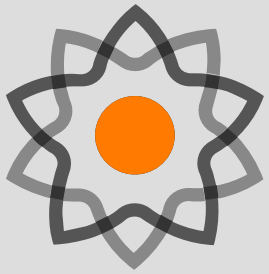
Math Hacks for Life



North Carolina
School of Science
and Mathematics

SMATH HACKS 2026

> THINK. HACK. INNOVATE.

3/14 – 3/15

Andrew Wheeler, PhD
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CRIME De-Coder

My background

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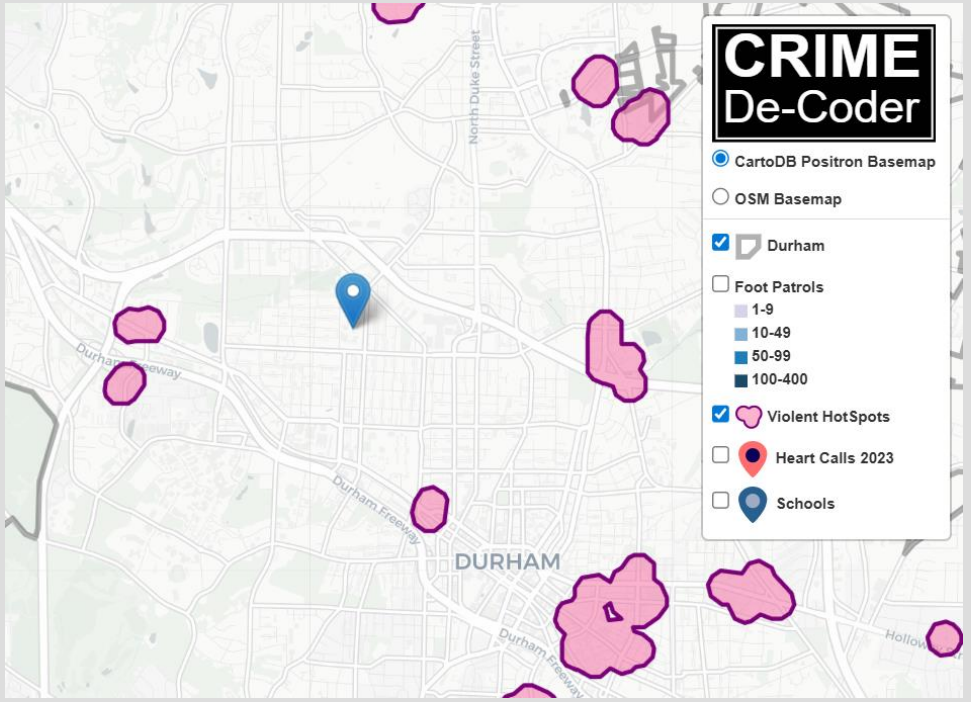
Degrees/Jobs past decade

- All degrees in Criminal Justice
  - Undergrad Bloomsburg (2008), PhD SUNY Albany (2015)
  - Work focuses on operations research with police
- Professor of Criminology, UT Dallas (2016-2019)
- Data Scientist in Healthcare (2019-Current)



Books I have written

- Data Science for Crime Analysis with Python
- Large Language Models for Mortals: A Practical Guide for Analysts with Python

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Math can be practical

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Not just for work, but also how you live your life

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Constraints always lower your objective function

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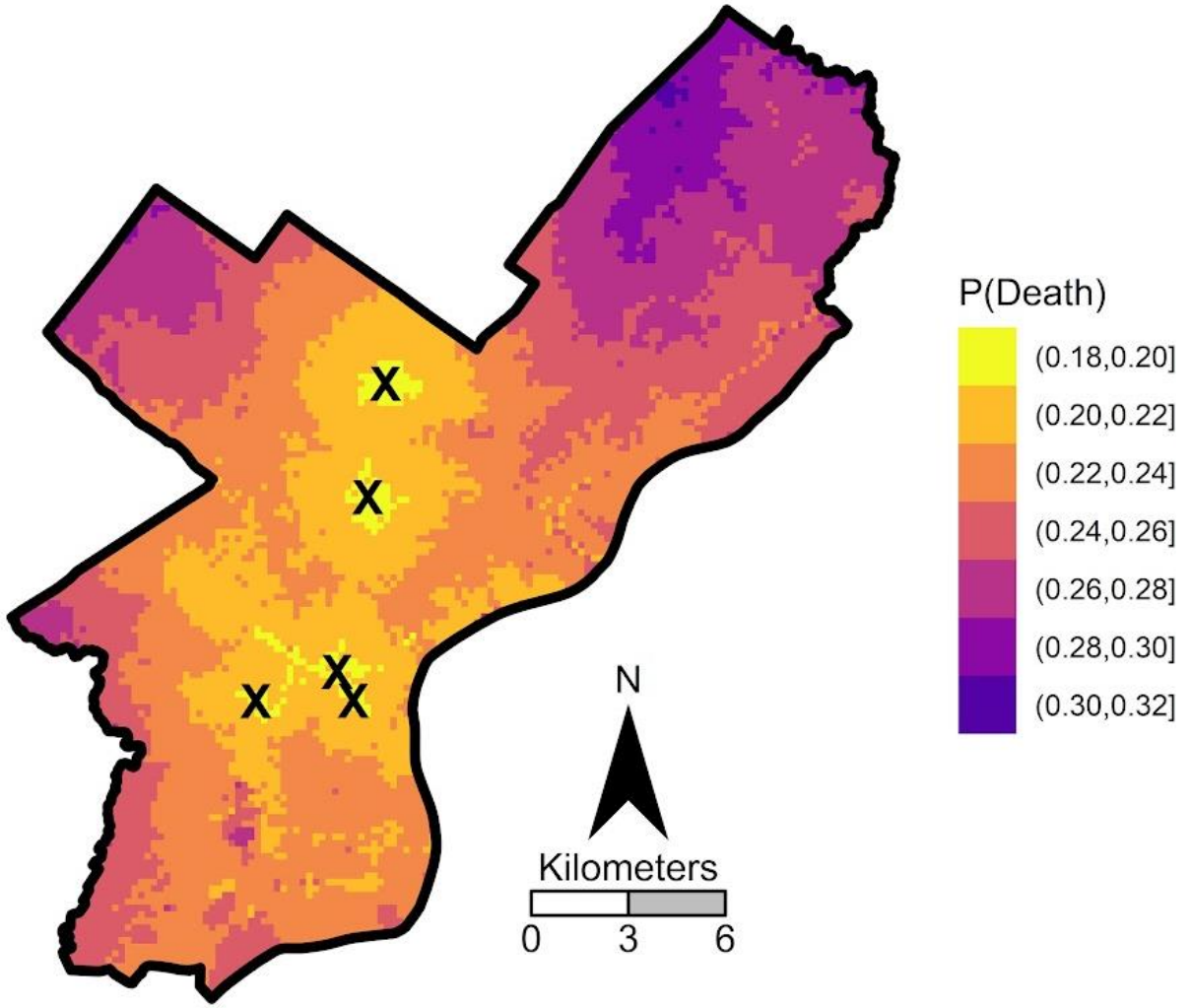
The Math

- **Unconstrained:** $\max f(x)$
- **Constrained:**
  $\max_c f(x)$, subject to $g(x) \leq c$

The Lesson

$$\max f(x) \geq \max_c f(x)$$



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Question the constraints!

- False dichotomy
- We have always done it this way

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Constraints always lower your objective function

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Question the constraints!

