Nicholas Caudill

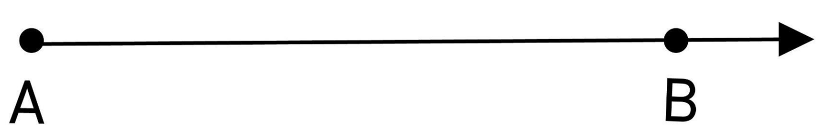
12th December 2021

Professor Andrew Rich
Manchester University

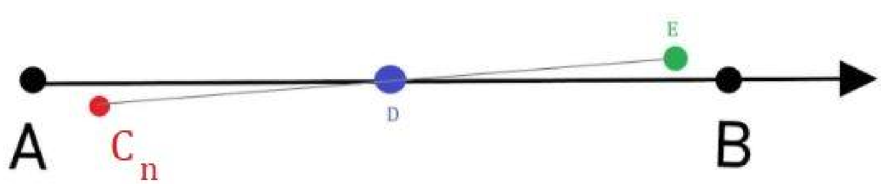
Dear Professor,

This is a paper I am writing in preparation for tomorrow's Calculus 1 final exam. After reading Aristotle's Organon in 4 days and nights, and then translating a few pages to more Modern English that I used in my final paper for the literature course, "Sherlock Holmes & Company," I am now curious if I can use the calculus objectives I have learned this semester to come to new conclusions about real data I have collected. The end goal is to read Aristotle's Organon several times before next semester begins and this paper may be a useful experiment for rapidly improving my reading speed & comprehension. We will focus on what we can actually measure well, which is lines per minute and not comprehension.

Let's say a good student wants to achieve a transcendental knowledge of reading. I like the Webster definition of transcendental: "being, involving, or representing a function (such as sin x, log x, e^x) that cannot be expressed by a finite number of algebraic operations." One might start by collecting data, analyzing that data, and then questioning or making conclusions for what data is useful for or could mean. Say I have a horizontal line $\overline{AB}$such that this represents a single line of a paragraph I am reading.

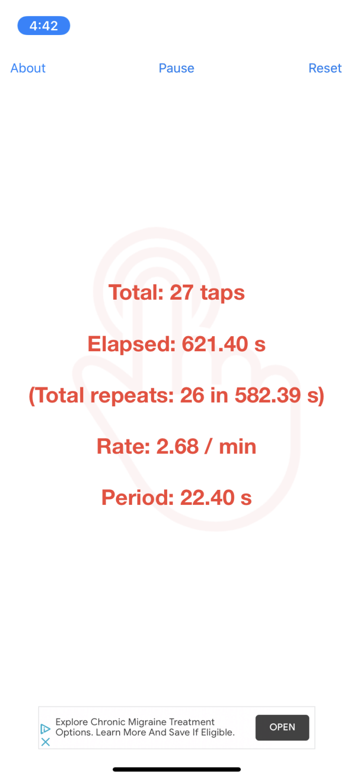


Let's also say that I read by fixating the eyes very briefly at Points C, D, and E and then subvocalizing each word at an inconsistent velocity (sometimes I may want to pause during my visual path and ponder upon an idea).



This method described above was abandoned later on when I tried to speed up my reading by several orders of magnitude because going up the page felt like a time waste and imagining gravity, Brachistochrone curves, or hypocycloids in general helped me move quicker through the page in the following trials.

To collect the data I will be afterwards applying the 20 Calculus Objectives to, I will be using the IPhone Mobile Application “Tap Tool.” With minimal effort, I can tap my phone everytime I return to Point C. Ideally, I will read for three uninterrupted sessions of length 20-minutes, 40-minutes, and 60-minutes to get a good variety of data. I also have auto-lock disabled for convenience. The actual interface of this Application “Tap Tool” looks like this:



α = **3 sessions of reading Aristotle’s Organon with 20-minute sessions**

For trial ¼ , I set a timer for 20 minutes on my mobile device, then read my book during this time and tapped each time I returned to Point C. In the line drawn above. After all the sessions

Note: The first paragraph is $\frac{\text{amount of words in each line of a paragraph}}{\text{total amount of lines}}$ or

$\frac{7+8+6+11.5+8.5+8+8.5+8+8+10}{10}$ = average of 8.35 words per line.

