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# Verbal Learning: Model of Linear Differential Equation of Third Level

Aminev E. G.[1]
Wang Qing[2]

***Abstract:***

*The hypothesis, that the information fixation processes in short-term and long-term person's memory are most adequately described by differential equation of the third order, is put forward. 36 men were surveyed by learning of 15 words line. Learning of 15 words line during ten presentations was made. The experiences were carried out three times with different word lines and further the learning average curve was counted. The opportunity of process modeling by the third level differential equation is shown. The model can be used for material mastering styles study, both in experiment, and at the educational process efficiency analysis. The individual equations parameters dependence from all individuality levels - from personal up to membrane is assumed.*

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## I. BACKGROUND

Academician A.N. Tihonov - expert in the field of mathematical technological processes modeling and the author of return tasks method in mechanical engineering - wrote: "The mathematical models allow to reduce research of real mathematical object to a mathematical task solving, use of the universal mathematical device for its study and to receive due to this detailed quantitative information about an object. Huge opportunities of mathematics as method of the real world laws' acknowledgment and their usage in people's practical activity are concluded in it" (Tihonov A.N., Kostomarov D.P., 1979, p. 28). From these positions the psychologists mathematical preparation should be provided with concrete examples from experimental psychology and practice. In particular, during study of matrix algebra bases, the regressional equation and neurocellular packages for forged answers correction, having the important value for psychodiagnostics in professional selection system and employees' personal deformations monitoring, can be examined (Aminev G.A., Aminev E.G., Mardanov D.A., 2001). In cognitive psychology the methods of groups algebra and multiple-valued logic are not applied. We bring an example of the linear differential equations device usage.

Let us remind, that in teaching processes of P.K. Anuhin's action acceptor is set by an experimenter, and gradual approach to it is described by exponential dependencies (Bush R., Mosteller F., 1962; Lomov B.F., 1963; Atkinson R., Bauer G., Krotes E. 1969; Granovskaya, 1974; Atkinson R., 1980; etc.), that corresponds to systems with transient process of the first level. Researches, especially in a pathology (Traugott N.N., 1973; Luria A.R., 1974; Jinhong D., Zhongxian L., 1998; Lixia Y., Yongming C., Yao C., Zhijin Z., 1998; Huahai Y., Chen Z., Kan Z., 2002), have shown, that the learning curve does not always looks like a smooth exponent, as it is assumed in Bush-Mosteller's model, and in this connection the hypothesis, that the processes of information fixing in short-term and long-term person's memory are most adequately described by differential equation of the third level, was put forward (G.A. Aminev, 1982, G. and E. Aminevs, 1995). This assumption check can be fulfilled within the framework of mathematical and experimental psychology courses.

**Technique.** 36 volunteers were surveyed, men, at the age of 25-45 years. Learning of 15 words line during ten presentations was made. Such experiences were carried out three times with different word lines and further the average curve of learning was counted:. $y_1$, $y_2$, ..., $y_{10}$. Discrete analogues of first, second, third level derivative, were then calculated:.$y' = y_2 - y_1$, $y'' = y'_2 - y'_1$, $y''' = y''_2 - y''_1$. By the method of the least exponents the regressional equation was built:

$$y = a + by' + cy'' + dy''' \quad (1)$$

$$-dy''' - cy'' - by' + y = a, \quad (2)$$

$$(-15d/a)y''' + (-15c/a)y'' + (-15b/a)y' + (15/a)y = 15, \quad (3)$$

$$\delta y''' + \gamma y'' + \beta y' + \alpha y = 15, \quad (4)$$

where $\delta = (-15d/a)$, $\gamma = (-15c/a)y''$, $\beta = (-15b/a)$, $\alpha = 15/a$.

The received expression we bring to a standard kind (4):

Here $\alpha$ corresponds to the opposite sign storing success ($1/\alpha$ means, which part out of 15 presented words the examinee has remembered). Factors $\beta$, $\gamma$, $\delta$ consecutively with an opposite sign correspond to the speed of learning, acceleration and so-called sharpness. In hypothesis authors' opinion these factors characterize dynamics of associative, thinking procuresses and intuition. Processing were made by high school seniors in the computer science club.

**Results.** Let's illustrate the received data on a concrete example (tab. 1). The regressional equation has turned out by the that:

[1] Hi-Tech Psychology Central Institute, Moscow, Russia
[2] School of Public Administration, University of International Business and Economics, Beijing, China

$y = 9.87 - 2.98y' - 2.75y'' - 0.93y'''$.

From here the standard kind of the transient processes differential equation:

$1.42y''' + 4.17y'' + 4.54y' + 1.52y = 15$

**The table 1.** Dynamics of 15 words learning.

Note. X - Presentation number, y - real quantity of remembered words, y′, y″, y‴ - derivative, y* - theoretical meanings.

| X | y | y' | Y'' | y''' | y* |
|---|---|---|---|---|---|
| 1 | 3.33 | 1.34 | 0.32 | -0.64 | 5.59 |
| 2 | 4.67 | 1.66 | -0.32 | 0.98 | 4.88 |
| 3 | 6.33 | 1.34 | 0.66 | -1.33 | 5.30 |
| 4 | 7.67 | 2.00 | -0.67 | -0.33 | 6.05 |
| 5 | 9.67 | 1.33 | -1.00 | -1.66 | 10.20 |
| 6 | 11.00 | 0.33 | -2.66 | 5.66 | 10.92 |
| 7 | 11.33 | -2.33 | 3.00 | -2.67 | 11.08 |
| 8 | 9.00 | 0.67 | 0.33 | | |
| 9 | 9.67 | 1.00 | | | |
| 10 | 10.67 | | | | |

Is shown, that the learning curve parameters have connection with multileveled mentality structure, including membrane and power structures, important for bioengineering verbal memory development questions solving.

## II. CONCLUSIONS

The differential equations of the third level can be used for material mastering individual distinctions study during both experiment, and educational process' efficiency analysis. The independence and psychological importance of the given parameters requires further profound analysis through comparison to person's hierarchical organization.