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EMT Response

- Scoop and Run
- Mobile EMT units
- Optimal location of blood banks

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Life is rarely optimal

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In theory, utility equation is

$$U^* = \arg\max f(x), \text{where } x \in \mathbb{R}$$

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Life is rarely optimal

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In theory, utility equation is

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Voltaire - *Il meglio è l'inimico del bene*

Don't let the perfect be the enemy of the good

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Life is rarely optimal

CRIME De-Coder

In theory, utility equation is

$$U^* = \arg\max f(x), \text{where } x \in \mathbb{R}$$

In reality, you can only evaluate a subset

- **Cannot evaluate all of $\mathbb{R}$!**
- **That is ok, can evaluate some and make decisions (rule of thumb evaluate 3)**

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Parallel vs Sequential

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Parallel vs Sequential

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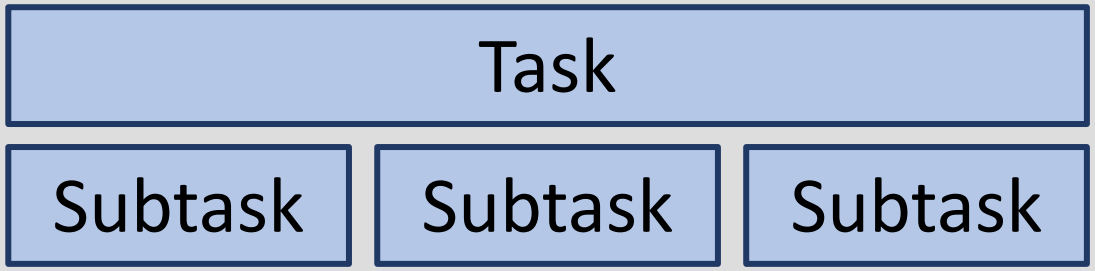
Sequential



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Parallel vs Sequential

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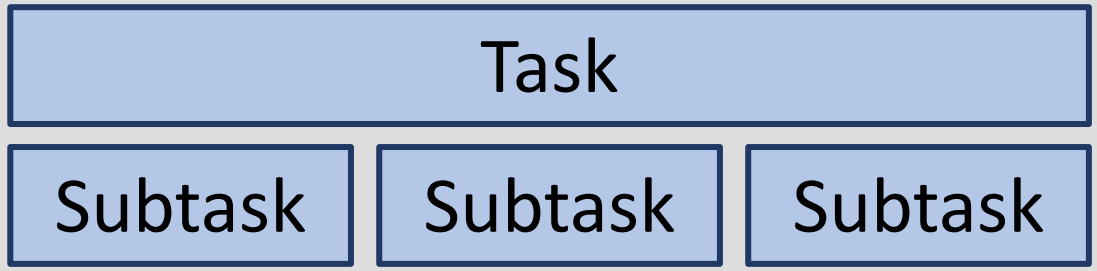
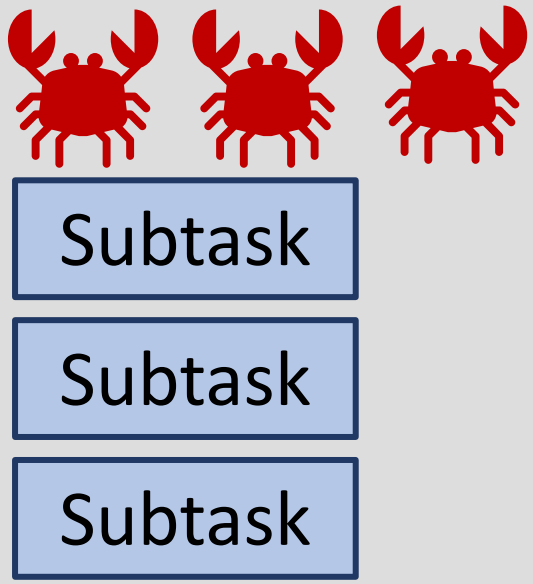
Sequential



Parallel



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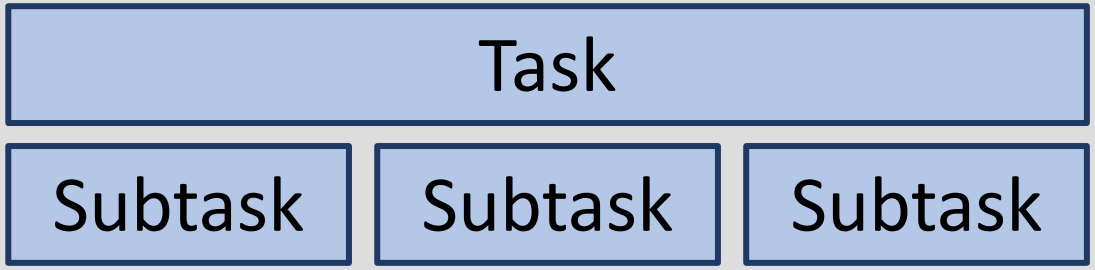

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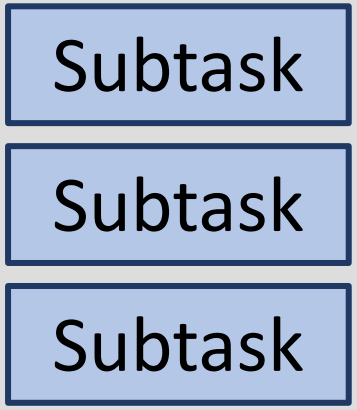
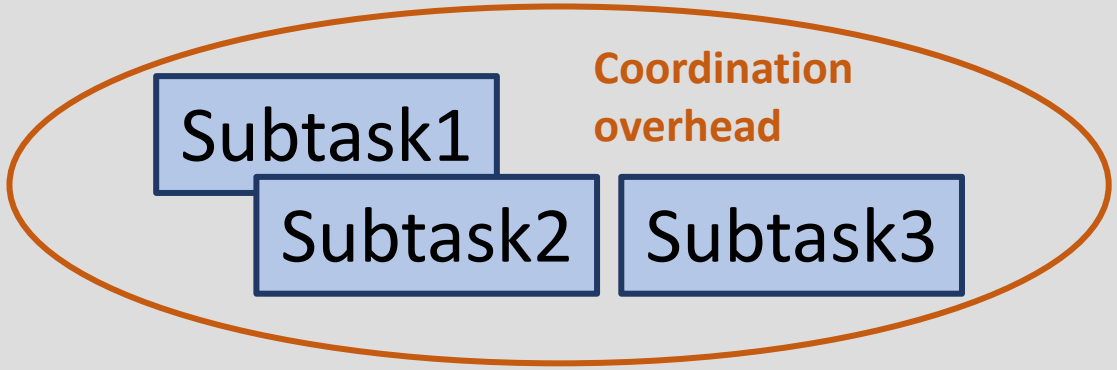


Reality



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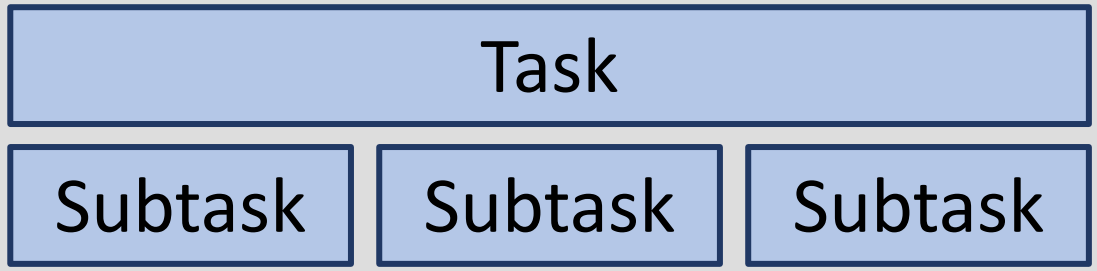
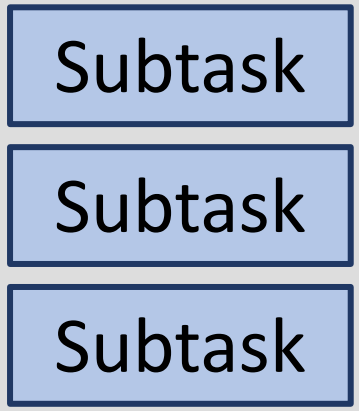


Life lesson: Two heads are better than one (sometimes!)

