. Cards of this type can be directly arranged into a synoptic table, if the arrangement is performed according to the number of statements.

The subsequent steps of Chebanov's procedure are the same as in the previous case.

The implementation of the first variant of cognitive activation involves a more detailed visual presentation of the material, although it is more labor-intensive. This version appears to be better adapted to the needs of individuals with the type of thinking that is called geometric by mathematicians, whereas the second version is apparently closer to the algebraic type of thinking.

Both variants were initially based on the exclusive use of paper or cardboard cards; they can be implemented using a computer as well.

The computer version

This version can be implemented using different kinds of software, such as *Word, Excel*, or software that allows a higher degree of automation. The problem of the different types of memory employed by the user becomes insignificant in this case.

First, the use of a computer makes the construction and processing of a synoptic table more convenient.

The identification of a new aspect or the need for an explanation, remark, illustration, etc. can be achieved by means of the introduction of additional lines into the synoptic table. These lines can have alphanumerical identifiers (for example, 73.1; 73.2; 45a; 45b).

Computer-based analysis involves the generation of a series of cards of a standardized type (Figs. 2 and 4) within a certain software package and the filling of these cards as described above. The use of a computer at this stage of the analysis facilitates the process (namely, the copying of the statements under consideration and the search for associations between the sentences) to a considerable extent; this is especially important if Petrov's version of the procedure is used. The synoptic table is located on the second computer screen or in a different window of the same screen; notably, the use of non-textual materials (images, graphs, schemes, tables, etc.) for the analysis is highly beneficial.

Working with paper cards should not be considered as an alternative to working with a computer, since these two approaches complement each other. This is applicable to individuals who are passionate about their work and to highly creative persons who are often involved in heuristic activities 24 hours a day (during the periods of sleep, different activities and the use of transportation during the period of wakefulness, and others).

Quantitative Measures of the Complexity of Analysis of the Situation

The assessment of the analysis of certain objects, situations, or problems according to the procedure described above is not limited to the assessment of content that is processed and generated, but rather can involve formal approaches, such as quantitative evaluation. Multiple scales can be used for the assessment; however, the not uncommon difference between the complexity of the problem itself and the complexity of the description, representation, or presentation of the problem should be taken into account as the assessment is performed. A primitive interpretation can be given to a complex problem, whereas an event that seems to be a mere trifle can unfold into an extremely complicated situation, a drama, or a tragedy (as demonstrated by Shakespeare's works). Thus, an indirect connection between the complexity of analysis of the situation and the complexity of the situation itself can exist; this issue requires specialized analysis.

The simplest approach to the assessment of "complexity" is based on counting the number of cards that contain information on the situation. However, this simplest measure ignores the difference in the numbers of factors (and effects) linked to the noemata. These differences can be taken into account if the ideas from Shannon's works on information theory are used.

The assessment of complexity according to Shannon's procedure starts with the estimation of the numbers of factors (effects) for the entire set of N sentences included in the analysis; at the next step, the numbers of factors (effects) n_i that correspond to each sentence are divided by the sums obtained: $n_i/N = p_i$. The p_i value (where p is the relative contribution and i is the number of the sentence in a specific list) reflects the "contribution to the importance" made by the factors (effects) of each sentence. The p_i values that are obtained are used in calculations according to the formula $H = -\sum p_i \ln p_i$.[2] The calculations yield two numbers: the measure of the complexity of the set of factors and the measure of complexity of the set of effects related to the discussion of the problem. Comparison of these numbers shows whether the set of the factors under consideration (that gives rise to the problem) is more complex than the set of new problems for analysis (that arises from the initial problem), or vice versa.

Thus, the analysis of the organization of field expeditions at the Leningrad State University in the late 1970s [27] that took the 20 most common factors and effects into account yielded nearly equal values of complexity H[3] (2.948 and 2.908, respectively), whereas the difference between the purity characteristics (the small contributions of the small frequencies), viz., the anentropy A and the tolerance T, was more pronounced (0.046 and 0.086; 0.080 and 0.145, respectively). This corresponds to a rather uniform distribution of the low frequencies of the factors and can be interpreted as higher diversity of non-principal factors as compared to the non-principal effects.

Thus, a formal assessment of the complexity of analysis of a situation can be provided; this type of assessment can be useful for comparing different sets of apparent costs and the distribution of forces for the implementation of solutions of the problems identified.

DISCUSSION

Prolonged use of etiological analysis for such tasks as the resolution of social conflicts, identification of the reasons for the low efficiency of the organizational structure of an institution of higher education [27], identification of the reasons for insufficient production quality at a facility for the production of materials for jewelry making [43], construction of a hypothesis

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[2] This formula was initially proposed for the assessment of the uncertainty of the result of a test; nowadays it is used for the assessment of complexity in different situations [39, 40].

[3] For more information on anentropy and tolerance/sterility see [41, 42]. The calculations used to obtain the results shown above were based on the formulae from the most recent version of the *RHAT* method: $H = -\sum p_i \ln p_i$; $A = -1/n(\sum \ln p_i) - \ln n$; $T = \ln[1/n \sum (1/p_i)] - \ln n$, where p_i is event frequency and n is the length of the part of the distribution of event frequencies (arranged in a non-ascending order) being considered.

related to the formation of a pattern in natural minerals used as raw material [38], identification of the major reasons for the impending eruption of the Yellowstone supervolcano [44] and the potential approaches for postponing or preventing the eruption [45], the analysis of the transformation of the [КРИН][4] concept into the [ЛИЛИЯ][5] concept in the concept sphere of Muscovy in the 17th century [46], during non-Gauss modeling of variative text [47], and for the implementation of other student, graduate, and postgraduate projects revealed the high efficiency of the approach for the enhancement of the intensity of work that is aimed at the identification of the "roots" (which are often very well concealed) of phenomena, both extremely relevant and seemingly unimportant (latent), and for the search for escape routes in complicated and hazardous situations. The use of the approach can be recommended for situations where explicit external information is either not easily available or non-existent; the latter is the norm for professional researchers who generate information of this type.

