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MATHEMATICAL MODEL OF HUMAN BEHAVIOR WITH RESPECT TO SECRETION OF A HORMONE

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Abstract

Mathematical modeling can simply be put as expressing human behavior or activities in the form of a mathematical expressions or equations. Modeling can be used when investigating a system that is too complex, too difficult or sometimes simply impossible to deal with directly. Mathematical modeling deals with representing human activities with Mathematical equations. Such equations often lead to either Ordinary Differential Equations (ODE) or Partial Differential Equations (PDE) depending on the number of variables (parameters) involved. Human being as an entity reacts in diverse ways to a situation or phenomena depending on the situations and circumstances. It is a general belief that the behavior of human being is often govern by the secretion of hormones which control the behavior of an individual. In this presentation the interest lies in the Mathematical model of human behavior governed by the secretion of a particular hormone named

SEROTONIN hormone which is one of the hormones that control the behavior of human being.

Key Words: Modeling, Hormone, Serotonin, Behavior, Equations.

INTRODUCTION

Human behavior is a complex phenomenon therefore to come up with a single Mathematical model of human behavior will be highly intractable. However, there is need to model the behavior of human being mathematically and in so doing, one have to focus on some aspect of human behavior. It is often reasonable to consider human as a device with a large number of internal mental stages, each with its own particular control behavior and interstate transition properties [1, 9]. In formulating Mathematical model, one need to determine which factor or variable(s) are significant and which are not. This kind of model could be in the form of a block of standard linear control system. These state of control can be hierarchically organized. In trying to model human behavior, it is imperative to note that human behavior is normally not a single dynamic model unlike population. In modelling human behavior, observing the person's state is very important. The overall behavior of an individual can be broken down into several proto type behaviors. For instance, in the driving situation, one can have a dynamic models corresponding to a relaxed driver, a very tight driver and so forth. The driver's behavior can be classified by determining which model best fit the driver's observed behavior. Therefore, in modelling human behavior, one is trying to deal with the cognitive sense of the individual.[2 ,4]

The cognitive science is trying to uncover how the mind of an individual works at a particular time and with given situation. To this end, the cognitive scientist have been developing an impressive array of empirical methods encompassing observational and correlational studies, human and animal experimentation, case studies of brain damaged patients, psychological recordings and more recently, neuroimaging techniques. The interest lies in using of modeling to advance the knowledge of cognition. [5]

WHAT IS MODELING?

Modeling can simply be put as a phenomenon used when one is interested in investigating a system or phenomenon that is too complex, too difficult or sometime simply impossible to deal with directly. In such cases, one tries to build a simple and less abstract version of the system and in such doing one tends to omit unnecessary details but keeps the essential features [3, 9]. However, if the model is a good one, the result obtained by working and experimenting with it could be applied to the original system (human behaviour). Intuitively a model is an artifact that can be mapped on to a phenomenon that seems to be difficult to understand [6].

A particular useful class of model is represented by computational modes. A computational model is a model that is implemented as a computer program, differently from statistical and mathematical models which only describe a phenomenon but they do not reproduce the model whereas computational models behave and allow us to observe and measure their behavior.

At this juncture we are presenting the mathematical model that describe the behavior of human being upon the secretion of a particular hormone known as serotonin hormone. Human system is govern with secretion of many hormones but the interest lies in the secretion of a particular hormone known as SEROTONIC HORMONE.

It is not surprising that often when people are hungry, they become angry. There is a common saying that “an hungry person is an angry person”. This suggest that a person who is hungry loses patience to wait, and could even be more aggressive. In fact, hunger affects one’s mood more than can be imagined and people hardly pay an attention to it.

Researchers have discovered why hungry people easily become angry or why business transactions oftentimes are made over dinner. Serotonin hormone can be defined as “the hormone that helps to regulate human behavior”.

It was revealed that low level of this hormone in the body system can inhibit communication between certain parts of the brain thereby making it weaker than normal. Therefore, it was concluded that when this happens, it may be hard for the brain to control emotional responses to anger.