Parallel



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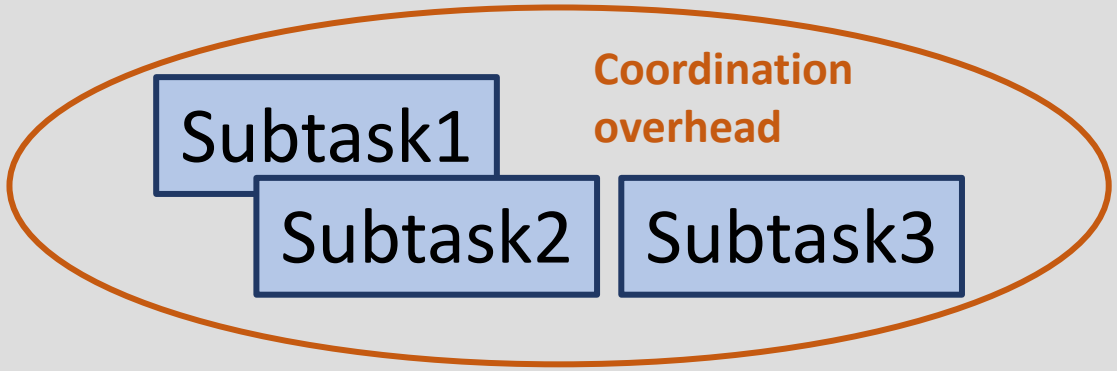

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Linearity of Expectations

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$$\mathbb{E}[y_1] + \mathbb{E}[y_2] = \mathbb{E}[y_1 + y_2]$$

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Linearity of Expectations

CRIME De-Coder

$$\mathbb{E}[y_1] + \mathbb{E}[y_2] = \mathbb{E}[y_1 + y_2]$$

Try, try, try again

- **If probability is p_i, then**
- $\mathbb{E}[\#\text{ of events}] = \Sigma_n p_i = n \cdot p_i$

Know when to keep trying vs increasing p_i

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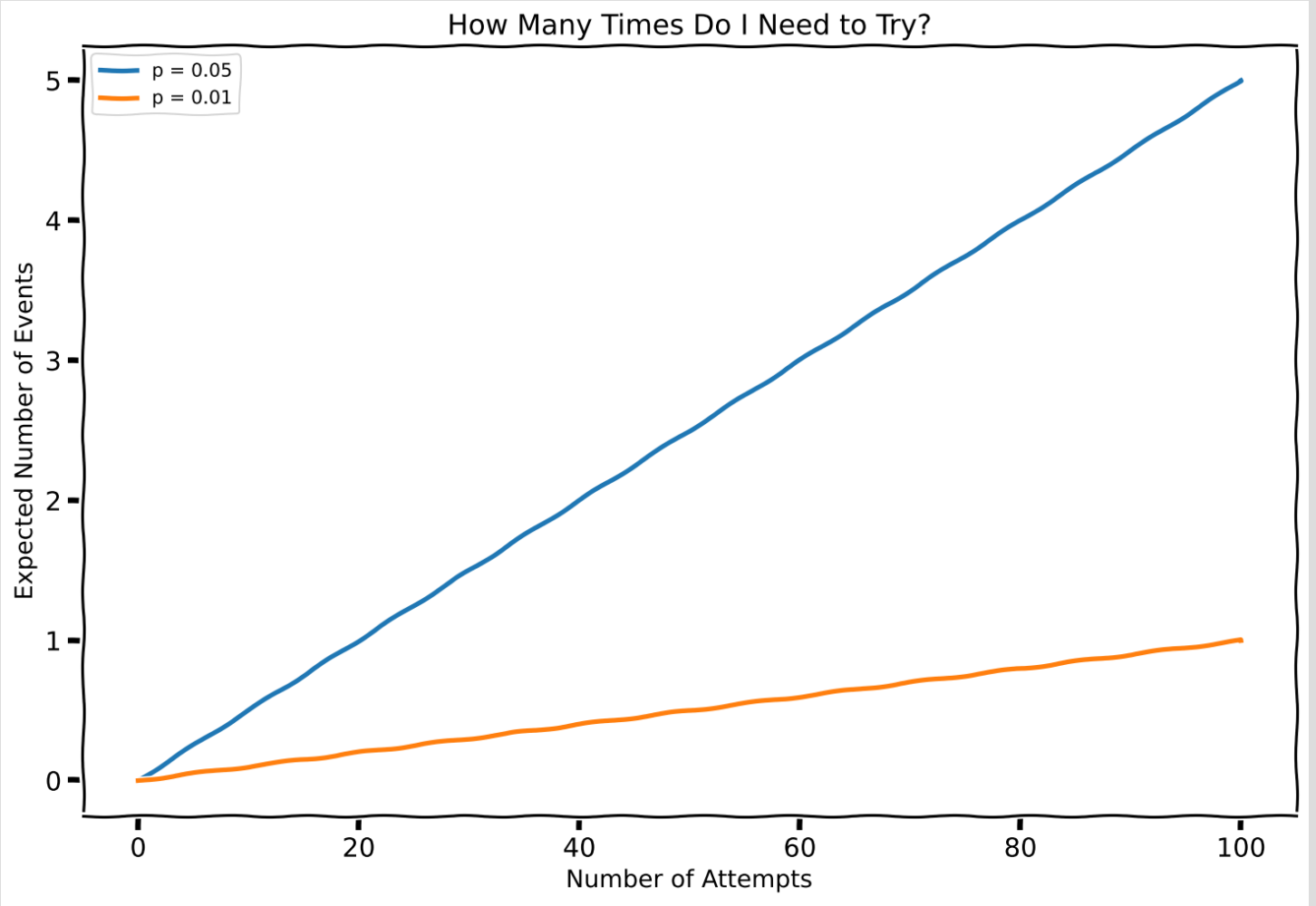

