THE ECOLOGICAL NETWORK APPROACH APPLIED TO BIOETHICAL ORGANIZATIONAL STRUCTURES

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The term 'bioethics' (in the narrow sense) or 'biomedical ethics' denotes medical ethics at the modern stage of development. Bioethics is currently institutionalized and falls under the responsibility of specialized organizational structures (bioethics commissions, 'divine committees', etc.). The article expounds the prospects of applying network structures to institutions and organizations dealing with bioethical issues and tasks (ethical aspects of reproductive technologies, biomedical experiments, organ transplantation, and bioethical education). With the principles of decentralization ('multiple authority') and ecology (an integrative approach to issues under study and integrity of a bioethical expert team), network structures promote creative and effective functioning of bioethical organizations. Nonetheless, the centralized hierarchies of traditional educational and research institutions are also expected to perform essential functions. A reasonable combination of network structures and hierarchies provides the latter with a new role: the hierarchies assess the activity of emergent network structures using competent experts and provide selective support (including financing) to the most effective among them.

Key words: bioethics, network structures, hierarchies, decentralization, ecological approach, hirama, biological paradigms of network organization, neuronal networks

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ЭКОЛОГИЧЕСКИЙ СЕТЕВОЙ ПОДХОД В ПРИЛОЖЕНИИ К БИОЭТИЧЕСКИМ ОРГАНИЗАЦИОННЫМ СТРУКТУРАМ

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Термин «биоэтика» (в узком смысле), или биомедицинская этика, обозначает медицинскую (или врачебную) этику на современном уровне ее развития. Биоэтика в настоящее время институционализирована и находится в ведении специальных организационных структур (биоэтические комиссии, «божественные комитеты» и др.). В работе демонстрируются перспективы приложения сетевых структур к институтам и организациям, посвящающим себя биоэтическим проблемам и задачам (этические аспекты репродуктивных технологий, биомедицинских экспериментов, трансплантологии, а также в применении к биоэтическому образованию). Сочетая в себе принципы децентрализации («многоначалия») и экологии (целостный характер подхода к исследуемым проблемам, целостность самого коллектива участников как единой сущности), сетевые структуры способствуют креативной эффективной работе биоэтических организаций. В то же время централизованные иерархии традиционных образовательных учреждений и исследовательских институтов не теряют своих важных функций. Разумное комбинирование сетевых структур и иерархий наделяет последние новой ролью: речь идет об экспертной оценке деятельности возникающих сетевых структур с селективной поддержкой (включая финансирование) наиболее эффективных из них.

Ключевые слова: биоэтика, сетевые структуры, иерархии, децентрализация, экологический подход, хирама, биологические парадигмы сетевой организации, нейронные сети

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The term *'bioethics'* (in the narrow sense) or *'biomedical ethics'* denotes medical ethics at the modern stage of its development [1–3]. Bioethics is distinct from traditional corporate ethics of the professional community and also differs from conventional medical ethics. In the wide sense, bioethics is viewed in terms of ethical naturalism that underscores the importance of life preservation on the earth as the supreme moral principle. Van Rensseler Potter was the first to coin the term in 1969 [4]. Per its most inclusive meaning, bioethics also includes the ethics of experiments with animals and ecological ethics [5]. Bioethics is a philosophically and also practically relevant area of knowledge encompassing long-standing moral issues such as the attitude of humankind to wild and domestic animals as well as issues that are associated with the rapid progress of biotechnology and biomedical research' [5].

In the modern-day world, bioethics is an 'extensive global movement and a social institution, which brings together scientists and scholars (philosophers, doctors, lawyers, biologists, etc.) and consists of numerous national and international structures (centers, ethical committees, and institutes) that hold plenty of conferences and publish scientific articles and monographs' [6]. Due to its interdisciplinary nature, bioethics attracts the 'attention of medical professionals, biologists, philosophers, lawyers, theologists, culturologists, sociologists, etc. It has some practical relevance because institutional structures and mechanisms of moral and ethical biomedical control with proven effectiveness — ethical committees — have been established and tested' [7]. These *(bio)ethical committees* (starting from the 'Divine Committee' created in the beginning of 1960s in Seattle with regard to a waiting list for kidney transplantation) play an important role in terms of modern biomedical techniques of transplantation of organs and tissues, reproductive technologies, life support under critical conditions, and experiments with animals.