However, resent researchers have documented that having an empty stomach which often results into low blood sugar level affects the working of the mind, as a result, any action that requires self-discipline such as quitting smoking, refraining from saying what not to be said, dealing with an annoying boss and so on are also affected.

Apparently, when the blood sugar is low, the brain is staved of fuel and the body produces the stress hormone (adrenaline). The presence of this hormone in the body system trigger up some reactions such as rage, violence, nervousness, panic, attack and palpitation among others. The brain which is only two percent of the body weight, consumes 20 percent of our calories thereby need not to be saved.

The idea that hunger corresponds with a short temper is not just in people's imagination. Non paying attention to hunger could affect the most intimidate relationship which include marriages. This is evident in a research conducted by a Psychologist who monitored the nightly blood sugar level of 107 married couples for three weeks. Each night, the blood sugar (glucose) is measured since this is important for self-control. Each participant was asked to stick pins in a voodoo doll representing his or her spouse. The pins serves as a measure of aggressive feeling. It was discovered that the lower the blood sugar the higher the crankiness and the more the pins pushed into the voodoo doll (Proceeding of the National academic of Sciences, 2008).

At this juncture one questions needs to be answered, that is "Does low blood sugar really affect emotion"? The brain which is the coordinating center of the functions of the body, should not be overly staffed of glucose under any circumstances. Since it is an undisputable fact that a low blood sugar level which is called hypoglycemia say from hunger tends to affect emotions. Howbeit, the effect of low blood sugar level is relative because some people in respective of hunger will still be able to adapt and cope. The normal make – up of man is such that when the blood sugar is going down, the body taps from its reserves to function. This is why people can cope with fasting for days, but at the point that the individual begins to exhaust those reserves that this situation starts to tell on him or her and at this point the brain may be in serious trouble of coordinating very well as a result of low sugar level in the body system.

It is a general belief that anger, fighting, bickering etc. does not originate within the couple dynamic all the time but rather it emerges from situational states like hunger which could potentially be resolved over a plate of food or bottle of chilled beer.

The model

In order to come up with the appropriate Computational / Mathematical model that describe the human behavior in the presence of an hormone (Serotonin), the human behaviour is narrowed down to one dimensional Fist Order Ordinary Differential Equation so as to avoid too many parameters. In this case, we assume that the secretion of the hormone (Serotonin Hormone) into the human system varies with time and according to needs. In order words, the hormone is time dependent. It is assumed that the rate of secreting the hormone is the difference between a sinusoidal input over a period of 24 hours from the thyroid gland and a continuous removal rate proportional to the level present. [7]

In setting up the model, we let $y(t)$ be the hormone level at any time t and the removal rate be $Ky(t)$ .Also we let the input rate of the hormone (secretion rate) be $A + B\cos\omega t$ where $\omega = \frac{\pi}{12}$, while A is the average input rate and B a constant. In order not to have negative input rare, we let $A \geq B$ and in order to have a continuous motion, we make use of $\cos \omega \, t$. Therefore the model which is a first order ODE is of the form:

$$y'(t) = Inpute\ Rate - Output\ Rate\ , \qquad (1)$$

That is

$$y'(t) = A + B \cos \omega \, t - Ky(t) : \qquad y(0) = 0 \qquad (2)$$

Such that the analytical solution is

$$y(t) = e^{-Kt} \int e^{Kt} (A + B \cos \omega t \,) \, dt + Ce^{-kt} \qquad (3)$$

Where C is an arbitrary constant. Further simplifying equation (3) yields

$$y(t) = \frac{A}{K} + \frac{B}{K^2 + \omega^2} (K \cos \omega t + \omega \sin \omega t) + Ce^{-Kt} \qquad (4)$$

Note that the first two parts are referred to as steady state solution while the last part Ce^{-Kt} decays experimentally since K is a positive constant and t is time which is always a positive quantity. The entire solution is called the transient – state solution. Hence the particular (analytical) solution yields upon applying the initial condition $y(0) = 0$ on equation (4) gives

$$y(t) = \frac{A}{K} + \frac{B}{K^2 + \omega^2} (K \cos \omega t + \omega \sin \omega t) + \left(\frac{A}{K} + \frac{B}{K^2 + \omega^2} \right) e^{-kt} \qquad (5)$$

For the proper interpretation of the model and demonstration of the model, we let $A = B = 1$ and varies the value of K which is the removal rate , then the effect of the hormone on human behaviour can be observed given the fact that K is small i.e. the transition period is small.