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Multiple Comparisons

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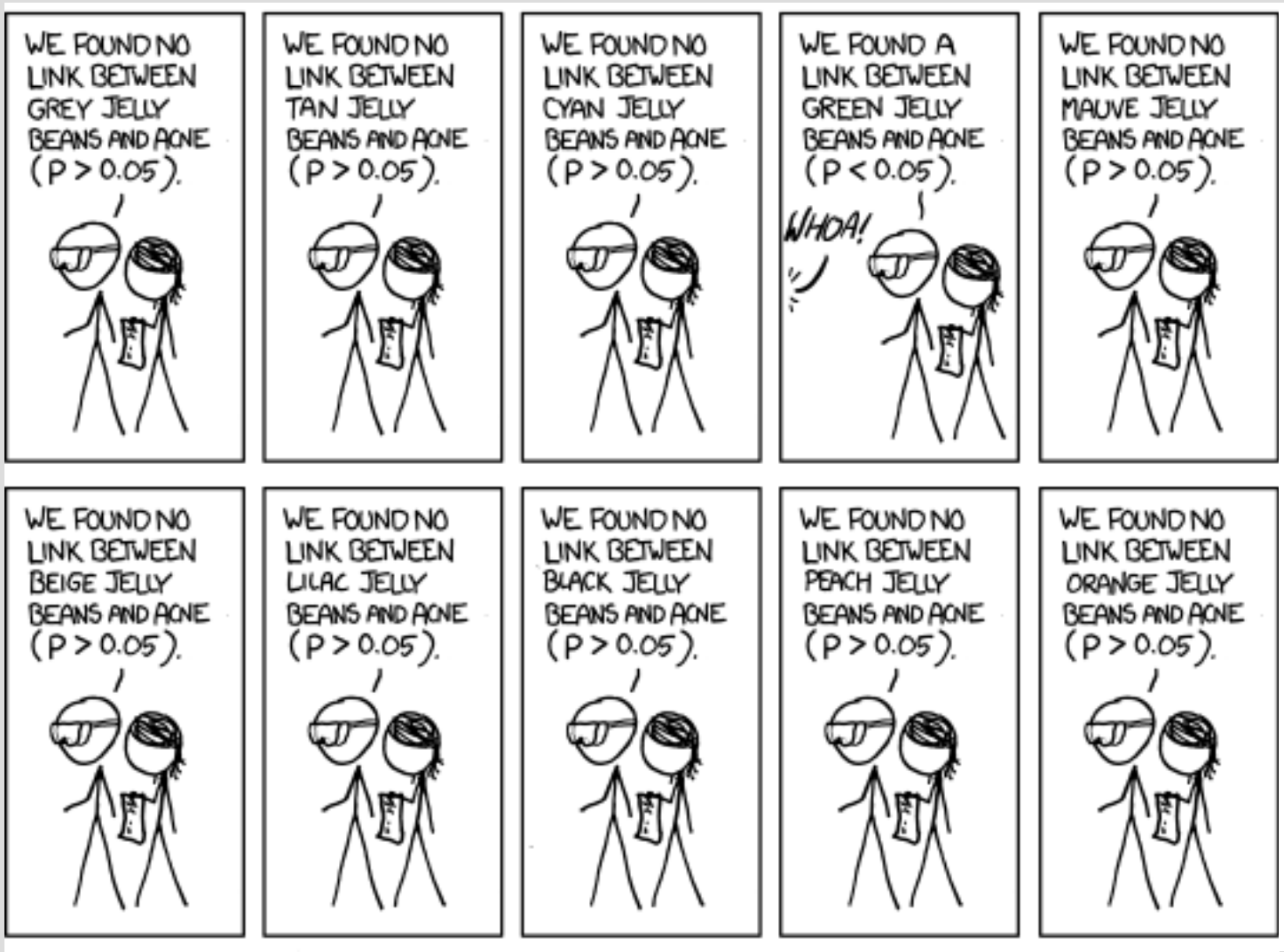