This article concentrates on the *organizational* aspects of ethical committees and similar structures concerned with bioethical issues. Two organizational approaches will be reviewed:

– *ecological approach*. It is widely accepted in the global scientific community that ecology is based on biological knowledge but reaches far beyond the scope of the life sciences. According to Reimers [8], generalized and philosophically funded ecology (megaecology) that aims to 'preserve the functional and structural integrity of the central subject singled out by researchers' is currently under development. These 'central subjects' can be diverse. The application of the ecological approach to bioethics deals with two kinds of central subjects. First, any ethical issue should be viewed in the unity of all its aspects. For instance, the issue on whether abortion is justifiable should be resolved analyzing in parallel the physiological, psychological, and ethical consequences of this intervention. Second, any ethical committee or other similar expert team should be more than the sum of its members: it should represent an integrated ecosystem with its own decision-making rules, behavioral norms, rituals, and basic values (which can be mystically interpreted as the non-material basis (egregor) of the committee);
– *decentralized approach*. Interdisciplinarity and multidimensionality of ethical committees promote the involvement of many partial leaders who deal with various aspects of a bioethical issue exemplified by the (bio)ethical dimensions of abortion. A strictly centralized hierarchy will inevitably narrow down the focus of the committee, overemphasizing the importance of the personal views of the boss, director or other dominant member(s).

DECENTRALIZED NETWORK STRUCTURES: APPLICABILITY IN BIOETHICS

Network organizational structures are created using both aforementioned approaches. It should be stressed here that network structures (or just networks) are in the spotlight of rapidly developing *network science* [9, 10]. Network structures are defined as a set of interconnected elements (nodes or vertices of a network) [11]. In recent decades, global literature has paid much attention to decentralized network structures, which are capable of coordinated functioning in spite of a lack of the central managerial agency typical of hierarchical structures [12–15].

In various social spheres, decentralized network structures commonly form spontaneously provided that their prospective members have common concerns, interests, objectives, behavior rules, and values. This promotes consolidation of network structures despite the lack of a single leader; these objectives, values, etc. can be regarded as the *matrix* of a network structure [9, 14, 15]. Within the modern society, virtual channels of knowledge transfer undoubtedly promote the collective interests of network members exemplified by food enthusiasts (the online Great Cooks Community), or scientists who focus on certain research subject (for instance, a house mouse or a serotonin molecule in neurochemistry), etc.

In this article, the application of decentralized network structures to bioethics is to be considered in detail. An introductory note: decentralized network structures within a human society are frequently outperformed by centralized hierarchies in terms of decision-making tempo; however, networks facilitate a creative approach to issues under study, especially if they deal with multi-faceted, fuzzy, transdisciplinary, and transrational [6] subjects that raise important bioethical questions.

HIRAMA

The following deals with an organizational model of network structures known as the HIRAMA (High-Intensity Research and Management Association). It has significant potential in terms of a collective expert assessment of issues related to biomedical ethics. An imaginable (hopefully feasible in the future) decentralized creative team of experts in the field of '*Medical and Ethical Consultation on In Vitro Fertilization*' provides an example to the point. In vitro fertilization (IVF) implies that 'ova are combined with sperms outside of a female body; a zygote develops in vitro for the first 4–5 days; subsequently, the fertilized eggs are placed in the uterus' [16]. Prior to the complex procedure, which is problematic from the ethical point of view, potential clients are to be filled in, in objective and impartial fashion, on issues regarding IVF acceptability and accessibility. Consultation services occur at every stage of IVF as well. Although a married couple or a single mother who wish to have a child prefer to contact a single expert (who is the external leader voicing decisions made by the whole hirama team), IVF-related consultation actually involves several different specialists (gynecologists, urologists, andrologists, therapists, psychiatrists, lawyers, etc.). Importantly, all the specialists set up a single coherent team with overlapping competencies of its members (e.g., they are assumed to be familiar with the IVF protocol as well as with relevant Russian laws).

