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Cognitive Process of Identifying in Researching Concepts of Emotions: Neuronetwork Approach

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Abstract— The paper focuses on the methodological status of the structure of the image identification cognitive process in developing a neural network model of identifying verbalized concepts of emotions. There has been substantiated and explicated the euristic potential of the approach under consideration, whose basis is the elaboration of the analogy between the structures of the cognitive process of identifying concepts of emotions and the activity directed at developing the corresponding neural networks, which enhances perfecting the neural network model of the research object in terms of broadening the analogy between the model and the prototype.

Index Terms — Cognition, cognitive process of identifying, cognitive stage, concept, emotional concept, image, language, neuronetwork modeling.

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1 Introduction

The question of studying emotions and their concepts is fundamental for the twenty-first century informational-communicative society which is developing according to the personal identity vector – through developing authenticities in the dialogue and polyphony of different worlds and cultures to be taken into consideration. Modern emotiology regards conceptualized emotions as categorization and conceptualization operators [9] of semantic space stability, entering structures of the ethnosemantic personality existence [10]. Together with this, the ontological correlation between cognition and emotions as the development of conceptual and verbalized psycho-empirical structured global differentiation expressed in articulating (emotional) experience of people's four main psychological dimensions (intellectual functioning, haptic experience, the feeling of one's personal identity and specialized protection systems [3] has been proved both by the cognitive and the communicative theories of emotions.

Thus, emotiological studies are getting oriented towards the cognitive field as a component of the whole system of framing techniques and technologies of organizing cognition, which can be explained by changes of a more global sociocultural scale, in particular, by the crisis of ontological monism and dualism under the conditions of dealing with plural and hybrid ontologies [7], including emotions and their concepts. That is why at the present stage, perfecting the existing systems of identifying discourse fragments of the actualization of emotional concepts and developing new higher-precision ones are among priorities in the theory and practice of improving expert systems for special purposes [1], [8], which is a considerable challenge for cognitive linguists. All the above determines formulating a deeply actual linguistic mission of our time, consisting in modeling the language behavior of a Homo Loquens as a Homo Sentiens, in other words, in creating a functional model of a natural language as the ecology of the objectivization of the conceptual picture of the world, which explicates the timeliness of our research.

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2 Neuronetworks as a tool of researching the cognitive process of identifying in studying verbalized concepts of emotions

In the connection with the above, the key objective of this paper is to explain the methodological role and function of the structured cognitive process of identifying images in researching verbalized emotional concepts (EC) as objects of neuronetwork modeling within the framework of cognitive linguistics.

This objective presupposes realizing the following tasks: a) to characterize the key stages of the cognitive process of identifying images (including EC); b) to compare the characteristics revealed with the corresponding stages of activities directed at creating a neuronetwork model of identifying EC; c) considering a fragment of the artificial neuronetwork of identifying verbalized concepts of positive emotions we have been developing as an example, to demonstrate the euristic potential of the neuronetwork approach based on developing analogies between the structures of the identifying EC images cognitive process and those of the relevant activities to create their neuronetwork model

Therefore, our scientific focus is the structure of the cognitive process of identifying as the basis of identifying images neuronetwork modeling. The subject of the work is the methodological aspects of the identifying cognitive process in terms of neuronetwork-modeling the identification of verbalized EC, which explicates the significance of artificial neuronetworks for revealing the linguocognitive architectonics of verbalized EC, which, in its turn, determines the novelty of the present research.

2.1 Neuronetwork approach versus linguistic methods of image identification: methodological perspective

In terms of identifying, linguistic methods have a number of considerable advantages [3], [13]. However, they also have certain disadvantages, such as the hyper-sensitivity of these systems to possible vocabulary changes and various metaphorical modifications of language representation formats of EC, a noticeable growth in the quantities of calculations when the precision of identifying increases, which causes difficulties while observing the on-line real time mode. It substantiates the necessity of conducting research connected with developing systems of identifying ideally without the above-mentioned drawbacks. That is why we are working at developing our neuronetwork approach to creating systems of identifying the conceptualized emotional intensity of verbal information as the verbal reaction to emotiogenic stimuli, including visual stimuli (for instance, looking through photos by means of Facebook, Pinterest, Carde, Instagram etc.), audio- and haptic ones, building neuronetwork systems of identifying concepts of emotions (NNSICE). It is the feature of representing knowledge acquired by a neuronetwork in the process of its training and its ability not only to correctly react to signals received in the process of training, but also to generate the right output for input signals that have not been used in the process of training, together with the colossal speed of functioning that have served as the determining factors while selecting artificial neuronetworks as the best candidate to develop a system of identifying to meet the existing needs and to correspond to the goals set.