The question of discrimination between "knowledge," "facts," "reliable estimates," and "truth," on one hand, and "opinions," "fakes," or "lies," on the other hand, is highly relevant for the implementation of the analysis. Conscious or subconscious failure to discriminate between these types of information puts the analyst at risk of retrieving useless or even hazardous information instead of valuable and positive knowledge. If the situations that involve maniacal pursuit of a certain objective or aggressive defense of one's interests (which can be justified in an emergency or during a war, for example) are disregarded, the relatively small number of faulty decisions made at different levels turns out to be a consequence of the failure to extend the analysis beyond the closest effects and lack of attention to statements that seem "trifling." This can occur due to insufficient professional skills, lack of information or attention, excessive attachment to personal interests, emotions, ideological concepts, and other similar factors.

The construction of an oriented graph with attention foci in the nodes facilitates the registration of the character of the associations between the factors if the analysis of issues related to the capacity of the factors to enhance or attenuate the effects is relevant. The line that shows the association between a factor and an effect is complemented by an arrow directed towards the effect and a "+" or "−" sign in case of positive (enhancing) or negative (attenuating) action of the factor on the effect. This can result in the detection of closed chains of attention foci within the network of the associations. These chains converge on rings of feedback associations that can be represented by circular chains (contours) of *positive* feedback associations ("increase−increase") leading to enhancement of the

effects upon the movement along the cycle (such as the functioning of enhancers) or to the attenuation of the original effect ("decrease−decrease" the exhaustion of soils), and *negative* feedback rings that function according to the "increase−decrease" rule (the functioning of regulators).

Thus, etiological analysis reveals the pattern of associations within a body of data that can be regarded as an oriented network within graph theory. This issue is worth mentioning both due to the transition from tree-like structures to networks in practical informatics and computer architectonics during the late 20th century and due to the expansion of the network approach as a methodological tool for general application (see, for example, [48, 49]).

Etiological analysis can be regarded as a working tool in rhetorics as understood by Cicero and Quintilian, since the stage of the invention (inventio) of the main idea of speech involves the collection of the largest possible set of noemata, or the content of thoughts, whereas the stage of disposition (dispositio: the formation of the structure of an essay) is essential during the preparation of any presentation or written text [50].

The main prerequisite for the use of the approach consists in concentration (including directed introspection and the associated reflection) on a single object of intellectual contemplation and the associations that involve this object. Concentration allows the identification of noemata and the fixation of noemata in a sentence that can serve as a factor and as an effect. This level of cognitive activity and the related state of subconscious disregard of prohibitions and fears provide for the detection of facts and features that seemed completely irrelevant or negligible (of little significance) in the context of analysis of a specific situation, or problem. Even basic skills related to the use of the method often lead to results that appear to be amazing to the user of the method, since the user finds out that his/her abilities, knowledge, and understanding are much broader than they seemed prior to the beginning of the analysis; **this** cannot be regarded as a simple consequence of the use of memory. This result is due to the elucidation of implicit [51] and background [52, 53] knowledge that is present in every person's mind but remains overlooked due to the absence of reflection on the presence of such knowledge. The application of introspection and careful collection of noemata allows the detection of knowledge of this type; thus, the knowledge can be included into the sphere of interest of informatics.

CONCLUSIONS

An important characteristic of any technical appliance or tool is that of being "fool-proof" or protected from interference by incompetent users during operation. Protection from the interference by individuals who are devoid of moral scruples can be considered as

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[4] Greek, East Christian word for "lily" (translator's comment).
[5] Latin, West Christian word for "lily" (translator's comment).

one of the components of such protection in a broad sense. It is therefore important to keep in mind that any tool, including any cognitive tool, can be applied for purposes that are antagonistic to the principles of humanity, such as both for the detection and improvement of lies, for the enhancement and restriction of personal freedom, for the identification of crime and for criminals to avoid punishment. The dominance of good over evil, which often is not achieved, is something to hope for. However, the approach presented here provides especially good grounds for optimism in this regard.

In fact, the choice of the evil side usually requires rapid actions, since the character of evil is temporary. On the other hand, the good side is timeless and thus does not require haste. The approach proposed here implies the analysis of the maximal possible number of statements, accepts the use of an indefinitely large number of iterations upon the construction of synoptic tables, and allows, and even favors, the expansion of the set of noemata during the working process. Thus, the very nature of the approach precludes haste, since the analysis of a larger set of details would improve the quality of the result and require more time for the conversion of a larger part of personal knowledge into *externalized* information. Therefore, the temporal advantage of evil will turn into a disadvantage and the information will turn into disinformation...

At the same time, skill at multifactorial analysis of problems that form during cognitive work allows the rapid formulation of a preliminary expert assessment of considerable complexity in the case of a shortage of time.

In order to find out whether the information that is already available is extracted from poorly accessible areas of consciousness or the emergence of potential information occurs, one should turn to a separate scientific discipline at the interface of informatics [54] and heuristics [6], whereas the present study was centered on the technology of elucidation of novel information, mostly without external assistance.

The combination of an intrapersonal information seeking based on introspection and the conventional means of searching for information in standard documents is indicative of the formation of a novel branch of informatics oriented towards the humanities and related to Yu. A. Shreider's concept [55] on the role of the cognitologist in the communication between a human and a machine.

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