The overarching interdisciplinary project carried out by the hirama team includes several interacting subprojects such as:

1. *Medical and physiological aspects* of IVF (e.g, indications and contraindications; IVF protocol choice, etc.; this subproject, if necessary, can be broken up into gynecological, urological, therapeutic, and mental "subsubprojects").
2. *Economic and legal aspects* of IVF: financial and contractual procedural conditions, compliance with the legislative framework in accordance with the law of the Ministry of the Russian Federation dated July 31, 2020 No. 803 'On using assisted reproductive technologies: contraindications and limitations'.
3. *Ethical aspects* of IVF including the fate of 'extra embryos' at the stages of their selective implantation into the uterus of the client or surrogate mother and subsequent 'embryo reduction'. This is the case when vitrified 'snowflakes' with an unclear ethical status are obtained. Ethical collisions occurring in this and other situations have mental, spiritual and even religious aspects (if the clients are believers). These more specific aspects can separately be considered by the network structure (recruiting an increased number of partial hirama leaders).

Every subproject has a *partial creative leader* with a possible assisting expert. The leader has no subordinates. His function is to record creative ideas of all members within the network

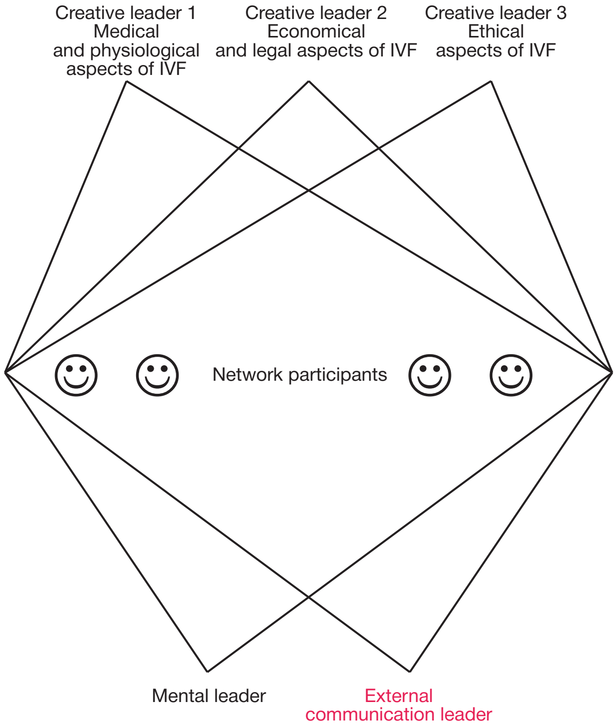

Fig. 1. Network hirama-like structure used to consult clients regarding IVF technology

structure for the respective subproject, encouraging them to develop valuable ideas and suggestions. The decentralized consultation network hirama-type structure represents a single team, and all experts have broad overlapping competencies. This allows them to interact with several creative leaders. *A psychological (internal) leader* is necessary to prevent other leaders to hog the covers, disintegrating the entire group. This leader is not responsible for a separate subproject. However, he tends to improve the psychological atmosphere within the group, ensure proper effectiveness of the group creative process, and allow all creative leaders to build cooperative (and not only competitive) relations.

The *external leader* who deals with the external audience is essential for the hirama structure. This leader acts as an authorized representative of the network structure when it interacts with other organizations (sponsors, clients, scientific institutions, representatives of the administrative bodies, etc.). This leader is used by the creative group for publicizing the results of its collective work. The entire model of the network structure is presented in fig. 1 [9, 10].

It is obvious that a similar multi-leader network can be used whenever a multidimensional bioethical problem is to be solved.

A brief discussion of biomedical experiments on human subjects will be the second example. '… A biomedical experiment is an unsafe, dangerous way of obtaining new knowledge in terms of biology and medicine. … Ethical regulation of the conditions of biomedical experiments is required' [16].