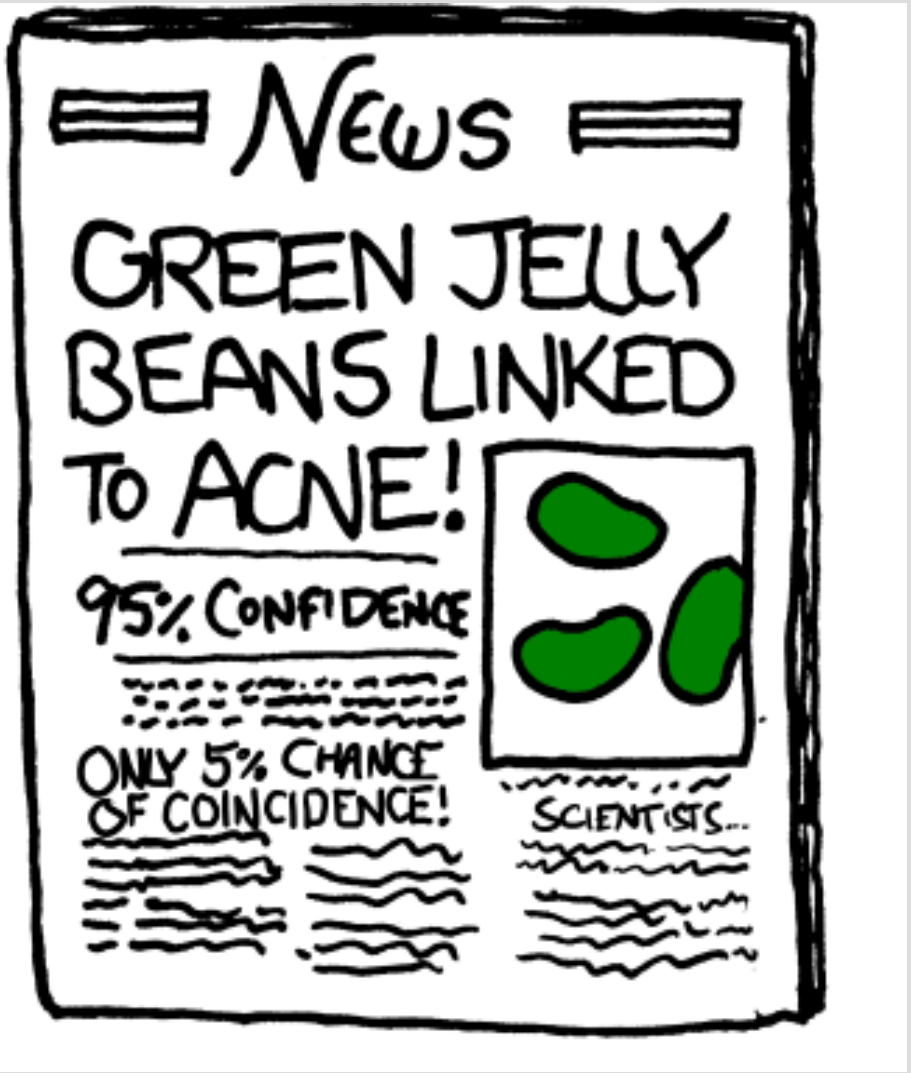

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Multiple Comparisons

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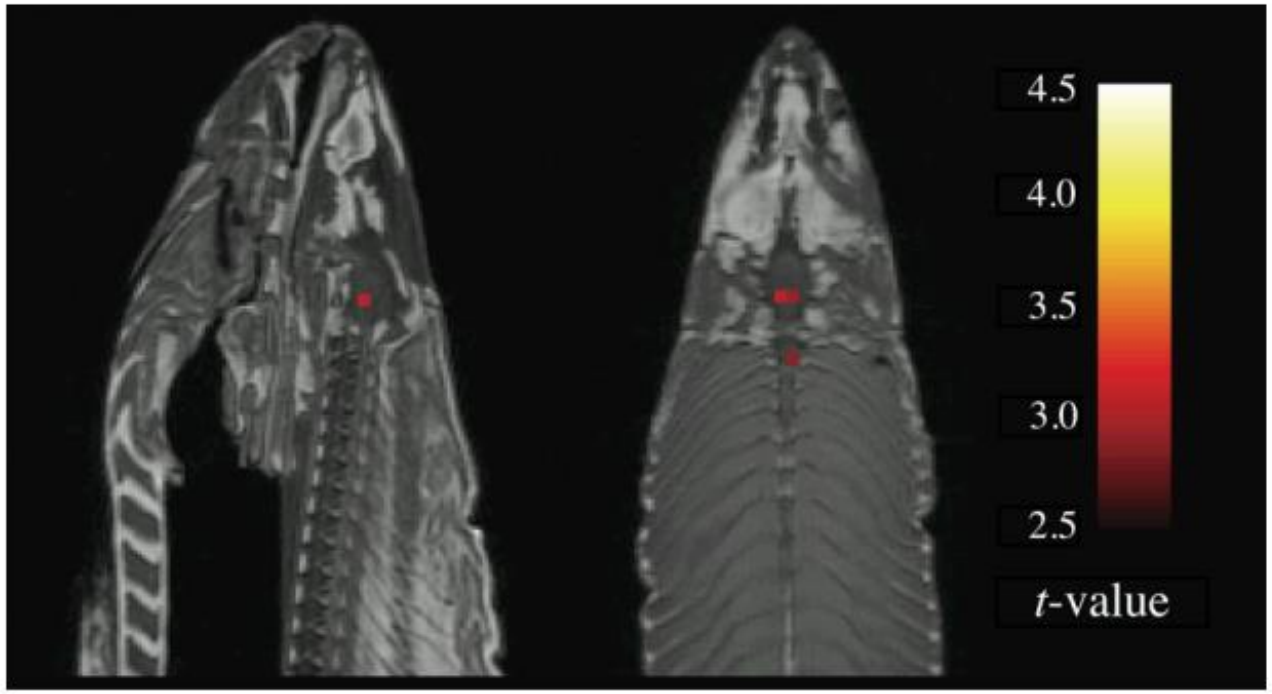
GLM RESULTS



A *t*-contrast was used to test for regions with significant BOLD signal change during the photo condition compared to rest. The parameters for this comparison were $t(131) > 3.15$, p(uncorrected) < 0.001, 3 voxel extent threshold.

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Precision and Recall

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Precision

- $p(y|\hat{y})$ – **probability of outcome conditional on predicting that outcome**

Recall

- $p(\hat{y}|y)$ – **proportion of all outcomes you captured with your instrument**

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Precision and Recall

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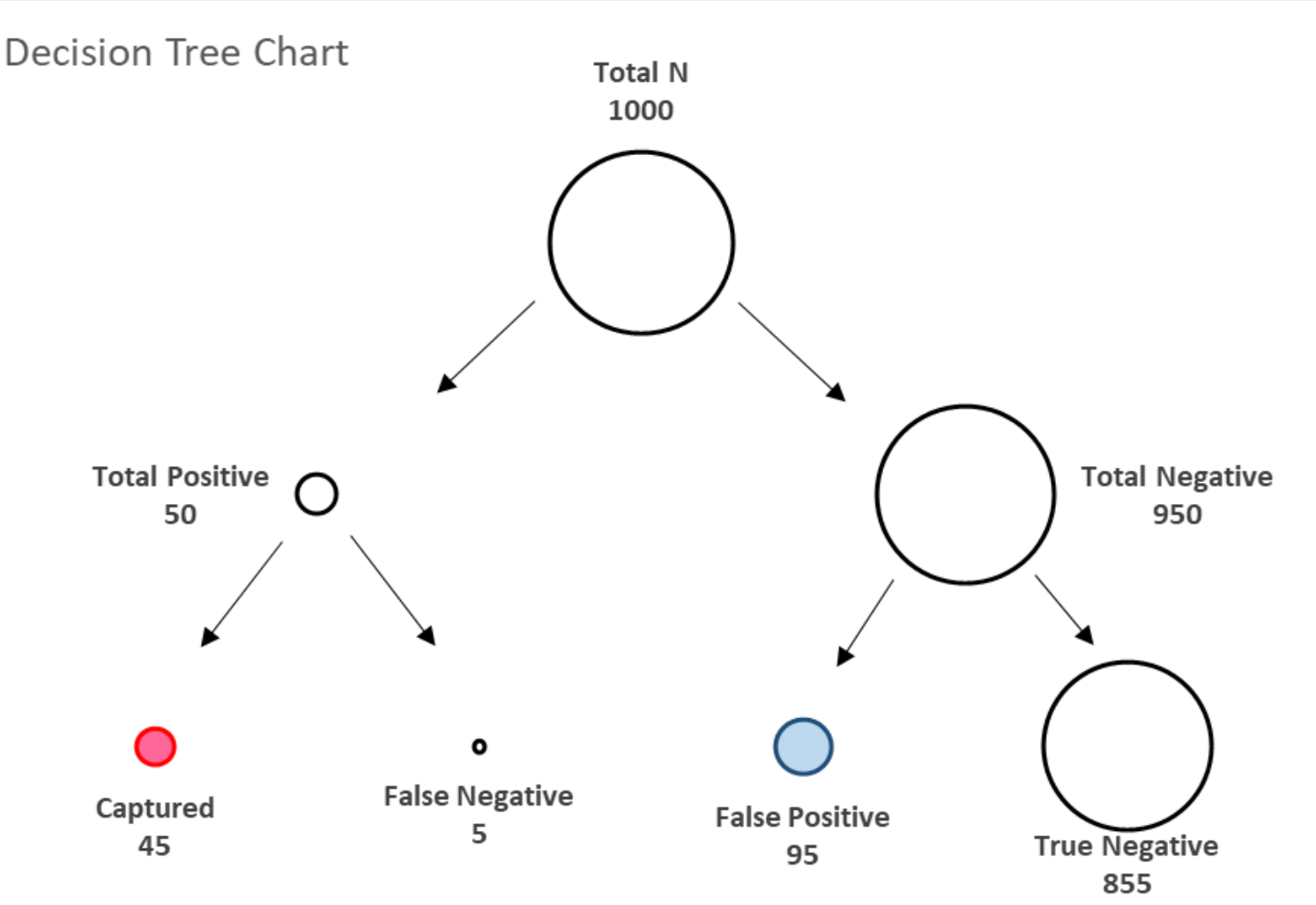