Moreover, within the framework of researching the issue of the neurophysiological adequacy of neuronetwork modeling on the whole and the neuronetwork modeling of EC, in particular, we have come to the concusion that the neuromorphous nature of the neuronetwork model of EC is connected with reproductively simulating a number of principles and mechanisms of representing and processing information that are intrinsic for brain neuroinformatics and closely correlate with the following aspects: a) the process of identifying: the insignificant depth of information processes coupled with their high parallelism [12]; b) an integrative usage of parallel and serial data processing in the process of identifying; c) the distributed character of information storage (in terms of understanding distributed cognition as a phenomenon when (emotional) knowledge and knowledge acquisition are activities that are inseparable from activities for perceiving environment [5]; c) the associativity principle; d) self-organization [2] and other properties. Here it is the cognitive process of identifying that appears to be methodologically fundamental for creating NNSICE, allowing not only to determine the precision degree of representing the essential peculiarities of a verbalized EC as a focus object in a neuronetwork model of identifying but also to develop further methodological recommendations concerning its improvement to broaden the analogies between models and prototypes.

2.2 Structural model of the cognitive process of identifying verbalized concepts of emotions: neuronetwork dimension

From the gnoseological point of view, the process of recognizing and identifying images is a component of any type of cognition, and it is necessarily connected with the process of training/learning or acquiring new experience/knowledge. Following T. Kapitonova [4], within the framework of cognitive sciences we define identifying as comparing the current perceptive (conceptual-verbal) image with the inner leading element which is represented in the central nervous system of a subject and includes receiving information (emotional information, in our case), its processing, comparing with memory models, classifying, informing about the fact of belonging of an object (a verbalized concept) to a certain category of objects (EC).

Since the process of human cognition (experiencing emotions) takes place under circumstances of an intensive interaction of a number of neurophysiological, psychological, language and cultural factors and the necessary condition for building information and knowledge models should be the psychological and physiological reality basis [6] we consider it to be rational to enrich the present structure by means of involving the stages of training/teaching-learning and post-identifying. It is determined by the polysystem nature of cognition which becomes obvious in the interaction of its perceptual, selective, mnemic and reason elements, which is crucial while identifying EC as verbalized mental representations of multi-aspect experiential emotional knowledge that cannot be comprehensively described by means of a simple range of obligatory and optional elements as knowledge of a matrix format, i.e. such knowledge that can be represented as a cognitive matrix or a synergetic system of interrelated contexts, each of which is a space of conceptualizing an object (emotions).

As a result, the structural model of the cognitive process of identifying a verbalized EC as an image comprises the stages of training, preliminary identification, comparing, classifying and post-identification. Let us focus on each of them in more detail in connection with the corresponding stages of creating NNSICE.

In general, the meaning of the cognitive process of training is to form and perfect skills and abilities, to accumulate the experience of representing the outer world while interacting with the training object/training system [1], [4]. The identifying system is supposed to actively interact with the world, which allows to compensate lack of a priori information, being the basis for changing the algorithms of the identifying system functioning. At the same time, the neurobiological dimension of the training process is connected with the functional changes of nervous system structures, leading to engramming [5], i.e. to creating a certain prototype that is represented in human long-term memory, generalizing the essential parameters of a certain field. Neurophysiological memory, in its turn, can be observed on the level of systems of neurons, as it is realized synaptically and is connected with neuronetwork populations' (including artificial ones') acquiring peculiar properties that enhance mastering a new skill.

The neuronetwork perspective presupposes that the basis of training is formed by a sequence of improving reactions to a sequence of stimuli united by a definite training goal [12]. Consequently, we understand neuronetwork training as the process of the adaptation of a neuronetwork to presented samples of the corresponding training selection through modifications according to the training algorithms of the weight coefficients of correlations between neurons. In this case, the stage which is prior to the training process is the initialization of the corresponding artificial neuronetwork, as a result of which there are certain weights and neuronetwork shifts set. The essence of the training process itself, thus, consists in the fact that at every training cycle the weight rates of the training selection are provided at the neuronetwork input point and the artificial neuronetwork starts functioning to calculate the

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gradient of the error surface.

The initial point of the cognitive stage of preliminary identification is the stage of the initial reception of information, i.e. receiving perceptual data determined by the object's influencing sense organs, as well as the procedure of identifying informative characteristics of an object to be identified – verbalized EC. This stage is immediately connected with the perceptual component of identifying images as the integration and the relevant interpretation of perceptual data on the basis of a certain interaction between the a priori and the a posteriori (perceptual) data components [11].

