FUZZY CATEGORIES IN USSR PHYSIOLOGICAL INVESTIGATIONS

O.G.CHORAYAN, D.I.SHAPIRO

USSR.

The present level of physiological knowledge of constructive peculiarities of organization and functional securing of physiological systems of the organism makes it as a rule impossible to describe in detail and per element various manifestations of their physiological activities. This concerns parts of all physiology of the brain- the leading informational-controlling system of the organism most aspects of which cannot be translated into the language of exact quantitative relationships. This allows to assume that the conception of fuzzy sets and algorythms,widely spread in many scientific branches dealing with complex and supercomplex systems,will be properly applied to neurophysiology which at present is closely connected with biological cybernetics,biological physics,and mathematical biology.

In sensory physiology especially in physiology of the higher nervous activity, during experimental and theoretical studies it is often necessary to identify individual elements or neuronal modules on the basis of their structural-functional characteristics [3,4] It is well known that in nervous cells /particularly in central neurons / impulse responses even to adequate stimuli vary considerably [9] .Due to this fact population of central neurons,sensitive to certain stimulus and localised in various analyzatory,associative,integrative and motor nervous structures,may be approximated not to the classical theory defined sets but to a fuzzy one belonging to which of

a separate neuron is evaluated by the corresponding estimate of the membership function.

Methods of the fuzzy sets theory are used for identification of functional cell ensembles in some subcortex structures of the human brain. Evaluation of a neuron's belonging to such functional ensemble or structural- functional unit in the brain is fulfilled with the help of a row of quantitative and qulitative signs characterizing peculiarities of neuronal background and evoked pulse activity. Such investigations are of great scientific and practical importance. Thus,for instance,in functional neurosurgery there are successfully used with medical purposes methods,of surgical intervention into deep human brain structures,requiring determination of locality of intrabrain nuclei formations subjected to destruction.

Incompleteness and indistinctness of initial information effectiveness of the operation and registration of neurographic data may be described by the totality of clinical-physiological indicators with the help of the expert's summarized value realized in fuzzy linguistic variables [10]. From the viewpoint of fuzzy sets an elementary neuron ensemble is a fuzzy with diffuse borders population of neurons which jointly fulfil a simple act of data processing . In experimental studies on ensemble organization and brain functions it was revealed that in the function of belonging of seperate neurons to some neuron ensemble numerical values depend on many factors: intensity and adequacy of the stimulus,functional state of the neuron,spatial characteristics of cells,activation mode and so on. With the help of the Zade modified equation for linguistic variables description there were elaborated algorythms for accounting numerical values of the function of belonging of every nervous cell

of a certain neuron ensemble /or its parts / in various functional states [2,3] . As a criterion of effectiveness of this method, comparison of theoretical values with experimentally obtained measures of probability of neuron's belonging to the general excited nucleus of the ensemble and to its inhibited surrounding in the ensemble. Calculations exposed discrepancy between theoretical and experimental data not above 10-15% which is quite satisfactory for neurophysiological investigations.

Advantages of the fuzzy sets and algorythms theory are even more obvious is psychophysiological analysis of the decision-making process in the problematic situation when information about this situation is insufficient [1,8,11,13,14,15,17]. Utilization of the mathematical aspect of the probability theory considerably enlarges the number of problematic tasks solved by man. However effective in such cases for usually a person making decision is not aware of the density of probabilities distribution and deals with an uncertain situation initially related with fuzzyness and inexactness of the concepts formed and imprinted in his informational thesaurus.

Practical application of the fuzzy sets theory to studying man's psychophysiological mechanisms of solving problematic situations requires development and check-up of techniques of determination of probability of fuzzy phenomena in the process of realization of fuzzy logic of human behaviour in a problematic situation. We worked out methods of calculating fuzzy probability $\tilde{p}$ for choice and evaluation of alternative actions in the process of pattern discrimination as a widely -spread process of decision-making in a problematic situation. The results of the experiments showed that pattern discrimination

process is accompanied by gradual increase in numerical values of fuzzy probability. While in case of correct pattern discrimination there is increase in numerical values of the membership function / according to increase in the "fuzzy probability" value / one can draw some analogy between real psycophysiological mechanisms and a model of pattern discrimination created in the ground of fuzzy sets ,numerical values of the membership function.

Fuzzy values and choice procedures are widely used in medicine. At that such aspects as state determination, diagnostics, medical tratment choice and interrelations in the "physician- patient" system are considered [7,8] . The work in identification of destruction place in neurosurgical tratment of parkinsony was mentioned above [10] .