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The Tables below show the various value of K, (the removal rate) with respect to change in time (t) over a period of 12 hours with an interval of 30 minutes.

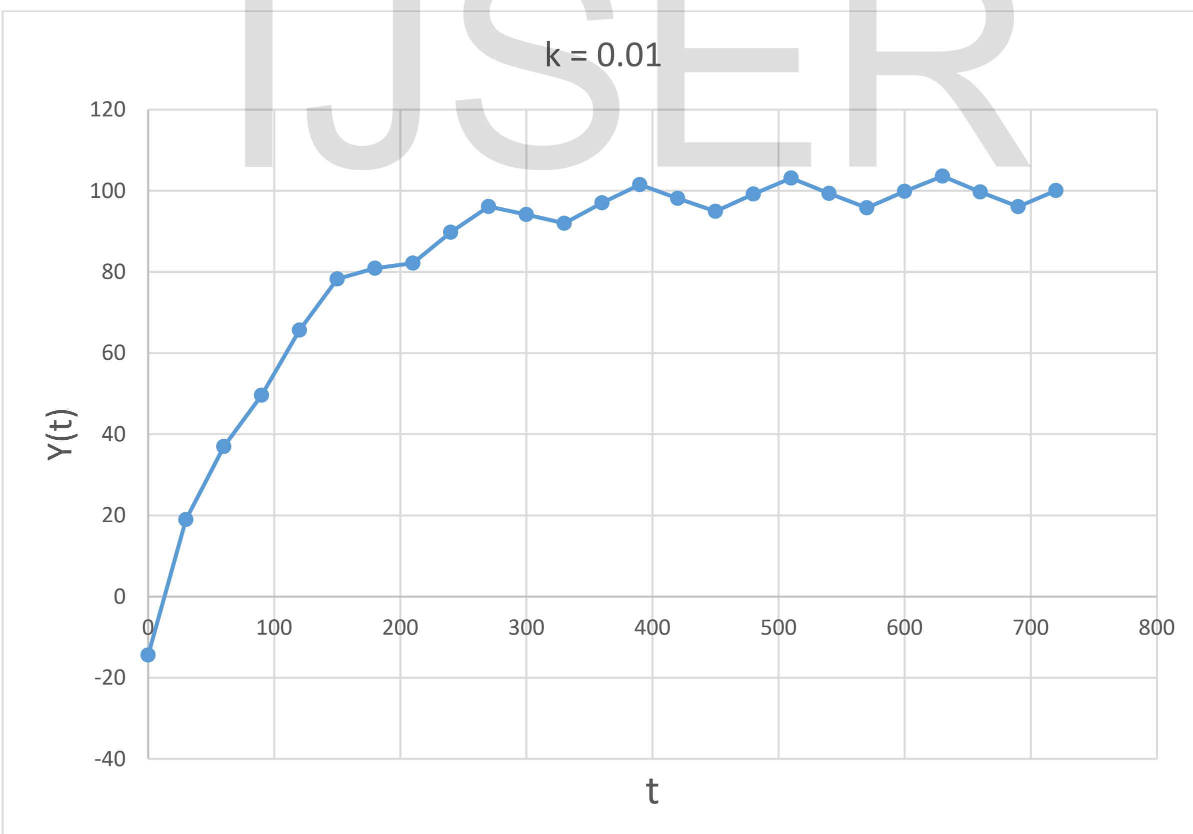
NUMERICAL EXPERIMENT

Tables I below show the removal rate with respect to time.

