Rate of Memorization

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Abstract

This project is designed towards corroborating the validity of the mathematical model for describing the rate at which one memorizes on a short term and simple level. This will be done by various means. The equation in question is $\frac{dL}{dt} = k(1 - L)$. This will be analyzed and solved first . Then, testing on human subjects will confirm whether or not the model is useful for determining the rate of human retention on a short term basis.

1 Introduction

Before getting started with the analysis of this model, a brief explanation of the subject at hand is appropriate. Due to the complexity of the human mind and its ability to store memory, the information received from short term studies is limited. Also it should be explained that mostly speculation exists as to the workings of the ability for humans to remember.

One of the explanations for the way in which memory works is a school of thought that has existed for a number of years, it says that memory works on a two level system. One being short-term memory, which allows for precise recall of events for a few seconds or minutes after their occurrence, the other level being long-term memory, which is a bit more complex and will not be delved into in this paper, we will be primarily looking at short term memorization rates. Another explanation and alternative view through experimentation shows that memory storage is a single process of short and long term memory with different ends to the continuum. One more suggestion is the possibility that sort term and long term memory are different but essential for the establishment of long term memory. It is equally possible that short and long term memory are based on two processes, each subject to associational influence. (Shroeder, UC Irvine,1979). There are many more explanations as to the way the human memory works, however the assumption in this paper is that the model describes the rate of memory on a short term and simple level.

1.1 Analysis of The model

K is the parameter,

$L(t) =$ fraction of list learned at time t.
$L(t) = 0 =$ Knowing none of the list.
$L(t) = 1 =$ knowing the entire list.
$(1 - L)$ says that the entire list learned is subtracted by a fraction of the list learned.

The solution the Differential Equation gives a continuous function of the amount of the list learned with respect to time. We are assuming that the rate of learning is proportional to the amount left to be learned.

$$\begin{aligned}
\frac{dL}{dt} &= K(1-L) \\
\frac{1}{1-L}dL &= kdt \\
\int \frac{1}{1-L} &= \int kdt \\
\ln|1-L| &= kt \\
e^{\ln(1-L)} &= e^{kt} \\
1-L &= e^{kt} \\
L &= 1-e^{kt}
\end{aligned}$$

The parameter k is different for different individuals, an example of the solving technique for k is shown below. say for example that after one minute the subject learns 15% of the list. plugging these values into the solved D.E. gives us an approximate value for k.

Plugging this k value into the equation we get $L = 1 - e^{-.16252t}$. The graph for this is shown in figure 1.

1.2 Experimentation

The real data was compiled by testing individuals with a list of formulas and a list of integrals. The list was studied at one minute intervals and the subjects were then required to reconstruct the list from memory. This process was repeated until the list was learned in its entirety. The experiments in this project were interesting. Subjects were chosen that were familiar with the material on the list and some were chosen that had not seen the material at all. The fact that the material on the list were of mathematical nature made the experiments somewhat unique. One list consisted of formulas for moments and centers of mass in three dimensions, the other list consisted of 10 basic integrals.

Interestingly one of the subjects tested, being in calculus, was familiar with the material yet took some time to reconstruct the list in order. Another subject was tested who had never seen material before and actually learned the list quicker than the calculus student. The reason for this side note is that the author of this project felt there should be a parameter for the boost of retention through understanding the material on the list and there may very

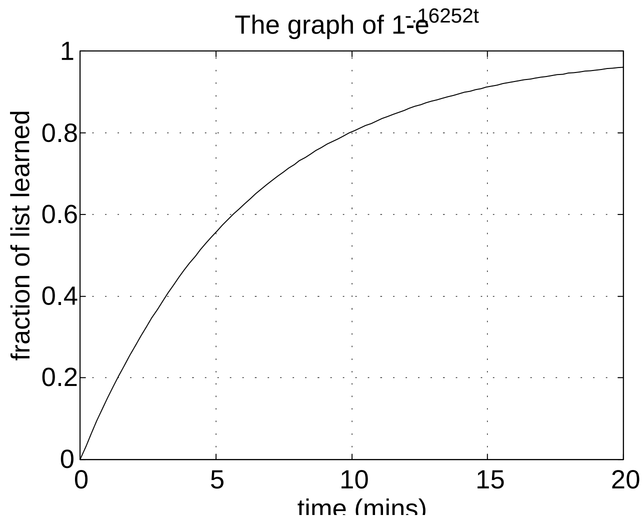

Figure 1: Example of the curve the model makes with a K value.

well be something to that, however, the resulting information still shows a great deal of accuracy in approximating the rate of memory.

