Exploring the Effects of Time Dilation on Formula 1 Drivers

Aging (or Not) at High Speeds

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March 29, 2023

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Time Dilation?

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The lengthening of the time interval between two events for an observer in an inertial frame that is moving with respect to the rest frame.

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- Only noticeable in very fast things
- Always observed, though

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How much more time has passed for the audience over the course of a season than for the drivers, thanks to the effects of time dilation?

How?

I'll use Formula 1 lap times from the 2020, 2021, and 2022 seasons to approximate the time delta.

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Data Overview

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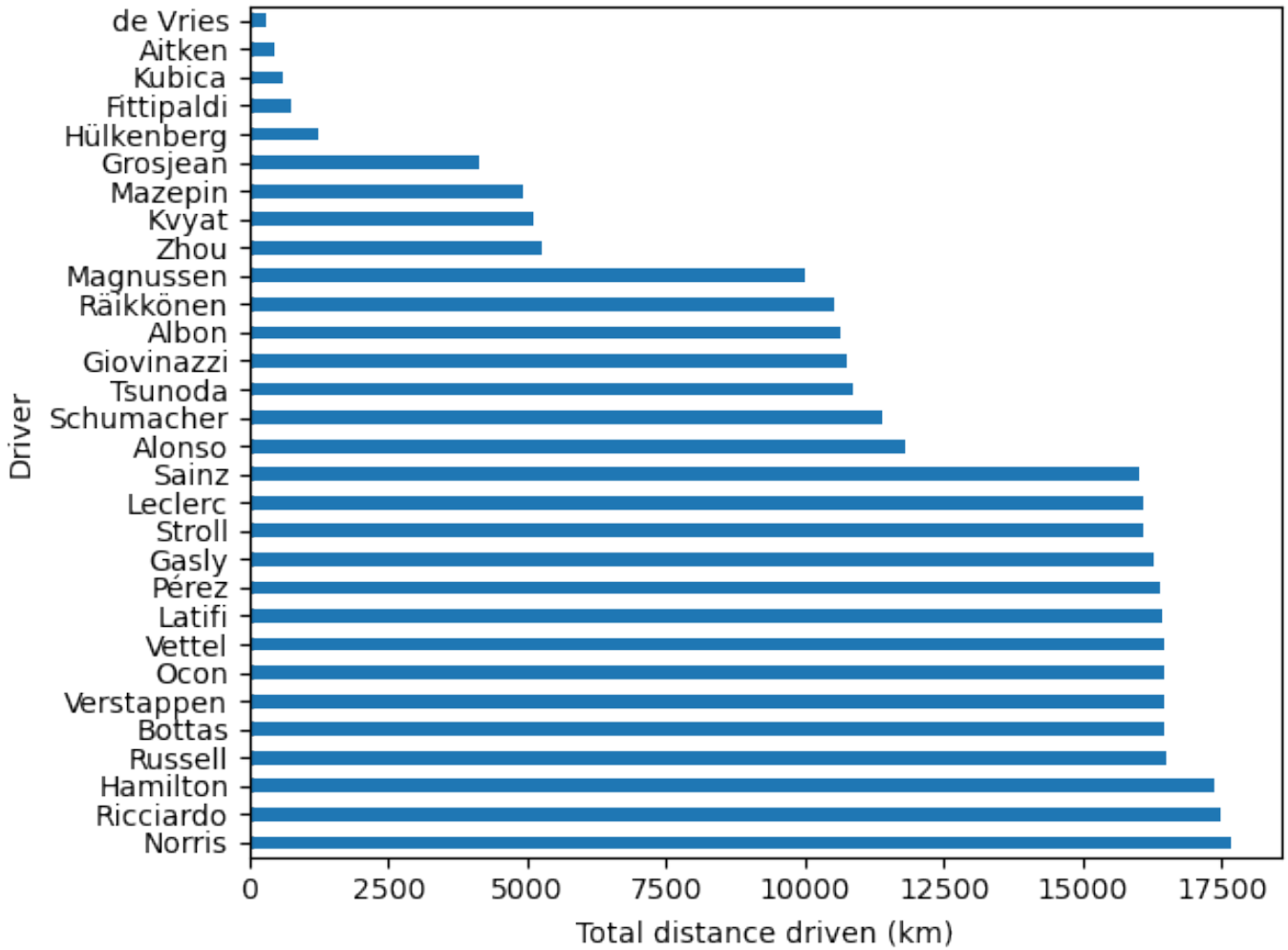
Warning

This approximation is the best it gets, but it isn't perfect.

- This estimated velocity is not really constant, relative to the spectators.
- The drivers follow the track's curves, accelerating and decelerating around.

