18.06.2008. URL: http://www.pcweek.ru/spheres/detail.php?ID=111239&SPHERE_ID=13906 (дата обращения: 22.04.2014).

3. Экономическая информатика: Введение в экономический анализ информационных систем: Учебник. М.: ИНФРА-М, 2005. 958 с.

APPLYING LYAPUNOV'S METHOD FOR ANALYZING RHYTHMS OF NIGHT BREATHING OF PATIENTS SUFFERING FROM BRONCHIAL ASTHMA

A.V. Prisakar
(s.Tomsk, Tomsk Polytechnic University)

This article focuses on the method of analyzing experimental data of people's airflow, who have bronchial asthma, which is a serious global health problem. It presents the results of using the Lyapunov's method – features of people with different types of bronchial asthma.

Introduction. Bronchial asthma is a chronic disorder characterized by widespread and largely reversible reduction in the caliber of bronchi and bronchioles, due in varying degrees to smooth muscle spasm, mucosal edema, and excessive mucus in the lumens of airways. Cardinal symptoms are dyspnea, wheezing, and cough. Attacks or exacerbations may be induced by airborne allergens (molds, pollens, animal dander, dust mite and cockroach antigens), inhaled irritants (cold air, cigarette smoke, ozone), physical exercise, respiratory infection, psychological stress, or other factors [1]. Bronchial asthma is a serious global health problem, and from 5% to 10% of persons of all ages suffers from it [2].

There are the following types of bronchial asthma:

1. Bronchial asthma psychogenic-induced (BAPI). Asthmatic attacks are developed after emotional stress, mental shock or a stressful vital event.

2. Bronchial asthma non-psychogenic (BANP). Asthmatic attacks are often preceded by allergic rhinitis, urticaria, eczema and physical factors (cold and temperature difference). Psychological factors are missing in this category.

3. Bronchial asthma somato-psychogenic (BASP). In this category the standard disease progress of patients was altered by stress, after which the psychoemotional triggers (exogenous irritants: chemical irritants, respiratory infection, drugs and etc.) caused asthma attacks [3].

4. Psychogenic dyspnea (PD). Asthmatic attacks and dyspnea are connected with stressful vital events. The bronchial obstruction and other signs of asthma and organic pathology were ruled out there.

At present we have a lot of different methods that allow defining features. For example, there is the Lyapunov exponent (λ) - entropic index that characterizes the rate of separation of infinitesimally close trajectories. It is a measure of "irregularity", smaller values indicate a greater chance that a set of data will be followed by similar data (regularity), and a greater value for the Lyapunov exponent signifies a lesser chance of similar data being repeated (irregularity) (Table 1) [4].

Table 1. Lyapunov exponent

$\lambda < 0$	It is dissipative or non-conservative systems that exhibit asymptotic stability.
$\lambda = 0$	The system is in some sort of steady state mode.
$\lambda > 0$	A positive largest Lyapunov exponent indicates chaos [5].

Research materials. 30 people are investigated: 10 healthy (5 men and 5 women), 20 people with bronchial asthma who are divided into 2 groups. The first group includes 12 patients

with BAPI (onset and progression of disease associated with psychological stress, psychotraumatic situation), there are 7 men and 5 women. The second group includes BANP, there are 8 people: 4 men and 4 women. While all examinees were sleeping, continuous monitoring of airflow at the nose and mouth was conducted by a cardiorespiratory monitor.

Method. There are two general methods of calculating the Lyapunov exponents: the first is used for the data generated by the known system of differential or difference equations (we do not know its differential equations) and the second is for the data from experimental time series (we have the data of people's airflow in the form of experimental time series) [6].

We define the spectrum of Lyapunov exponents in the manner most relevant to spectral calculations. Taking into account a continuous dynamical system in an *n*-dimensional phase space, we monitor the long-term evolution of an infinitesimal n-sphere of initial conditions; the sphere will become an *n*-ellipsoid because the flow has the locally deforming nature. The *i*th one-dimensional Lyapunov exponent is then defined in terms of the length of the ellipsoidal principal axis $p_i(t)$:

$\lambda_i = \lim_{t\to\infty} \frac{1}{t} \log_2 \frac{p_i(t)}{p_i(0)}$, where the λ_i are ordered from largest to smallest.