Table I Shows Removal Rate for values of $K = 0.01, 0.05\ and\ 0.1$

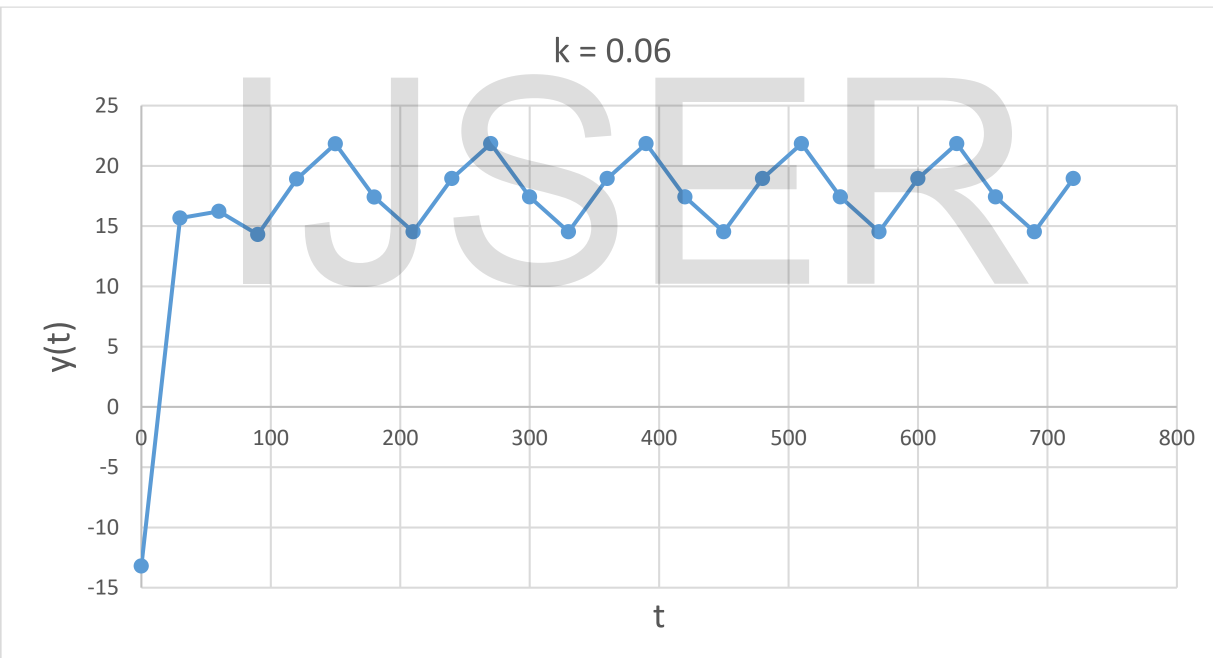
	When K = 0.01	When K = 0.05	When K = 0.1
t	Y(t)	Y(t)	Y(t)
0	-14.4233	-13.205	-11.4593
30	18.9394	15.6646	12.2016
60	36.9775	16.2273	8.6704
90	49.6056	14.2958	6.6638
120	65.6382	18.9066	11.2731
150	78.2504	21.8317	13.3334
180	80.9162	17.4117	8.7267
210	82.1561	14.5232	6.6666
240	89.7522	18.9503	11.2733
270	96.1145	21.8401	13.3334
300	94.1503	17.4133	8.7267
330	91.9602	14.5236	6.6666
360	97.0152	18.9504	11.2733
390	101.4951	21.8401	13.3334
420	98.1363	17.4133	8.7267
450	94.9131	14.5236	6.6666
480	99.2028	18.9504	11.2733
510	103.1157	21.8401	13.3334
540	99.3368	17.4133	8.7267
570	95.8025	14.5236	6.6666
600	99.8617	18.9504	11.2733
630	103.6038	21.8401	13.3334
660	99.6985	17.4133	8.7267
690	96.0704	14.5236	6.6666
720	100.0602	18.9504	11.2733