Meet the Drivers



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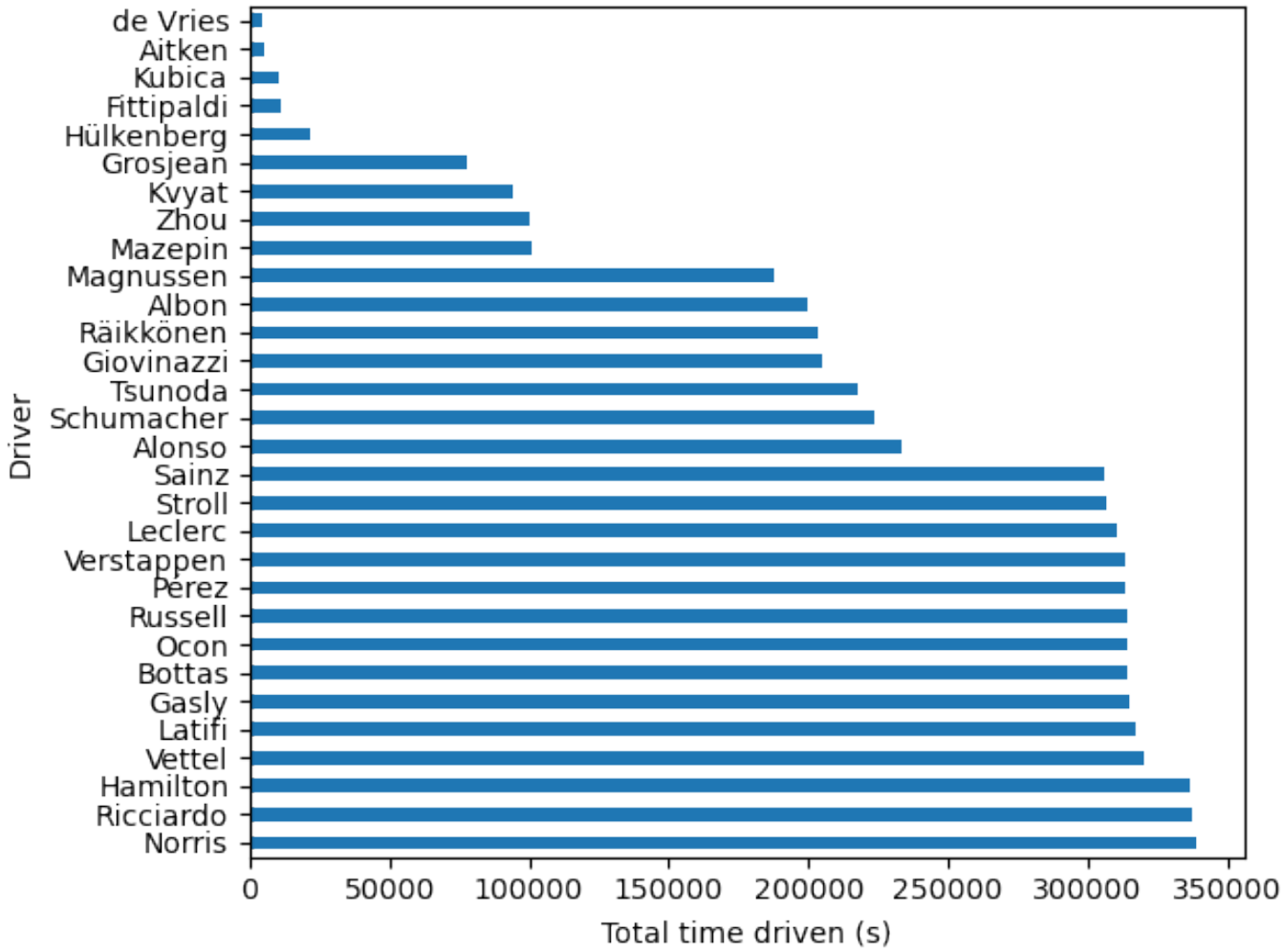

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Since I want the difference in the two intervals, my final result looks like:

$$\Delta T = T - T_0$$

$$\Delta T = T - \left(\sqrt{1 - \frac{v^2}{c^2}}\right) T$$

$$\Delta T = \left(1 - \sqrt{1 - \frac{v^2}{c^2}}\right) T$$

Finding a Delta

```
c = 299792458 # in m/s

def time_finder(df):
    total_length = mp.fsum(df['length']) # in m
    total_seconds = mp.fdiv(mp.fsum(df['milliseconds']), 1000) # in s
    avg_speed = mp.fdiv(total_length, total_seconds) # in m/s

    time_factor = mp.fsub(1, mp.sqrt(mp.fsub(1, mp.power(mp.fdiv(avg_speed, c), 2))))

    return mp.fmul(total_seconds, time_factor)
```

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Important consideration

With numbers this small, I need to use more precision in my math. I used the mpmath library to accomplish this.