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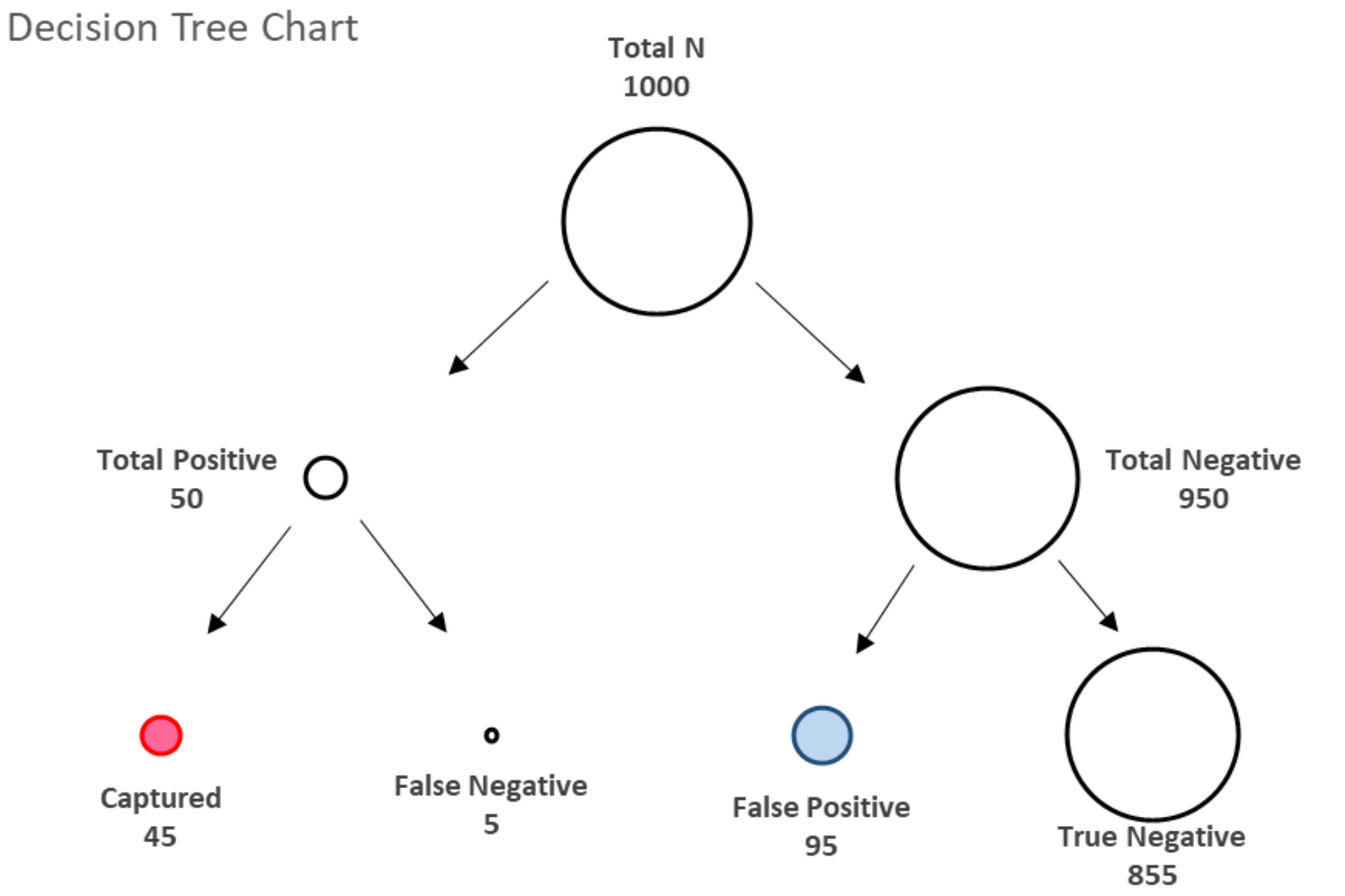

