Mathematical Modelling of Delayed Behavior

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Introduction. Nowadays a wide range of mathematical methods gain a prominent position in biological sciences. As a result of cross-disciplinary studies, mathematical approach is believed to explain all probabilistic and stochastic phenomena where at least one variable varies towards other variables or effects them. Due to a large number of possible parameters involved in such probabilistic and stochastic processes as adaptive learning, repeated decision tasks, reinforcement, and strategic changes, sometimes it seems difficult to generalize the results of neuropsychological studies. From this point, mathematical approach should be considered as the most reasonable means to identify the behavioral features, interpret numeric data and therefore, the wide range of mathematical approaches and models are proposed for the data analysis in ethology, psychology, neuroscience, etc.

Aim and Objectives. The aim of the research was the study and modelling of complex perception process in rats by assessing of food-obtaining behavior in T-maze in conditions of two feeding racks. For this purpose mathematical methods were integrated in behavioral study. For the assessment of optimal behavioral strategy across learning process, algorithmic description approach was proposed. The compliance of Markov Chain method for spatial memory behavioral patterns was tested.

Methods. The modified direct delayed reaction method was used for the evaluation of behavioral conformities across food-obtain spatial learning tasks. Food was provided according to the time-spatial program, in conditions of fixed delay for each feeding rack and inter-trial interval throughout the whole experiment. All reactions were recorded in special designed protocols using the following figures: "1" - rat performs the action; "0" - researches interfered in the test. As a result, the protocol records represented sequences of "0" and "1", which gave possibility to characterize animals' behavior and identify learning algorithms. Chaotic and optimal behavioral algorithms described by consequences "0" and "1" were obtained. The optimal behavioral algorithms for each experimental day have been defined. The mathematical apparatus describing the direct delayed reactions using the discrete - time Markov chains was considered.

Results. The behavioral experiment using a modified method of direct delayed reactions made it possible to observe the learning process along with establishing the maximal delay and identifying an optimal algorithm for minimal errors and maximal rewards. Each behavioral algorithm consisted of 5 digits. From the consequence of the all of theoretically calculated ($2^5 = 32$) algorithms chaotic (7), optimal (8) and methodically exclusive (17) behavioral algorithms were defined and experimentally obtained behavioral algorithms were assessed. Behavioral algorithm was considered to be optimal if it promotes successful access of correct feeding-rack in minimal errors. Chaotic behavioral algorithm implied frequent intervention of experimenter in behavioral treatment. At the initial stage of the experiment optimal algorithms of food-obtain behavior had not been elaborated yet. In the second half of the experiment as a sequence of learning process optimal algorithms were successfully developed.

Using Markov Chains method we generated transition probabilities which are probabilities of moving from one state to the next. For the modeling of food-obtaining spatial memory tasks the recurrence equation has been proposed. Such approach gave possibility for prognoses of rats' delayed reactions during spatial memory acquisition tasks. The proposed method was tested for randomly chosen n^{th} trials of 10-trial behavioral tasks. The calculated probabilities for all measured patterns of food-obtaining behavior coincide with empirical probabilities.

Conclusion. We have demonstrated compliance of Markov Chains method for prognoses of spatial memory behavioral patterns and made ground for further studies across different behavioral tasks.