The obviously multidimensional and transdisciplinary nature of biomedical experiments impedes the hierarchical organization of a group of experts that are tasked with assessing the affordability and degree of risk for any project within the area. A decentralized network hirama-like structure could include partial creative leaders concerned with the following subprojects: (1) assessment of the scientific significance of the biomedical experiment project and quest for alternative strategies to achieve the project goal (e.g., testing a drug or developing a surgical technique); (2) direct evaluation of health-related risk factors endangering the life of test subjects and potential strategies to overcome/mitigate the risks and to provide compensation for the subjects; 3) ethical and legal assessment of the project acceptability (will the subjects be stigmatized in the society because of their involvement in an experiment fraught with long-term psychiatric aftereffects? Will they have reasons for suing the experimenter?'). The hirama has a pool of nonspecialized assistants helping prepare the final communiqué; it also includes a psychological leader and an external communication leader.

In the author's opinion, the hirama-type network structure can also be utilized in the bioethical committees of research institutions that conduct animal experiments. Evaluating their work is a multifaceted task. It can be subdivided into several subprojects (which entails assigning respective creative leaders to the hirama team).

ALTERNATIVE SCENARIOS: QUASI-NATURAL PARADIGMS

The spectrum of organizational models of networks structures includes not only the hirama option. The author earlier suggested other models of decentralized network structures that are based on typical patterns used by living nature. They can be referred to as *quasi-natural paradigms*. Although some fish shoals have a centralized hierarchical structure (like gourami aquarium fish [17]), many of them prefer decentralized structures (in accord with the *equipotential* network paradigm), and they lack a constant leader. A chance individual temporarily leads the way in such a shoal. However, the shoal is capable of efficient behavior coordination. It can perform complex maneuvers to escape from predators or to hunt the prey. It was demonstrated in earlier publications [9, 10, 18] that various quasi-natural paradigms including the equipotential paradigm can be used to deal with complicated tasks (such creative teams can also used such techniques as role-playing games and brainstorming sessions).

The cellular *(microbial) paradigm* is implemented by microorganisms and cellular cultures; its organizational analogues in human society represent creative teams whose members collectively constitute a single 'supermind'. This collective 'supermind' has much better creative capabilities than each of the individual participants. The 'supermind' is analogous to the microbial matrix, i.e., the biopolymer substance cementing all cells within the microbial colony or biofilm. The *modular paradigm* exemplified by cnidarian, bryozoan, or ascidian colonies generates a creative stress (tension) because interindividual competition inside a creative team coexists with cooperation aimed at successfully carrying out the team's collective project (e.g., *effective prenatal diagnostics of chromosomal anomalies*). In the case of the *rhizome paradigm* (vegetable rootstock or fungal mycelium), units (nodes) of the network form strong interindividual connections (social analogues of the filamentous structures (hyphae) of fungal mycelium) enabling their merging into a single think tank.

If the human decentralized network relies upon the *eusocial (formic) paradigm*, the group is divided into small subteams (analogous to a group of ants collecting honeydew or constructing anthills) with working leaders. These leaders form a flat network and have no superordinate ants ('bosses') above them. Issues are resolved by way of conducting negotiations and reaching consensus. The *egalitarian ('monkey') paradigm* is based upon some degree of rank differentiation within a group composed of individuals enjoying much personal freedom (typified by apes) that include high-ranking individuals, e.g., high-status gorilla males.

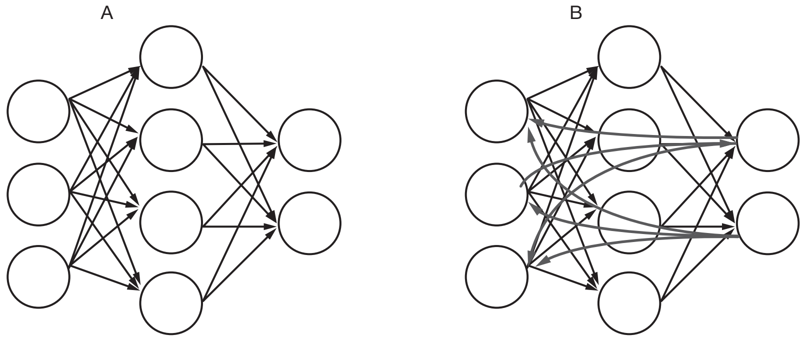

Fig. 2. Simple neural network (A); network with feedbacks from the output to hidden and input layers (Hopfield network) (B)

NEURONAL (NEURAL) PARADIGM OF NETWORK ORGANIZATION AS APPLIED TO BIOETGICAL ISSUES

The scope of the present work does not allow us to consider all quasi-natural paradigms in relation to their application to bioethical problems. This section specifically deals with applying the *neuronal* paradigm to bioethical issues.