Let us assume that I want to read better exponentially over time like e^x, how do I make the data from my trials look functionally identical to e^x ?

Let's say ideally my reading speed ω $over\ some\ amount\ of\ trials\ \alpha_n \Rightarrow e^x$, or "should appear functionally equivalent to the function e^x.If ωdeviates from e^x,then a good reader may see it wise to make an effort to read faster so the numbers match.

For example, in hypothetical trials $a_1$and α_2, say we recorded a reading speed $\omega_n$as 80 lines per minute and 120 lines per minute respectively. The ideal reader should have recorded 80 words per minute which would be similar to the expression $2.71828182845905 = e^1$. To go on, $7.38905609893065 = e^2$.

Also, $\frac{e^2}{e^1}$ =2.71828182845905. Therefore the reader that improve his reading speed ω at a rate similar to e^x should have read maybe 20 lines per minute in the first trial, then 10 lines per minute in the second trial, giving an average ωvalue of $\frac{20+10}{2} = 15$lines per minute. Then by trial 3 he should have read at an ω value equal to $\omega^2 = 15 \cdot 15 \Rightarrow 225\ lines\ per\ minute$.So someone who reads and their reading speed improves after each session at a rate of

$$\frac{\int_1^\infty \omega^{\alpha_n} dt}{\infty - 1} = \omega_{\alpha_n} \frac{lines}{minute}$$

$where\ \omega\ is\ the\ number\ of\ lines\ read\ per\ minute\ recorded\ from\ trials\ \alpha_n\ where\ \alpha_n\ is\ an\ integer\ and\ C\ is\ some\ const$

This constant C would be someone's lifetime average reading speed. Let us actually try to mimic this in experiments to appreciate the actual growth rate and maybe how disappointing or its converse is for the ability Homo sapiens have at improving the rate at which they can digest data (bandwidth). Bandwidth is measured as the amount of data that can be transferred from one point to another within a network in a specific amount of time. Here, a book made for a human to read and the human itself form a network and the book can be some point and the human another. Typically, bandwidth is expressed as a bitrate and measured in bits per second (bps) (https://www.paessler.com/it-explained/bandwidth).

$$Say\ \omega_{\alpha_1} = reading\ speed\ (lines\ per\ minute)\ for\ Trial\ 1$$

Trial $\alpha_1$returned the results:

> 926 lines in 20 minutes for a reading speed $\omega = 46.17\ lines\ per\ minute.$ The e^xvalue that could come close could be $e^{3.83} = 46.06$.I set the timer for 20 minutes and 10 seconds then began reading and tapping my Iphone after 10 seconds counting down in my head.

We could then say

$$\omega_{\alpha_1} \approx e^{3.83}$$

One bias I noticed was that I hypothesized I would read where I would stop and ponder some ideas but due to being aware that I was collecting data for this experiment, this awareness made me want to tap at a more consistent rate and travel through the lines on the page of my book at a constant velocity with no acceleration, though I did notice some increase and decrease acceleration at times, maybe there is a rising crescendo roughly between t = 0 and t-5min10sec or a descending crescendo at t= 15min10sec and t = 20min10sec.

A third party would be useful for tracking this because I could see fatigue as being a factor and I could see a ∩shaped parabola for reading speed over the trial. I am not sure if the ideal reader should work on reading speed while reading or rather proactively after one has observed the data after each session. It would make more sense to try to read at a constant velocity and without stopping the motion of the eyes to ponder an idea. For example, you could ponder an idea while moving one's eyes at a continuous velocity and read blindly during that time and maybe still have better comprehension than one who stops moving the eyes altogether to ponder an idea.

For trial α_2, I will try to read double my reading speed v(t) from α_1. I hope to see what it feels like to be a reader who reads exponentially faster after each session but tries to read in each moment of the session at a constant velocity. Some errors in data can be distractions like a cat jumping on the bed, wanting a quick drink of water, or regressions during the reading itself like losing one's place (which a good reader should constantly be trying to minimize). During these trials I do use the bathroom before they start and I used 45 Watt, 6500K Fluorescent CFL Daylight Balanced Light Bulb for Photography Photo Video Studio Lighting to improve the reliability of this experiment just in case eye strain or inconsistent lighting can affect reading speed or comprehension.