In neuronetwork modeling of identifying the above stage can be compared with the stage of receiving pre-processed input data by an artificial neuronetwork and its selecting informative variables (features) together with focusing on a certain number of samples in the training selection.

As for forming the raw data bank of our neuronetwork model, the process of identifying with the help of an artificial neuronetwork is carried out on the basis of the data "input – output", received during experimenting with the object of identification (textual data of various degrees of emotional intensity) and a number of verbalized EC. Combining these data, we get a full set of training pattern samples that describe the availability of the set verbalized EC in the input information.

To train efficiently, the following training pattern sample is helpful:

$$\Xi:\{\mathbf{x}_i, \mathbf{d}_i\}\big|_{i=1,\ldots N}, \mathbf{x}\in\Re^p, d\in\Re^m, \qquad (1)$$

where $\mathbf{x}_i$ - input training pattern sample; $\mathbf{d}_i$ - output training pattern sample; N – quantity of samples; p – size of the input training pattern sample, m – size of the output training pattern sample.

The procedure of creating training pattern samples to teach artificial neuronetworks as the basis of NNSICE developed by us is shown below.

To take into account possible reconfigurations of the object to be identified it is necessary to analyze (predict) possible distortions and misinterpretations of the reference model information (RMI) which is represented by emotionally colored texts and to create the so-called bank of textual blocks Ψ (Fig. 1), where

D – quantity of possible reconfigurations of the object to be identified;

$\mathbf{I_0}$ – non-reconfigurated RMI;

$\mathbf{I_1}$ – information that has undergone a reconfiguration of the first degree, etc.

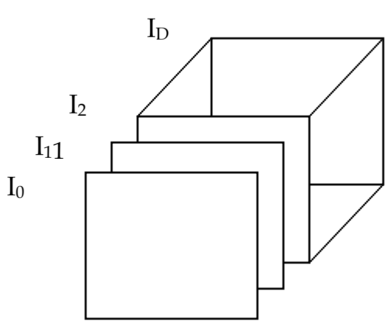

Fig.1. In-put emotionally colored textual blocks to train the artificial neuronetwork NNSICE

Having transformingly reconfigurated each of the RMI emotionally colored textual blocks that belong to the space Ψ throughout the whole continuum of parameters (for example, there can be certain pronunciation or spelling mistakes, peculiarities of different dialects) we make our selection $\mathbf{x}_i$, i = 1, 2, …, N, called the in-put selection sampling.

Having found the vector of the corresponding emotional concept $\mathbf{d}_{il}$, called the vector of the desirable output, for each emotionally colored textual block $\mathbf{x}_{i/}$, we form a number of training pattern samples (TPS) $\{x_i,d_i\}$ that describe the behaviour of the identification system.

The cognitive stage of comparing in the procedure of identifying images serves to reveal the similarities between the created perceptual image and those prototypes that are kept in the long-term memory, using the mechanism of content addressing to directly appeal to the memory [3]. The methodological analysis of the comparison cognitive stage requires determining the role of the mnemonic component in the overall structureof the process of identifying, since the procedure of training which allows to construct a certain generalized image inherently presupposes creating engrammes as ceratin prototypes in the long-term memory.

The stage of comparing can logically be followed by the stage of classifying as an element of the cognitive process of identifying, the former being the procedure of making a decision concerning the issue of the image under identification belonging to a certain class/category. This stage bases on categorizing, closely connected with the rational component of the identification process [4].

The neuronetwork stage is also the procedure of making a decision about the in-put image under identification belonging to a certain category of the artificial neuronetwork alphabet of classes [] and it is carried out on the basis of the results of the previous comparison stage. The categorization procedure consists in locating the input image within the framework of a certain category with the maximum degree of similarity.

In our case, the task of creating a recognizing/ identifying neuronetwork system roots from the global problem if interpolation [12] which for the scientific situation under consideration can be formulated in the following way: on the basis of the given selection sampling N of emotionally colored textual blocks $\{\mathbf{x}_i \in \Re^p \,|\, i = 1, 2,\ldots, N\}$ and the corresponding set of emotional concept vectors (ECV) $\{\mathbf{d}_i \in \Re^3\}$, which satisfies the condition:

$$\mathbf{F(x_i) = d_i}, i = 1, 2, \ldots, N, \qquad (2)$$

where i – dimensionality of an emotionally colored textual block.

It should be pointed out that if we use the above formulation of the question the interpolation surface (**F**) has to go through all the points of the TPS set.

However, in practice, the condition (2) can look like this:

$$\|\mathbf{d}_i - \mathbf{F}(\mathbf{x}_i)\| \leq \varepsilon, \qquad (3)$$

where ε – interpolation error; ‖.‖ – Euclidean distance (norm).