Neural network structures rely upon models developed in research on the nervous system and especially on the brain [19]. A neural network can process external data and create untrivial problem solutions (at the level of the entire network). Such a network can solve a complex problem even though the data seem insufficient, by way of creating the problem solution image utilizing the few available fragments (e.g., making a correct medical diagnosis despite the scarcity of available data). In many cases, neuronal networks conform to the ecological approach: the issues they deal with are perceived as integral structures. The neuronal network has a variable configuration enabling it to adjust to a new task. If some network elements are faulty, the rest are sufficient to carry out the whole task. The fact is well-known to heatlcare specialists dealing with the rehabilitation of patients with local brain problems.

McCulloch and Pitts [20] singled out three main types of elements in their classical model: (1) input elements perceiving the incoming data; (2) hidden-layer elements that process the data obtained from input elements; (3) output elements that generate the final results of the entire neuronal network's activities. The subsequent development of the theory of neuronal networks and research on the human brain added much complexity to McCulloch's and Pitts' model. It incorporated multiple input elements (Frank Rosenblatt's perceptron, 1962), several internal processing (hidden) layers (multi-layer perceptrons), and was suplemented with feedback loops that enable output elements to influence the processing and input elements (Hopfield and Hemming networks) (see fig. 2A and B).

The author believes that analogs of neuronal networks can be fruitfully used in terms of *bioethical education*, which is of paramount importance to healthcare professionals. The neurons' work can be imitated by teams of students during interactive lessons that deal with basic bioethics. The network composed of students can meet difficult challenges using limited data sets. Their classwork will result in increasing the creative potential of the entire neuronal network as well as that of each student involved (that represents an analog of brain neuron).

The following part of this work demonstrates how the neuronal scenario can be utilized by students dealing with *euthanasia*. Euthanasia is defined as 'providing aid to a critically ill patient with an incurable disease whose suffering cannot be mitigated' [16].

– The student team is divided into three basic *levels* (subteams):
– *the input layer* that collects the data on related topics that are provided by the teacher or acquired by the students themselves, exemplified by case studies contained in the literature including the Internet);
– *the processing (hidden) layer*: these students generalize the data obtained by the input layer and lay the foundations for the strategy used to carry out the creative project (e.g., they form their opinion about the ethical justification of euthanasia or create a review paper on such topics as 'The attitude of the church towards euthanasia' or 'Ethical assessment of assisted suicide');
– *the output layer*: the students voice the final comunique regarding the results of the work of the entire creative network quasineuronal team.

COMBINATION OF SEVERAL NETWORK PARADIGMS IN BIOETHICAL PRACTICE

The hirama, neuronal networks, and other network structure types can be applied in combination, enabling the creation of multi-order complex structures that conform to ecological principles and espouse a holistic approach to the issues under scrutiny. The network paradigms considered heretofore are comparable to colors in the palettes used by "artists" painting novel structures based on complex combinations of several organizational scenarios.

Combined use of various paradigms of network organization is exemplified by a creative team of experts concerned with *organ and tissue transplantation*. Organ/tissue transplantation is currently making spectacular progress; and, in many cases, it already represents a routine procedure [16].