The procedure of medical treatment choice included compilation of a set of data about situation ,evaluation of current data by fuzzy scales,elaboration of rational recomendations,and teaching the system. Similar procedures are developed for concrete tasks of practical theurapy such as medical tratment choice of ray-theurapy of malignant tumor.

Problems of formal representation of fuzzy categories are closely connected with determination of their peculiarities development of methods of work with experts and investigations of experts themselves. Peculiarities of fuzzy categories are defined in psychological studies,that allows to devise classification and summarized procedures of formalization for such categories,

Investigations of brain asymmetry functions in conformity with formalization of methods showed that peculiar features of these functions should be taken into considerati-

on while defining the concrete tasks facing the specialist while developing the mode of data representation and also while choosing specialists [II,8].

It seems that research work on functional peculiarities of human physiological systems by means of the fuzzy sets theory is rather promising which is primarily connected with: I/ the fact that in the picture description there are qualitative uncertainties and parameters characterizing the state of the person and his behaviour and 2/ necessity of application of neurophysiological evidence to fuzzy categories formalization procedures.

References.

I. Bassin A.E. On manifestation of the unconscious in artistic activity. Philosophical Problems, I978,p.556.

2. Chorayan O.G. Fuzzy Algorothms of Thought Processes. Rostov on Don, Rostov State Univ. Press, I979.

3. Chorayan O.G. Identification of elements of the probabilistic neuron ensemble in terms of the fuzzy sets theory. Physiol. J. USSR,I979,65,p.759.

4. Chorayan O.G. Identifying elements of the probabilistic neuronal ensembles from the standpoint of fuzzy sets theory. Fuzzy Sets a Systems, I982,v.8,p.I4I.

5. Chorayan O.G., Kogan E.A. Probabilistic changes of fuzziness in processes of pattern discrimination. Problems of Psychology, I983, NI,p. I83.

6. Chugunov V.S.,Vasilyev V.N.,Shapiro D.I. Prognosis of neuro-

tics state by evidence of sympato-adrenaline system by means of the situational model of rational recommendation choice. Abstracts of Fuzzy Sets Theory Application in Control Processes. Permi, I982,p. 60.

7. Egikova J. V. Cure of neurological diseases with the help of the state value by the universal scale. Preprint, Moscow,I980.

8. Ivanov V. Linguistic semantics ,fuzzy categories and physiological asymmetry. Abstract of Fuzzy Sets Theory Application in Control Processes, Frunze, I98I,p. 63.

9. Kogan A.B., Chorayan O.G. Probabilistic Mechanisms of the Nervous Activity. Rostov on Don, Rostov State Univ. Press, I980.

IO. Lukashev A.O.,Rayeva S.N. On the analysis of the value of effectiveness of surgical intervention into deep human brain structures with fuzzy initial information. Abstracts of Fuzzy Sets Theory Application in Control Processes. Frunze, I98I, p. 58.

II.Nevskay L.L. Pavlovskay M.B. Brain hemispheric asymmetry from viewpoint of visual images discrimination. In:Sensory Systems, Leningrad,I982,p.76.

I2. Raeva S.N., Voinberg N.A., Sobol A.U., Lukashev A.O. On application of fuzzy multitudes as a possible approach to comprehension of identification principles of functionally combined cell complexes of some subcortex structures of human brain. Abstracts of Fuzzy Sets Theory Application in Control Processes. Permi ,I980, p. 86.

I3. Rasin O.S. Application of fuzzy sets in problems of evaluation of psychological state of the operator. Abstracts od Fuzzy Sets Theory in Control Processes. Permi, I982,p. 56.

I4. Shapiro D.I. Vasilyev V.I. On communicative processes in decision-making. In: Summaries of IX All-Union Symposium on Cybernetics, Sukhumi, I98I,p. 95.

I5. Shapiro D.I.,Bondareva I.M. On investigation of behavior with the help of the fuzzy sets theory. Problems of Neurocybernetics. Rostov on Don, I983,p. 63.

I6. Shapiro D.I., Leontyev A.A. Fuzzy categories in decision-making solutions /psychological aspect/ . Intercourese Theoretical and Pragmatic Problems. Moscow,I978,p. I35.

I7. Shapiro D.I., Vasilyev V.I. On communication in decision-making. Summaries of IX All-Union Symposium on Cybernetics. Sukhumi,I98I,p. 9I.