Trial α_2 returned the results:

1504 lines in 20 minutes for a reading speed $\omega = 75.05$ *lines per minute.*

The variation of acceleration in this trial was great in the beginning because I realized I had to accelerate to a consistent velocity that was of a greater order of magnitude than my speed in the first trial. My speed was way off the desired 46.17^2= 2,131.67 *lines per minute.* I was able to accelerate up to a velocity that was 47% faster than the previous trial but I needed to accelerate to a velocity 191% faster in the next trial to return to a consistent exponential growth rate.

Like before, we could say

$$\omega_{\alpha_2} \approx e^{4.32}$$

The ideal reader that readers exponentially faster after each 20-minute reading session would, in Trial α_3, would be reading 4,544,012 lines/min, given his first trial was 46.17 lines/min. We now need to accelerate our reading speed from $\alpha_2$almost 200% to average. In α_2 ,I tried getting to Point C as fast as possible by using a Brachistochrone curve because by definition straight lines can not be exponential as exponential is a property of curved figures and not linear ones. So if I am to get close to 4.5million lines/minute then it would make sense to try a different method of reading lines with possibly Brachistochrone curves.

Trial $\alpha_3$returned the results:

4,615 lines in 20 minutes for a reading speed $\omega = 230.26\ lines\ per\ minute.$

Like before, we could say

$$\omega_{\alpha_3} \approx e^{5.44}$$

The % error of this data seems larger than the previous two trials. It really felt like I was just tapping as fast as I could and skipping through the columns of paragraphs. I am kind of split between subvocalizing the text and not, so maybe a combination of both is best.

With all our data, our three trials $\alpha_1,\ \alpha_3,\ \alpha_3$,we can take the average of these trials which would be

$$\frac{e^{3.83}+e^{4.32}+e^{5.44}}{3} \approx 117.23\ \text{lines/minute}$$

For context, one page of my copy of Aristotle's Organon consists of differing translations for each of the 6 subjects covered and each page is about 90 lines. Reading about a page and a quarter per minute seems like a good average speed. Meaning it is possible to read this whole work in 3.16 hours with effort.

$$\frac{\frac{248\ pages \times 90\ lines/page}{117.23\ lines/min}}{60\ minutes/hour} \approx 3.17\ \text{hours}$$

If we look at our growth graphically such as Points $\alpha_1(1, e^{3.83})$, $\alpha_2(2, ,e^{4.32})$, and

$\alpha_3(3\ ,e^{5.44})$, we could predict trial α_4 *to be at point*

$$(4, e^{\frac{3.83+4.32+5.44+(x+0.467)}{4}})$$

where 4.67 = average growth rate change

When trying to solve for x, it looks like we can factor out constants and then divide both sides by that constant.

In [2]:
```python
from sympy import *; x = symbols("x")
e1 = Eq(E**((x+3.83+4.32+5.44+0.467)/4) ,4)
e1
```
Out[2]: $33.5907254300964e^{\frac{x}{4}} = 4$

$$e^{\frac{x}{4}} = 0.11908048869989887$$

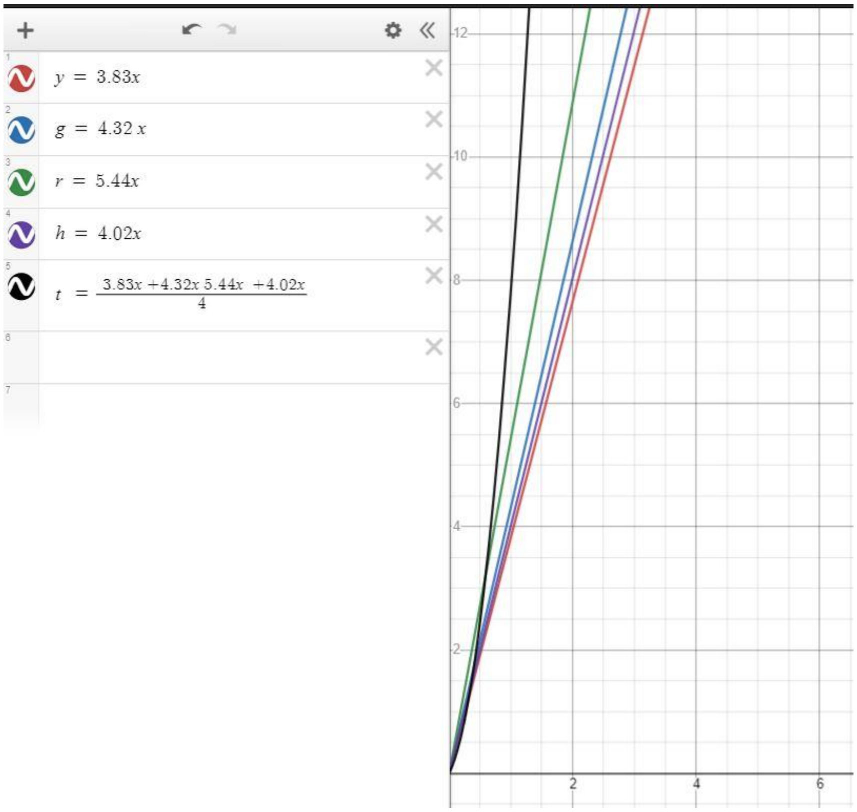
This works out to x = -8.5 , which I am having trouble making sense of.