Taking into account the above, the stage tasks of the present fragment of our work can be formulated in the following way: on the basis of the TPS set $\{\mathbf{x}_i, \mathbf{d}_i\}$, i = 1, 2,…, N it is necessary to develop an artificial neuronetwork with the following char-

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acteristics:

- with the current emotionally colored textual block **u** at the in-put point of the system that matches any emotionally colored textual block from the input selection sampling $\mathbf{x}_i$, i = 1, 2,…, N this artificial neuronetwork has to generate the corresponding emotional concept vector $\mathbf{v} = F(\mathbf{u}) = F(\mathbf{x}_i) = \mathbf{d}_i$ at the output point;

- with the current emotionally colored textual block **u** at the in-put point of the system that does not match any of $\mathbf{x}_i$, i = 1, 2,…, N but belongs to the space of in-put signals this artificial neuronetwork has to generate the corresponding emotional concept vector $\mathbf{v} = \mathbf{F}(\mathbf{u})$ at the output so that the identification mean-square error could not be more than a certain preliminarily fixed one, i.e. $\|\mathbf{v} - \mathbf{d}_i\| \le \varepsilon_{доп}$.

Our analysis has proved that for identifying it is reasonable to use a three-ply forward oriented neuronetwork with radial basis functions (RBF-network). In general, RFB-network consists of three layers of neurons (Fig.2). The first layer is the “in-put” stratum, it serves to receive and to retranslate the in-put signal. Neurons of the second “hidden” layer are responsible for the non-linear transformation of in-put signals. Neurons of the third “output” layer summarize the output signals of the second layer and form the output of the neuronetwork (the procedure of training this RBF is presented in [11]).

The cognitive stage of post-identification that comprises the procedure of empiric and theoretical interpretation to evaluate the correctness of the procedure of identifying and potentially modifying behaviors/transforming models of the world shows the subordinate status of identifying in biological systems (the linguocognitive system being one of them) as to the purposes of environmental orientation and completing the generic program of development and self-sufficiency, which, in its turn, determines the active character of the processes of identifying EC images as a vital means of realizing global media interaction objectives.

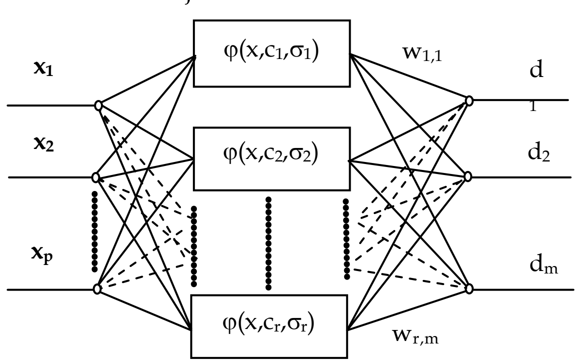

Fig. 2 Architecture p-r-m of an RBF neuronetwork

The artificial neuronetwork evaluation of the correctness and validity of the recognition/identification results is realized through feedback procedures that are similar to positive feedback mechanisms that change the coefficients of the weight matrix and their nature, depending on the results of identifying and its purpose.

Therefore, with NNSICE, whose feature is lack of a priori knowledge about the mathematical model of the focus object and only the in-put and output points of the system to analyze and to synthesize, with the usage of the above algorithm of the cognitive process of image identifying, there has been created this artificial neuronetwork which, when tested by means of emotionally colored textual blocks that have not been used for its training, presented such a vector of verbalizing emotional concepts that the results of the expert evaluation and the obtained ones coincide in 85% of cases.

Conclusion

This paper presents an enriched by involving the training and post-identifying stages structural model of the cognitive process of identifying images and the corresponding integrity of activities directed at creating a neuronetwork model of identifying, comprising the cognitive stages of training, preliminary identification, comparing, classifying and post-identifying. The key methodological implication of reconstructing the pattern of activities to creat an artificial neuronetwork system of identifying is its analogy with the structure of the cognitive process of identifying images, including verbalized concepts of emotions. The euristic potential of this analogy, enabling to substantiate the methodological status of the problem of self-organization as fundamental when modeling processes of identifying images, is revealed in the process of our developing the neuronetwork system of identifying concepts of emotions (NNSICE).

A perspective extension of the research is seen in elaborating methodological recommendations as for the further development of neuronetwork modeling, as well as in optimizing and perfecting the RBF-networks in question in terms of minimizing the hidden layer without losing the representativeness rate of the corresponding training pattern sample sets on the basis of using genetic cognition algorithms.

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