Figures 2 and 3 show the rate for subject #1 and the accompanying curves. This subject was not familiar with the information on the list, yet shows an extremely high rate of retention.This subject was quizzed with a list of integrals and a separate list of math formulas (a list of formulas for moments and centers of mass in three dimensions). The curve shows a good approximation of the rate for this persons memory.

The graphs for subject #2 are shown in figures 4 and 5, this subject was familiar with the material and through understanding the material perhaps retained the information a little bit better than someone who has not seen the material before however, the graphs in figures 2 and 3 do not show that this is the case.

1.3 Conclusion

The results of the graphs from the preceding experiment are somewhat skewed. unfortunately the author of this paper has little experience with experimentation. It just so happens the people tested have extremely high retention rates. There is an assumption through the graphs presented here that the human memory works on a high level. Although the model is simple and the human mind is extremely complex, the model works better than one might imagine at first glance. we actually get quality information from this differential equation. The function that describes the real data forms a discontinuous function of time or piecewise function because it takes on discrete values. However, The

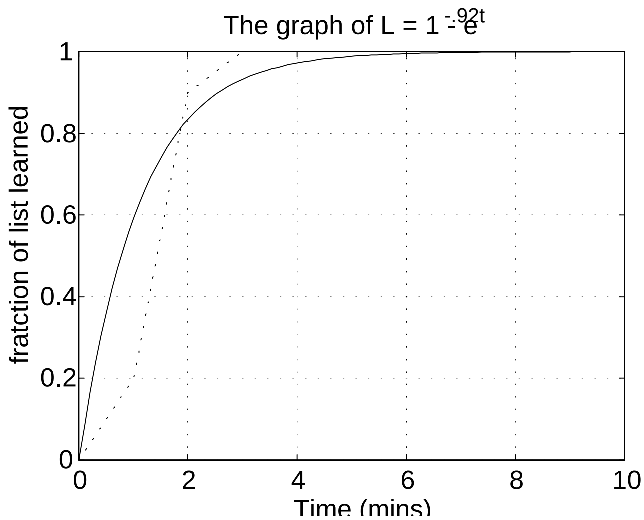

Figure 2: The rate for subject #1 (Integrals).

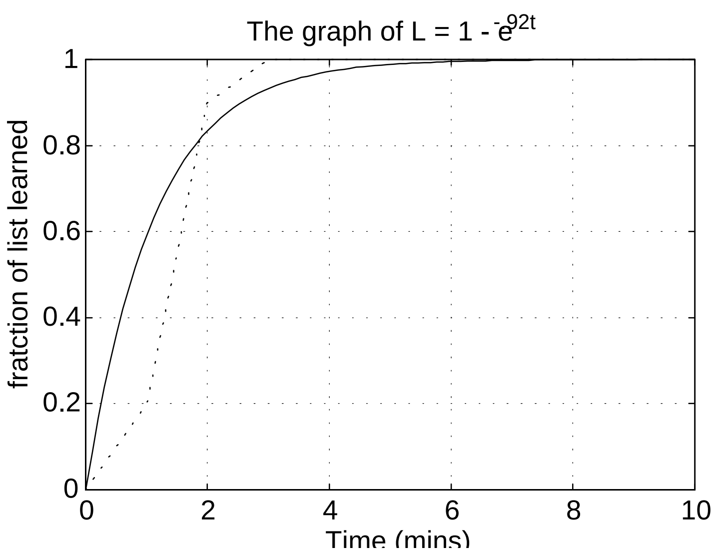

Figure 3: The rate for memorizing a list of integrals.