Trial α_4 returned the results:

$\omega = e^{4.02}$ lines per minute.

$\dfrac{e^{3.83}+e^{4.32}+e^{5.44}+e^{4.02}}{4}$ = 101.85 average lines per minute of all trials thus far.

Does the change in x-value of $e^{f(x)}$ follow any simple algebraic expressions? The fourth trial I read is quite normal, like the first trial. It felt that during the 4th trial, it felt that, by moving through the lines and tapping my phone at a consistent rate, my reading comprehension *felt more clear*. There are many factors that make this method of reading particularly interesting and approaching to be simply fun. These factors might be using both my hands to perform tasks such as the right hand collecting data or the left hand pointer or middle finger pointing to each Point A_n *with varying elbow arc* θ. The 20-minute timer helps tremendously well with focus, letting you really drift off into the mind until you are snapped out of the trance of ideas with a subtle alarm. The fourth trial I only did single taps like the first as well. So far, given all the data, a pattern I see for x-values of $e^{f(x)}$ might be something like $e^{f = x^2}$ because if you graphed all the x values it would look like this with an average change of line t in the figure below.



The expression for line t in desmos can be simplified to

$$t(x) = 4.4025x$$

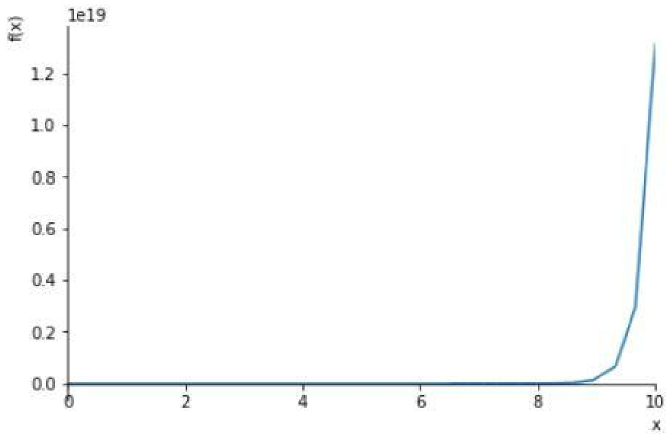
Therefore, we could make the guess that our current growth rate for reading speed is $e^{t(x) = 4.4025x}$

With more data manipulation and plotting, we see that there should be some breakthrough between trials 8 and 10 based on the data below.

In [1]:
```python
from sympy import *
t,x  = symbols('t x')
t = lambda x: (3.83*x +4.32*x +5.44*x +4.02*x)/4
t(x)
```