Even though network decentralized organization can promote the development of techniques related to the transplantation of any organ or tissue, the utilization of multi-level (multi-order) network structures will be discussed here below in relation to a specific futuristic project envisaging *the technology of successful transplantation of a functioning eyeball*'. This fascinating project has not been carried out yet. Undoubtedly, eye transplantation could raise new hopes and prevent the suicidal attempts of millions of blind people including those with damaged optic nerves (like admiral Nelson) or lacking both eyeballs (like the Czech hero Jan Zizka who lost them on the battlefield). Technically reliable eye transplantation would fullfill the dream of those whose eyeballs are just cosmetic organs. The extreme complexity of this intervention that has not become feasible yet clearly demonstrates that all human organs are interdependent *holomerons*. This implies that they constantly interacts with the 'living matter' of the

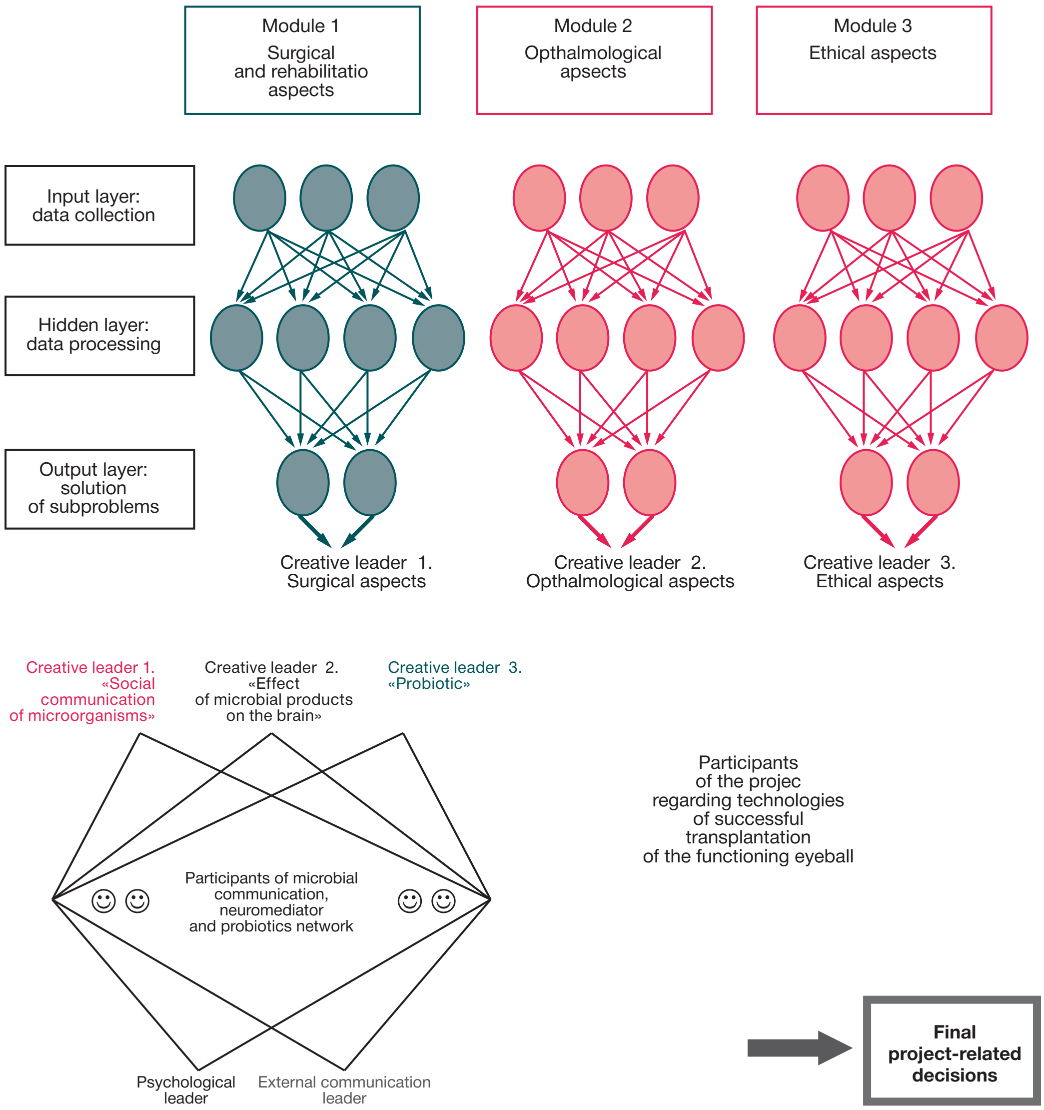

Fig. 3. Multiordinal combined network structure for a creative group dealing with the task of *developing the method of successful transplantation of the functioning eyeball*

entire human body. An eye is connected to all systems of our body. This makes irridodiagnostics (estimation of the state of various organs by examining the iris) possible.