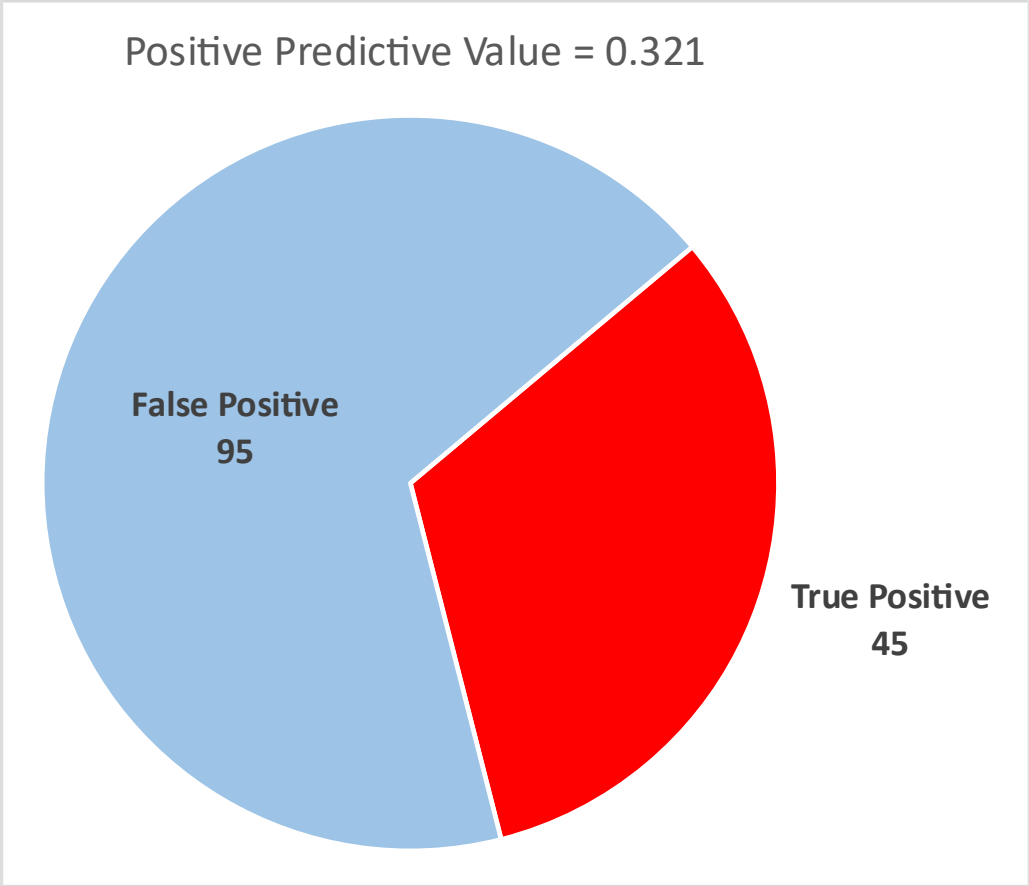

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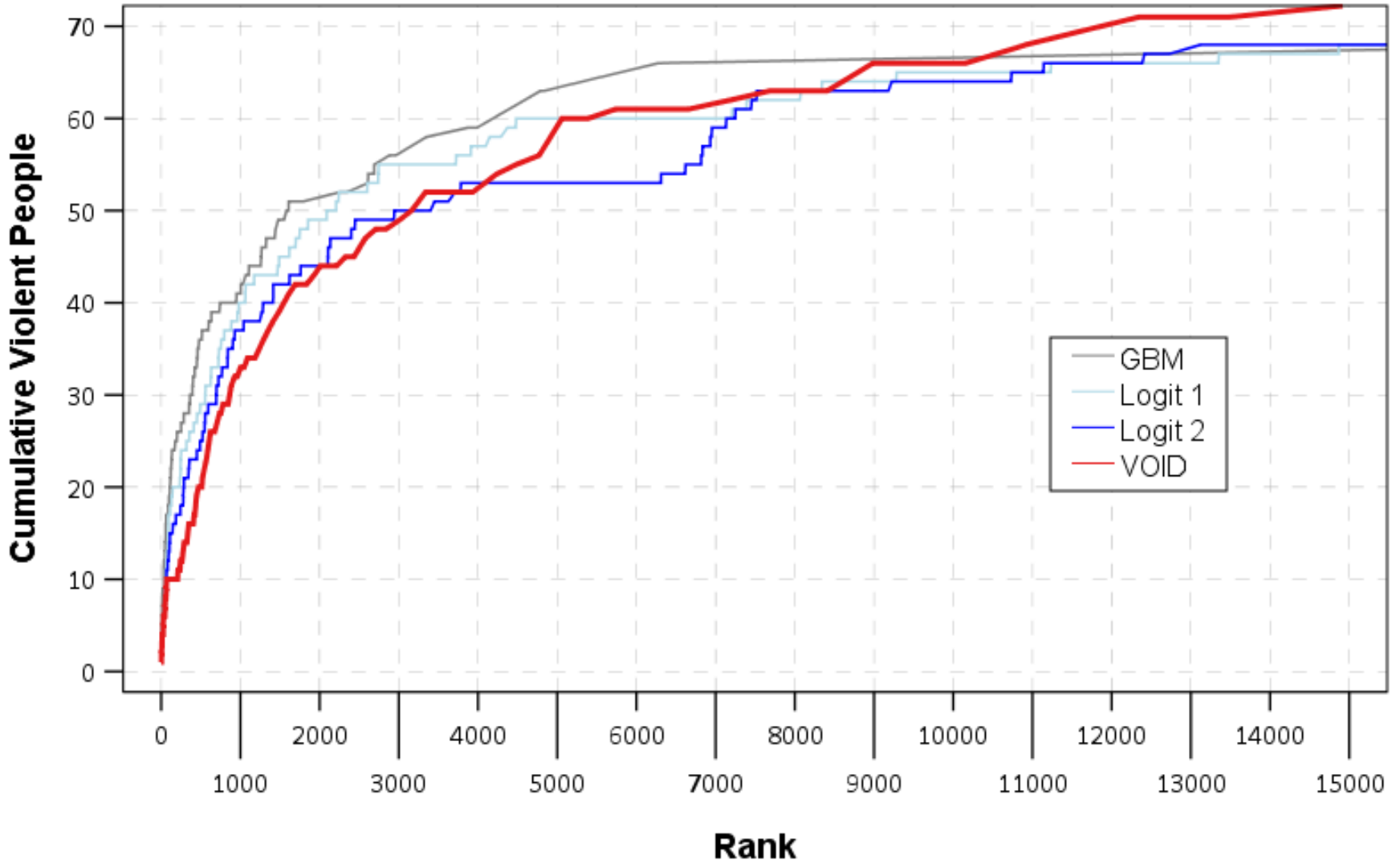

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Precision and Recall

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- $p(y|\hat{y})$ – **probability of outcome conditional on predicting that outcome**

Recall

- $p(\hat{y}|y)$ – **proportion of all outcomes you captured with your instrument**

Very hard to predict rare events, need to trade off false positives and false negatives

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Avoid Chasing the Noise

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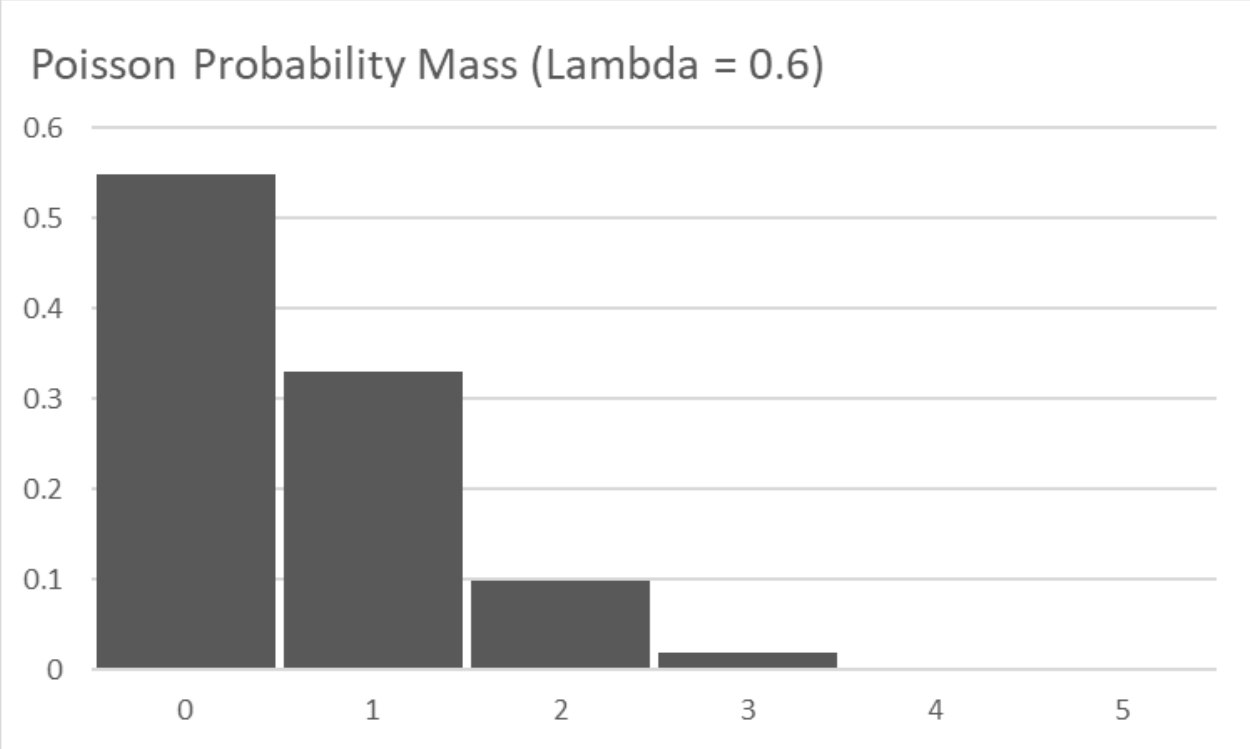
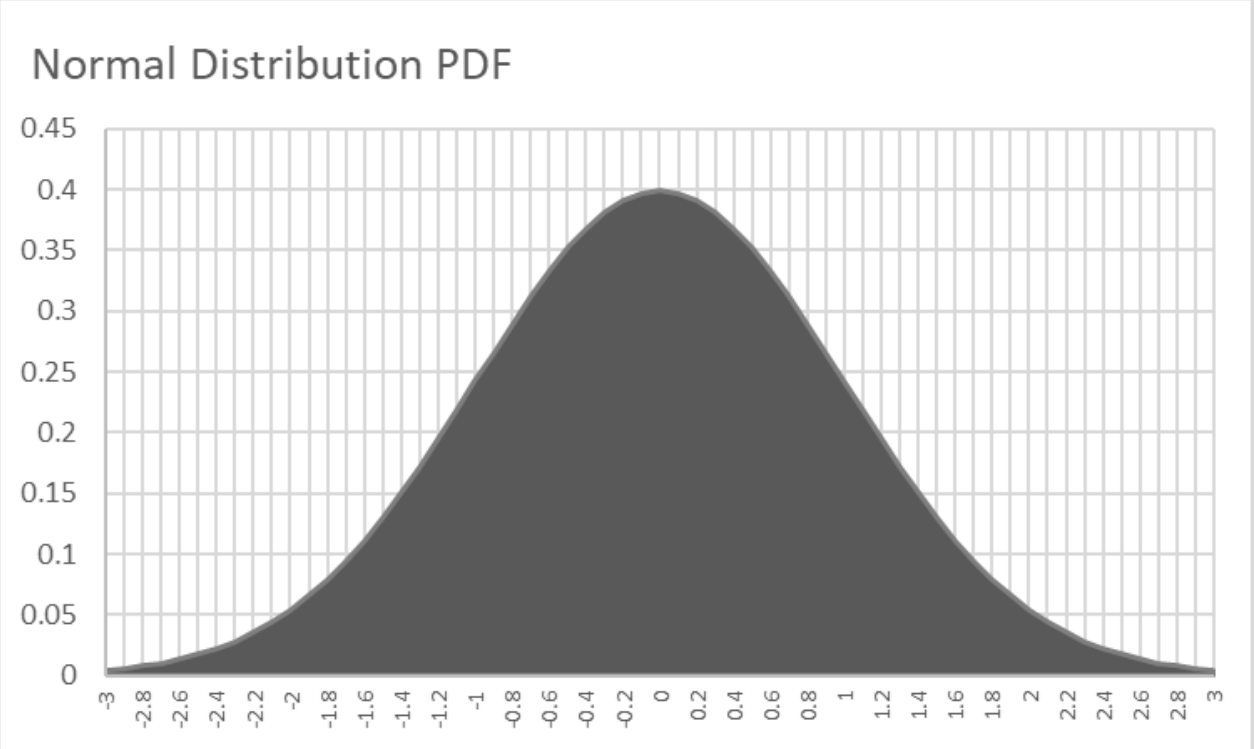
If you on average had 0.6 shark attacks in a month, would it be weird to have a month with 2?