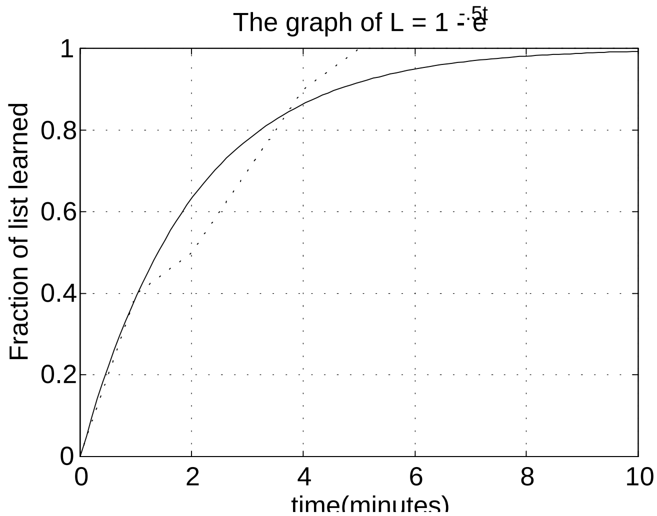

Figure 4: The graph of subject #1 (Formulas).

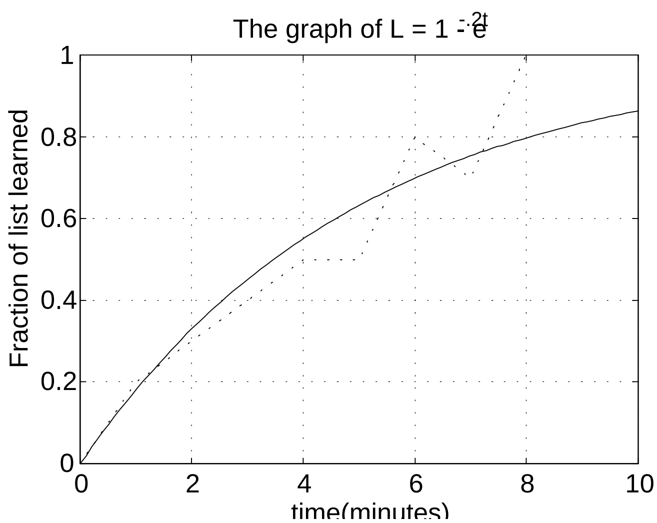

Figure 5: The graph of subject #2 (Integrals).

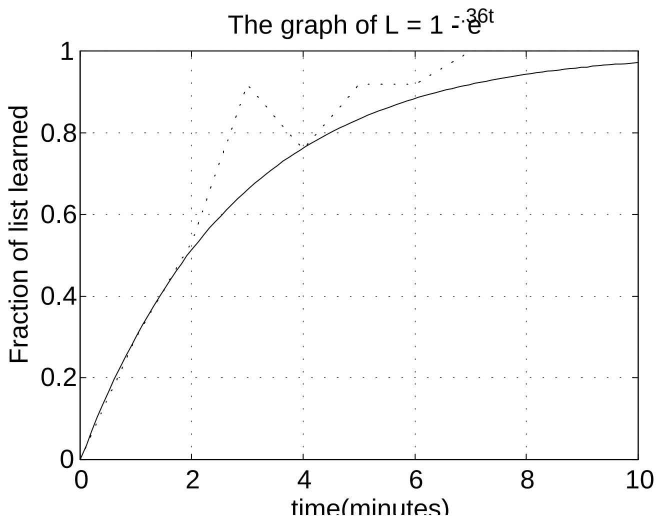

Figure 6: The graph of subject #2 (Formulas).

model can safely be described with a continuous or even differentiable function. $\frac{dL}{dt} = K(1 - L)$ is a good model for describing the rate of remembering on a short term basis. Theoretically, as to the practical application of this model, one could determine how long it would take to learn a long list of formulas or any type of list style learning.