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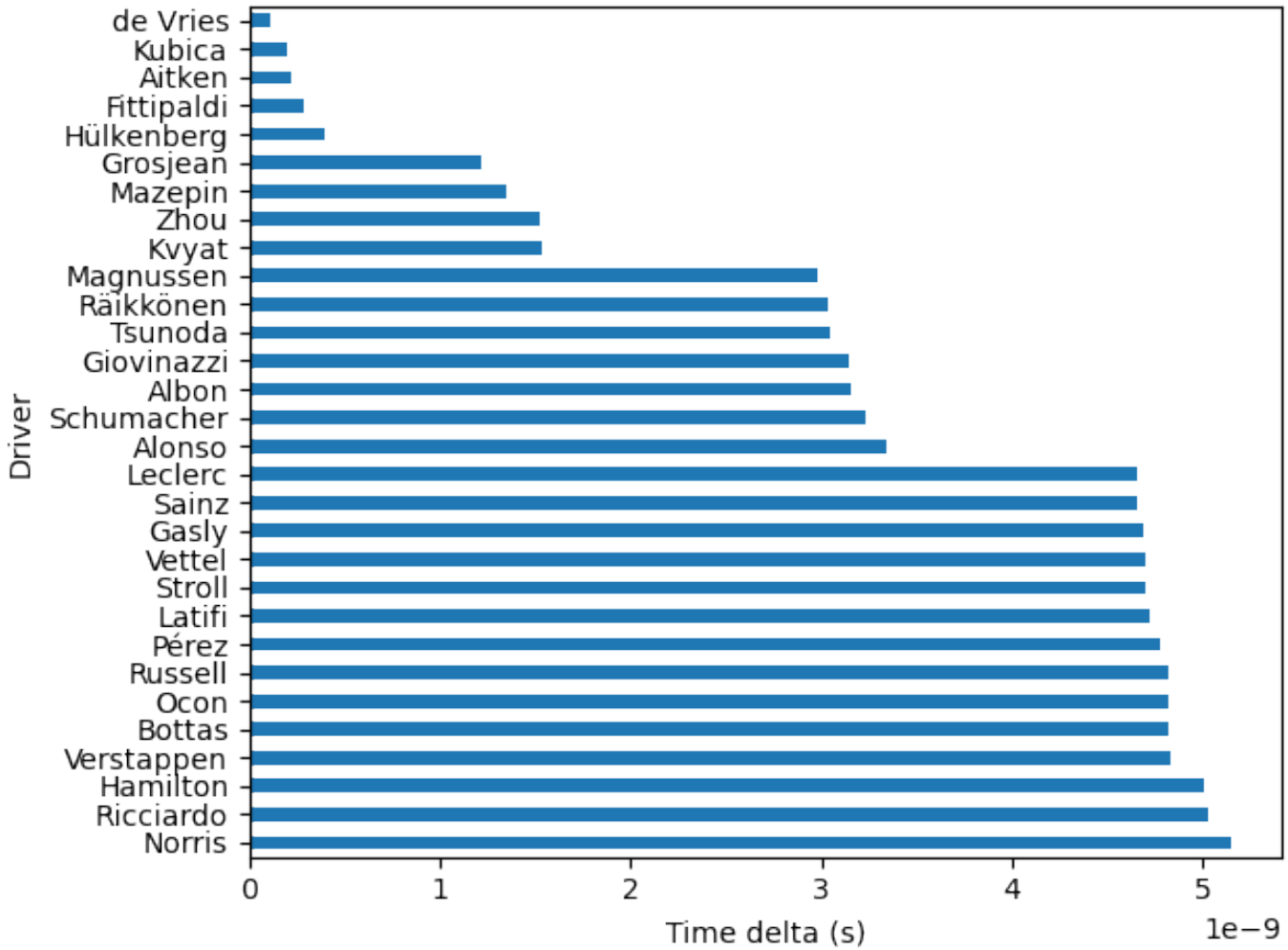
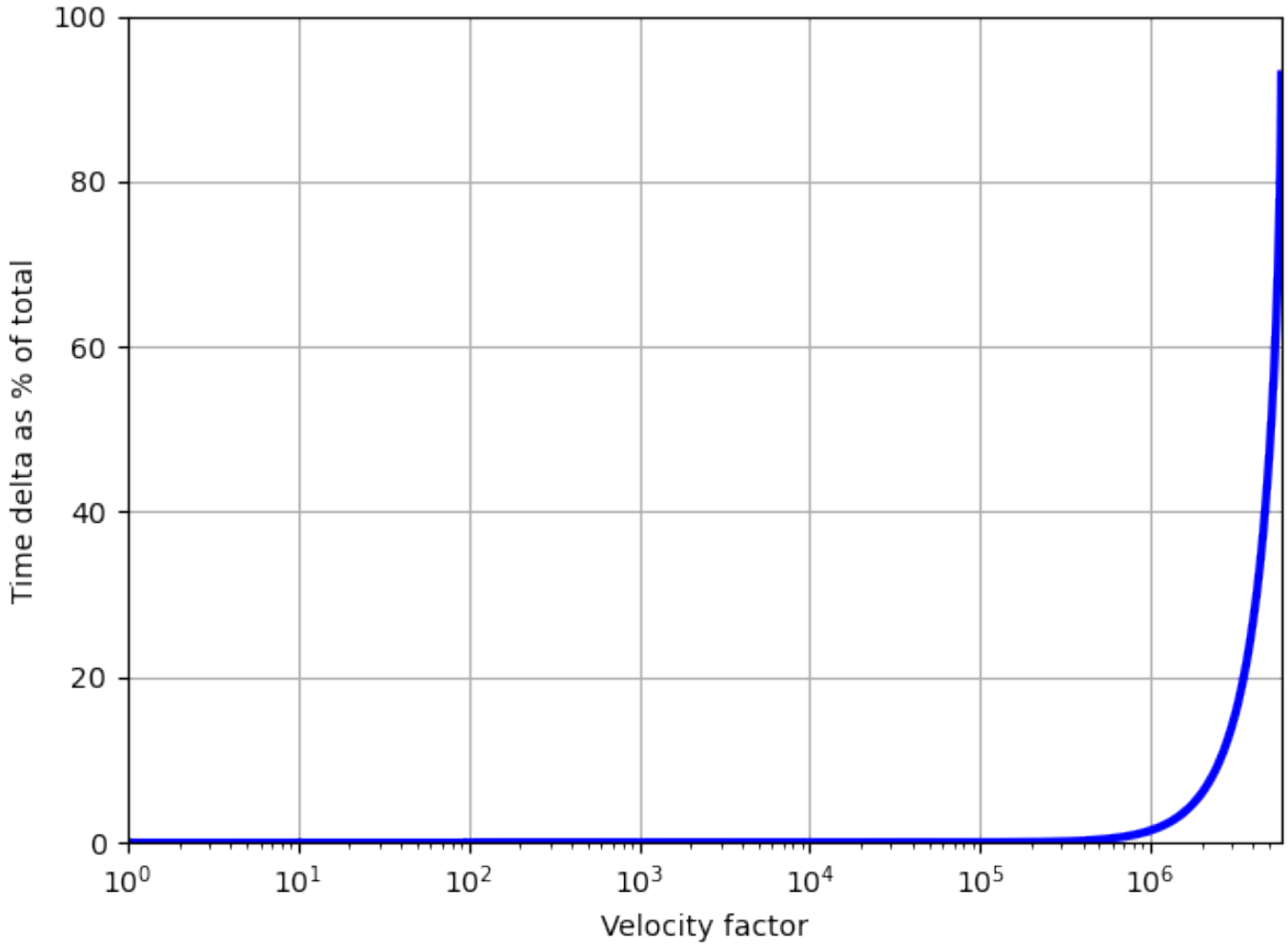
Results

Season	Time Delta (10^{-8} s)
2020	2.92
2021	3.34
2022	3.36

Results


de Vries
Kubica
Aitken
Fittipaldi
Hülkenberg
Grosjean
Mazepin
Zhou
Kvyat
Magnussen
Räikkönen
Tsunoda
Giovinazzi
Albon
Schumacher
Alonso
Leclerc
Sainz
Gasly
Vettel
Stroll
Latifi
Pérez
Russell
Ocon
Bottas
Verstappen
Hamilton
Ricciardo
Norris
Driver
0
1
2
3
4
5
Time delta (s)
1e−9

Results


100
80
60
40
20
0
Time delta as % of total
10^0
10^1
10^2
10^3
10^4
10^5
10^6
Velocity factor

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- Different answers could be reached with different assumptions
  - Aren't the spectators moving through space?
- Questions!

Sources

- *Ergast developer api*.
- *Length contraction*.
- *Welcome to mpmath's documentation!*
- *List of formula one circuits*, Mar 2023.
- Libretexts, *5.4: Time dilation*, Sep 2022.