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Avoid Chasing the Noise

CRIME De-Coder

If you on average had 0.6 shark attacks in a month, would it be weird to have a month with 2?

- **2 events will happen 10% of the time**
- **Would expect that to happen almost once a year**

Number in Period	% Expected	% Cumulative Expected
0	54.9%	54.9%
1	32.9%	87.8%
2	9.9%	97.7%
3	2.0%	99.7%
4	0.3%	100.0%
5	0.0%	100.0%

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Avoid Chasing the Noise

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If you on average had 0.6 shark attacks in a month, would it be weird to have a month with 2?

- **Poisson distribution rule of thumb**

$$2 \cdot \left(\sqrt{C_1} - \sqrt{C_0}\right) \approx \mathcal{N}(0,1) \Rightarrow Z$$

- **Going up or down if** $|Z| > 3$

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Avoid Chasing the Noise

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If you on average had 0 … month, would it be weird to hav… 3?

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.0%	99.7%
.3%	100.0%
.0%	100.0%

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Most things suck, you can make them better

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$$U_t \geq U_{t-1}$$

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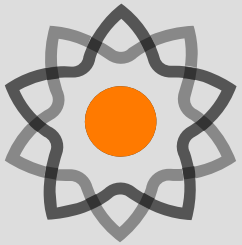
Most things suck, you can make them better

CRIME De-Coder

$$U_t \geq U_{t-1}$$

- **Stuff gets better over time, not worse**
- **From the effort *you* put into them**



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Automation and Actual Savings

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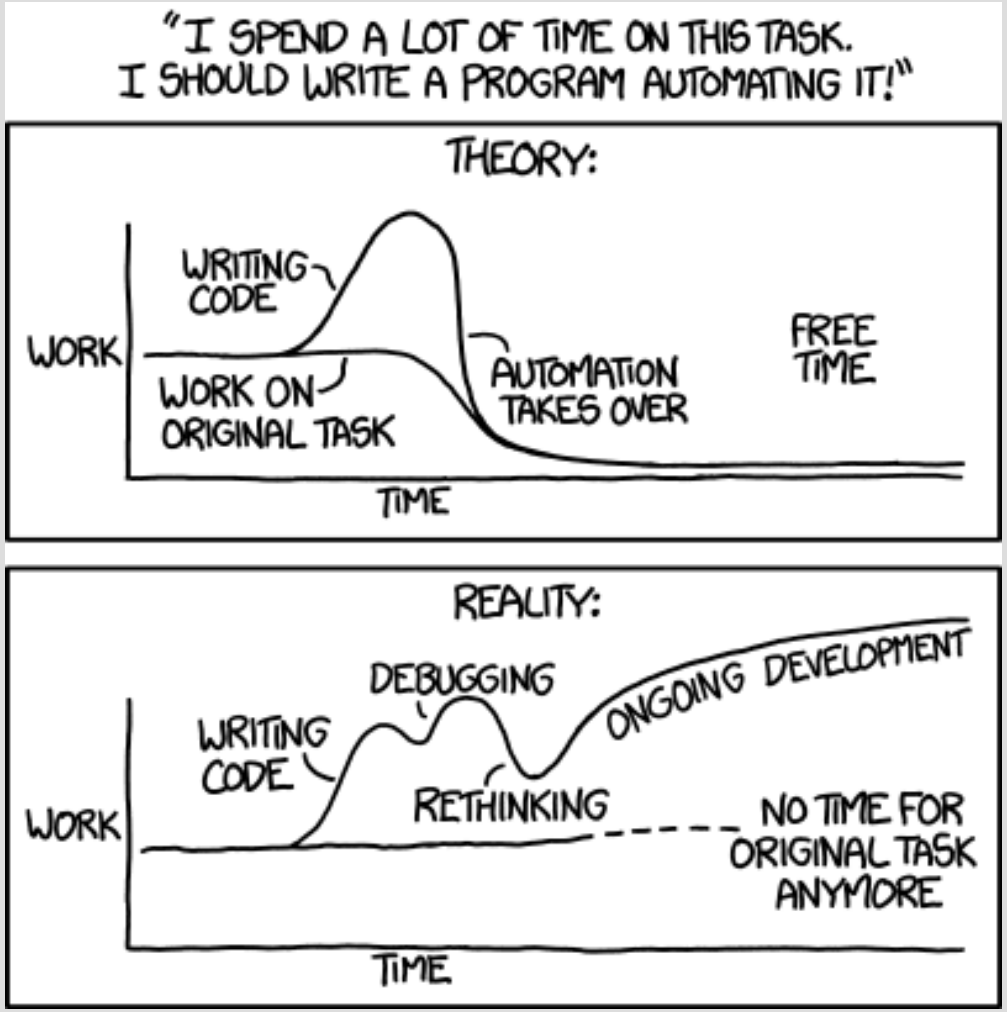

HOW LONG CAN YOU WORK ON MAKING A ROUTINE TASK MORE EFFICIENT BEFORE YOU'RE SPENDING MORE TIME THAN YOU SAVE?
(ACROSS FIVE YEARS)

HOW MUCH TIME YOU SHAVE OFF	HOW OFTEN YOU DO THE TASK: 50/DAY	5/DAY	DAILY	WEEKLY	MONTHLY	YEARLY
1 SECOND	1 DAY	2 HOURS	30 MINUTES	4 MINUTES	1 MINUTE	5 SECONDS
5 SECONDS	5 DAYS	12 HOURS	2 HOURS	21 MINUTES	5 MINUTES	25 SECONDS
30 SECONDS	4 WEEKS	3 DAYS	12 HOURS	2 HOURS	30 MINUTES	2 MINUTES
1 MINUTE	8 WEEKS	6 DAYS	1 DAY	4 HOURS	1 HOUR	5 MINUTES
5 MINUTES	9 MONTHS	4 WEEKS	6 DAYS	21 HOURS	5 HOURS	25 MINUTES
30 MINUTES		6 MONTHS	5 WEEKS	5 DAYS	1 DAY	2 HOURS
1 HOUR		10 MONTHS	2 MONTHS	10 DAYS	2 DAYS	5 HOURS
6 HOURS				2 MONTHS	2 WEEKS	1 DAY
1 DAY					8 WEEKS	5 DAYS

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