Graph I


k = 0.01
120
100
80
60
40
20
0
-20
-40
Y(t)
0
100
200
300
400
500
600
700
800
t

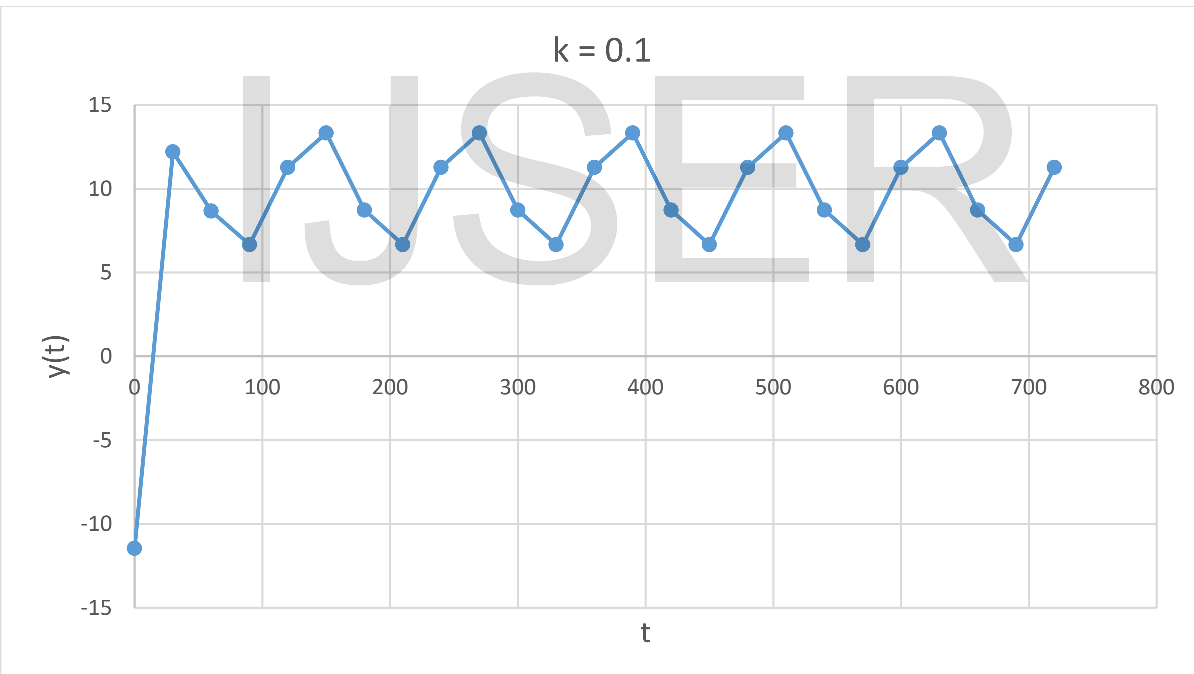
GRAPH OF $y(t)$ AGAINST t WHEN $K = 0.01$

Graph II



GRAPH OF $y(t)$ AGAINST t WHEN $K = 0.06$

Graph III



GRAPH OF $y(t)$ AGAINST t WHEN $K = 0.1$

DISCUSSION OF RESULT

Table I below shows the output with various values of K , that is the removal rate. It is interesting to note that from Table I above, when the removal rate $K(t)$ is very small that is 0.01, the output was very sharp. On plotting the graph, it was shown that the curve moves fast upward. On the other hand, when the removal rate i.e. the level of satisfaction in providing food which is the determining factor of the secretion of the hormone is slightly increased from 0.01 to 0.05, the output gives a very gentle slope, that is the behavior of human being under examination is becoming satisfactory as equally shown in Table I above and as demonstrated in the graph 2. However, when the removal rate is increased to 0.1, the output (level of satisfaction) is equally increased but not as sudden as it was when $K = 0.01\ and\ 0.05$. For further illustration of these, the graph below equally show how significant the removal rate, that is the value of K is.

CONCLUSION:

From the fore going and from the inference drawn from numerical illustrations shown above, it was evident that when a person is hungry and food (substance) is given to satisfy his/ hunger, the behavior of the person will definitely change with respect to time. It was observed that the behavior of an individual with respect to the need in terms of hunger differ with respect to when the fellow is given something to quench his/ her hunger that is food. That is to say that satisfaction of hunger in human beings is directly proportional to the time when the food or substance is given.

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