Out[1]: $4.4025x$

In [23]:
```python
plot(E**(4.4025*x),xlim = (0,10))
```



Out[23]: <sympy.plotting.plot.Plot at 0x1cc48044130>

In [19]:
```python
Eq(Derivative(E**(4.4025*x)),diff(E**(4.4025*x)))
```

Out[19]: $\frac{d}{dx}e^{4.4025x} = 4.4025e^{4.4025x}$

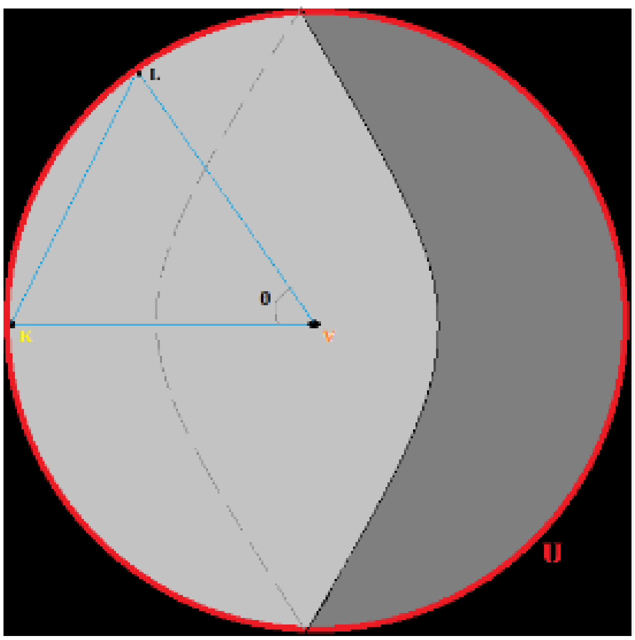
I am not sure how many trials I will do, but doing 6 more would definitely be interesting. At this point in the experiment, I doubt any human could read faster each session at an exponential rate due to the limit of bandwidth for the eyes, which, if i can recall, correctly, was something like 3Ghz is the actual quantity? Besides that, it is fun to look for patterns and to decipher x as if my learning was an exponential $e^{t(x)}$ curve.

I now wonder, is there a method of exhaustion, like what Archemedes used to explain the area of a circle by using varying equal-sided polygons? Wikipedia's 'Area of a circle' phrasing is quite clear as well, "Archimedes viewing the circle as the limit of a sequence of regular polygons." Except, in my case, I assume there exists a continuous function s(t) that when, with some real algebraic function, also includes the function e^{x}but I am not sure how it could be expressed mostly clearly using symbols. Maybe the expression$\lambda = s(t)e^{x}$ where λis my ideal growth rate like a 'wavelength; a rate; linear density' would work.

What if we rephrase the problem, and change 'lines per minute' to 'waves per minute' and say moving from Point C_n to Point C_{n+1}, as discussed in the beginning of this letter, is some sinusoid, that, its affection from gravity may not have the same influence as say, an apple falling from the sky.

How does gravity affect my reading speed really? This force G is coming down at a constant velocity on my person and visual system which includes the eyes and its pupils and retinas. In Trial 3, in particular, I tried moving from Point C_n to Point C_{n+1} in a $\frac{+}{-}$ Brachistochrone pattern of motion, but the problem formulating around the Brachistochrone problem may not be an applicable solution to the best way to move my eyes through the paragraphs of a book because gravity and the motion of things is different in these cases.