In this way the Lyapunov exponents are related to the expanding or contracting nature of different directions in phase space. Since the orientation of the ellipsoid changes continuously as it evolves, the directions associated with the given exponent vary in a complicated way through the attractor [7]. The attractor is a set of states - points in the phase space, invariant under the dynamics, towards which neighboring states in the given basin of attraction asymptotically approach in the course of dynamic evolution [8].

Results. The table 2 shows the Lyapunov exponents (within the accuracy of up to 4 signs) according to the sex of healthy people and patients with BAPI and BANP.

Table 2. Lyapunov exponents of healthy people and people with BA

Sex	Lyapunov exponents	Healthy people	BANP	BAPI
Women	λ	0,2687	0,2138	0,2477
Men		**0,2592**	**0,2563**	**0,2468**

Conclusion. Lyapunov's method is applied to study the stability of various differential equations and systems. It effectively identifies differences between healthy people and patients with BA (BAPI and BANP). Looking at the table 2, we can make the following conclusions:

1. Women's Lyapunov exponents are higher than men's ones, it means that healthy men have more rhythmic breathing.
2. Men with BANP have higher Lyapunov exponents than women do, therefore women have more rhythmic breathing.
3. Men and women with BAPI have approximately equal Lyapunov exponents.

Research of nonlinear parameters allows us to reveal different features (in our case features of healthy people and patients with BA). Thus the next step of this research will be to identify nonlinear parameter as correlation dimension to distinguish a "random" system and a system controlled by a small number of parameters, and to assess their complexity.

REFERENCES

1. Medical dictionaries, drugs & medical searches [Electronic resource]. Access mode: http://www.medilexicon.com/, free (access date: 6.02.2014).

2. Ukena D., Fishman L., Niebling W.B. Bronchial asthma: diagnosis and long-term treatment in adults [Electronic resource]. Access mode:

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2696883/pdf/Dtsch_Arztebl_Int-105-0385.pdf, free (access date: 7.02.2014).

3. Basic pathology. LUNGS – Bronchial Asthma [Electronic resource]. Access mode: http://basicpathology-histopathology.blogspot.ru/2009/03/lungs-bronchial-asthma.html, free (access date: 8.02.2014).

4. Seely A., Macklem P. Complex systems and the technology of variability analysis [Electronic resource]. Access mode: http://ccforum.com/content/8/6/R367, free (access date: 7.02.2014).

5. The Chaos Hypertextbook [Electronic resource]. Access mode: http://hypertextbook.com/chaos/43.shtml, free (access date: 7.02.2014).

6. Moon F.C. Chaotic Vibrations: An Introductions for Applied Scientists and Engineers. – New York: Wiley, 1987. – 312 p.

7. Determining Lyapunov exponents from a time series/ A.Wolf, J.Swift, H.Swinney, J.Vastano// University of Texas, Austin.–1984.–P.285–317.

8. MathWorld – A Wolfram Web Resource [Electronic resource]. Access mode: http://mathworld.wolfram.com/Attractor.html, free (access date: 13.02.2014).

МАТЕМАТИЧЕСКАЯ ПСИХОЛОГИЯ

А.О.Пуртова
(г. Томск, Томский политехнический университет)

MATHEMATICAL PSYCHOLOGY

A.O.Purtova
(s.Tomsk, Tomsk Polytechnik University)

The article is devoted to mathematical psychology. The processes associated with the emergence of mathematical psychology and its stages. Definition of the problem of limited modeling capabilities with the help of this psychology. We consider in this article are still major areas of mathematical professor psychology V.Krylov (he played a leading role in the development of mathematical psychology).

Математическая психология - это направление в психологии, разрабатывающее формальный (математический) аппарат, пригодный для адекватного описания и моделирования объектов, обладающих психическими свойствами (В. Ю. Крылов). Возникновение математической психологии связано с процессом математизации психологии, который прошел несколько стадий:

Первая стадия — это применение стандартных математических методов для анализа и обработки результатов и для установления простейших количественных закономерностей.

Вторая стадия — попытки построения математических моделей некоторых психических явлений и процессов — началась в середине 50-х гг. XX в. Она характеризуется попытками использовать имеющийся готовый математический аппарат для моделирования психических.

Несмотря на явные результаты в решении этой задачи, одновременно обнаружилась и ограниченность возможностей их моделирования при помощи аппарата, разработанного