This noble interdisciplinary project with surgical, ophthalmological, neurophysiological, immunological, psychological, ethical, legal, and philosophical aspects is still awaiting an adequate creative transdisciplinary network structure for its implementation.

A pilot network structure can have three subprojects that should correspond to the following modules.

Module 1. *Surgical and rehabilitation aspects* embracing all stages of eyeball transplantation from preoperative preparation of a patient and anesthesia to the last suture on the conjunctiva and postoperative rehabilitation with the training of the transplanted eye.

Module 2. *Ophthalmological aspects* envisaging the eye as a holomeron interacting with the nervous system, especially the brain ('the eye as a part of the brain'), the immune and endocrine system, the ENT organs, etc.

Module 3. *Ethical and legal aspects* (who may legally be considered an eye donor? Who is entitled to know that the young man they are dealing with has a transplanted eye? Can a loving mother donate an eye to her child?) with complex psychological, spiritual and religious overtones.

A creative team of experts combines the neuronal and the multi-level hirama pattern (fig. 3). Thus, module 2 ('*Ophthalmological aspects*') includes

- the input layer: acquiring the initial data (medical history, relevant literature data, etc.);
- the hidden layer: processing these data and drafting relevant medical documents (recommendations, indications and contraindications, etc.);
- the output layer: preparing the communique for the target audience (clients).

The representatives of the neuronal network's final output layer are also the creative leaders of the hirama:

- leader A deals with ophthalmological issues in relation to the transplantation procedure;
- leader B envisions the eye as a holomeron and takes into account its interaction with the nervous, immune, endocrine system and other parts of the organism;
- leader C uses the contributions made by leaders A and B to compile the final document, e.g., a set of rules and instructions for an eye transplantation specialist.

Module 2 also includes a psychological and external leader. The latter generalizes the data supplied by leaders A, B and C. Subsequently, the document is submitted to the external leaders of all three modules.

The combined principle (neuronal network + hirama) is also utilized in the other modules (1 and 3). The three external leaders cooperate to set up a higher-order network where they are the creative leaders of subprojects within a single overarching project titled, to re-iteterate, 'Development of the technology of successful transplantation of the functioning eyeball'.

The external leader of the entire higher-order hirama makes the results of the collective project available for the target audience ranging from the government of the Russian Federation to medical (e.g., ophthalmological) and scientific institutions. It is imperative that the project result should be communicated to all potential clients round the globe. This would imply that the creative network involved is supplemented with new participants (that are capable of making innovative suggestions) including healthcare specialists, business people, educators, public administrators and regulators, etc.

This discussion of the multilevel combined network organization of a future eyeball transplantation team is based on published original work in which similar network structures are suggested to cope with complex transdisciplinary tasks [10, 18].

CONCLUSIONS

Hence, decentralized network organization is in conformity with the integrated ecological approach to problems/tasks faced by a creative task force. A team organized in accord with network scenarios (e.g., dealing with bioethical issues) should act as a single entity, which 'is larger than the sum of its parts'. Network structures of various types are potentially applicable to diverse areas of bioethics from reproductive technologies and biomedical experiments to organ transplantation to bioethics classes in medical educational institutions.

This does not imply that centralized hierarchies typical of traditional educational and research institutions are to be considered irrelevant. Hierarchies in research and educational institutions should fulfill important supervising functions in terms of educational or R & D activities. Moreover, with the development of network structures, the hierarchies and their leaders (deans, directors, etc.) acquire a new important role. They make decisions regarding the promotion (and financial backing) of selected useful network structures or, alternatively, the elimination of networks that are inefficient or completely useless in terms of healthcare.

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