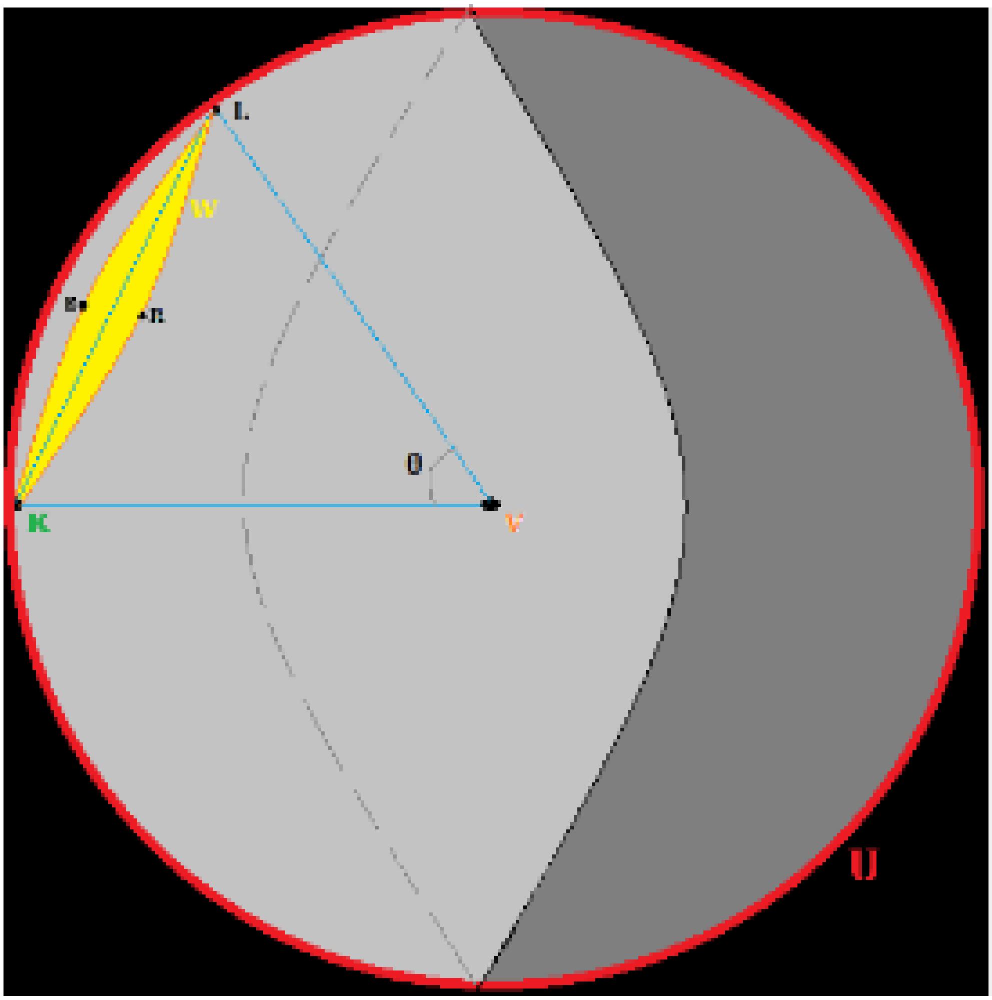
There is some muscle that moves both my eyes together in parallel motion to (x,y) coordinates on a curved surface. Space seems to be, from my perspective, a sphere whose inner surface is the world I see, where some point that seems to be between and behind my eyes, is at the center of this sphere. I have illustrated this in the figure below.



T

Where I would look at the paragraphs of a book through the thin cylinder of light $\overline{VK}$ which is fixed at some Point L which is the limit of how far I can look up. Not illustrated is the limit of looking down at some Point Q. My line of sight line $\overline{VK}$ can look up and down at arc θ.

There is another arc, θ_2 , which is also not illustrated, moves the eyes from left to right which are also fixed at some Points E and R for the left limit and right limit respectively. This means my entire vision forms a cone where my vision is a 2-dimensional representation of my 3-dimensional world. The surface area of the inside base of this cone is what the I see everyday and is what the muscles of my eyes move to see the lines on a paragraph.



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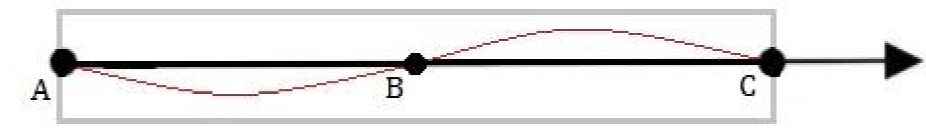
So assuming that the world around me is a 3-dimensional space which is an evolutionary useful hallucination created by my brain at point **V**, I see the world as a 2-dimensional plane W which is composed of two ellipses (maybe of positive and negative Brachistochrone curves) which are drawn from Line **LK**.

The polygon **W** ,formed from Points **LRKE ,**is this thing I move with the muscles in my eye. So maybe we could rephrase the original problem of maximizing reading speed to "What cycloid function, which resets at the start of a paragraph, could my eyes mimic that allows me to read quickly with minimal loss in comprehension." http://jwilson.coe.uga.edu/EMAT6680Fa05/Kennedy/Assignments/10/10-Cycloid0.html has a useful animation on the motion I am thinking of.

This figure below describes a new method I could try in later trials that seems to be mathematically and geometrically the best. I chose to begin with a negative cycloid from Point A to B because Brachistochrone curves move really fast with gravity, so I was thinking that I could use the imagination of gravity to briefly aid moving above the line of a paragraph between Points B & C.



Sincerely,

Nicholas Caudill