

Notes and Tricks for Teaching Statistics using Music and Magic

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IMTA Maths Conference 2024

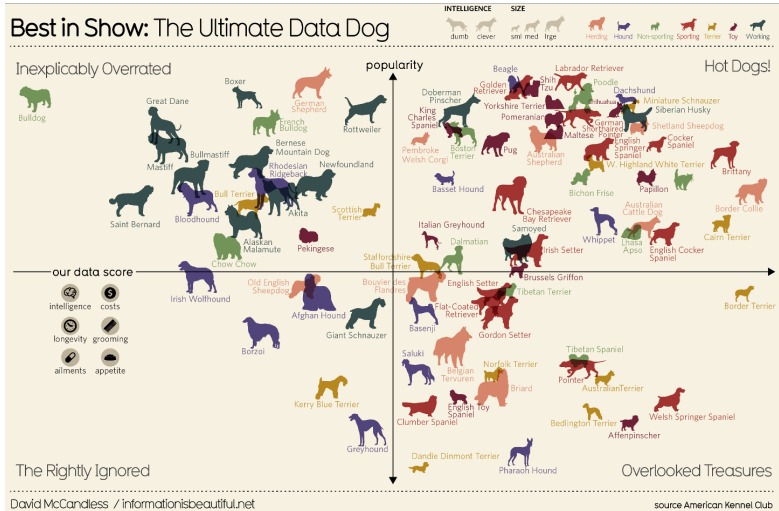
Outline

- Hooks and authenticity
- Teaching Statistics vs. teaching how to learn Statistics
- Breaking emotional objections
- Using magic tricks to teach
- Using music to teach
- Tips on how you too can use magic and music to teach

What is the best

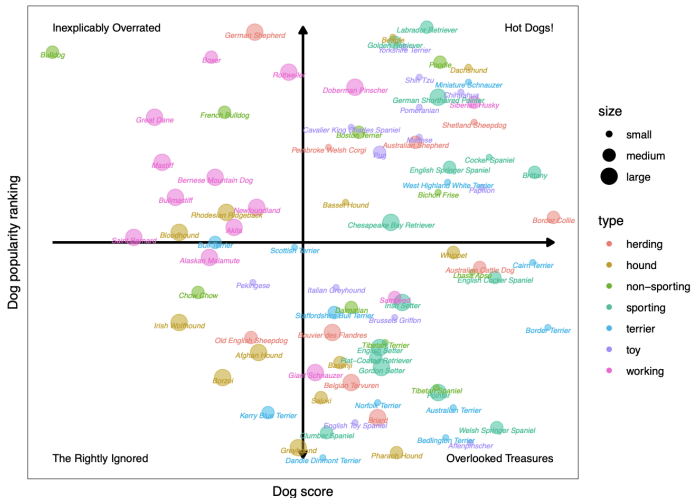
What is the best dog?

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Best in Show: The Ultimate Data Dog



What is the best dog?



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- It helps **breaking emotional objections**
- “To abstract is to exercise the ability to deal with ideas rather than events”
- “To analyse is to split a problem in smaller parts to better comprehend the whole”
- “To synthesise is to combine smaller parts into a clear, cohesive and precise whole”

I want to use techniques and demos that...

- increase student **interest**
- help those who are **afraid** or uncomfortable with quantitative subjects
- deliver content in an innovative and **memorable** way

Most importantly...

I want to be able to **teach how to learn**

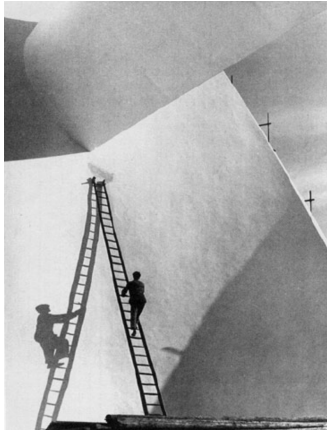
Most importantly...

I want to be able to **teach how to learn**

To do that I must provide evidence that I am

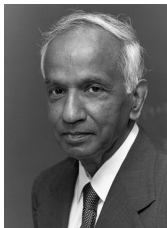
- 1 conscious of what I haven't achieved yet
- 2 conscious that I will never achieve a Platonic level of knowledge

Teaching how to learn



An Individual's View of the Individual (Man on the Ladder)

Teaching how to learn



“What impressed me about your picture was the extremely striking manner in which you visually portray one’s inner feelings towards one’s accomplishments: one is half-way up the ladder, but the few glimmerings of structure which one sees and to which one aspires are totally inaccessible, even if one were to climb to the top of the ladder. The realization of the absolute impossibility of achieving one’s goals is only enhanced by the shadow giving one an even lowlier feeling of one’s position.”

(Subrahmanyan Chandrasekhar)

“Students can *smell* lack of confidence”

- Where does confidence come from?
 - Expertise
 - Realisation of inaccessibility
- Not lying is easier than telling the truth: how to teach what we don't know?

How to break emotional objections?

- An emotional objection stems from the pain of living with the problem not being sufficiently greater than the pain of making the commitment to solve it
- As educators we must ease the pain of making this commitment
- One way to do this is by sparking interest

Keeping students' attention



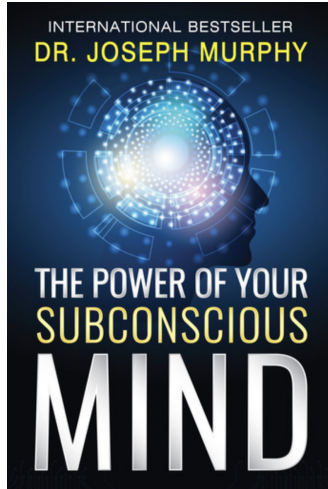
- Content, class size and duration all affect strategies on how to keep the students' attention
- e.g. GDPR and data privacy class, I start with "Is Facebook listening to you?"
- Jokes, magic and music: *intermittently scheduling positive reinforcements* that break emotional objections

Let's talk about magic tricks



- Magic is about unexpected coincidence
- Coincidences and probability are strongly tied (not just cards!)
- e.g. hook: “What I’m about to show you is 2 million times less likely than winning the Euromillions jackpot” ($2^{48}/(140 \times 10^6)$)
- Can use to teach correlation vs. causation, odds, probabilities, hypothesis tests, p-values. . .

Demonstration: The Power of Your Subconscious Mind



Any Card at Any Number: Why it works

- Specific stories stick!
- Practical meaning of probability towards abstract notions
- Analysis: $\frac{1}{52} \times \frac{1}{60} = \frac{1}{3120}$
- Synthesis: testing a hypothesis
- Null hypothesis: “this is all at random / this is a normal deck / we don’t know each other / etc”

Let's talk about music

- Music is a part of everyone's life
- I thought: if I make a new song, that would achieve some objectives, but a parody would achieve more

	New song	Parody
Build rapport	yes	yes
Correspondence with reality	yes	yes
Break emotional objections	yes	yes
Improve accessibility	yes	yes
Help overcoming fear	yes	yes
Immediate student participation	no	yes
Easy to remember	maybe	yes

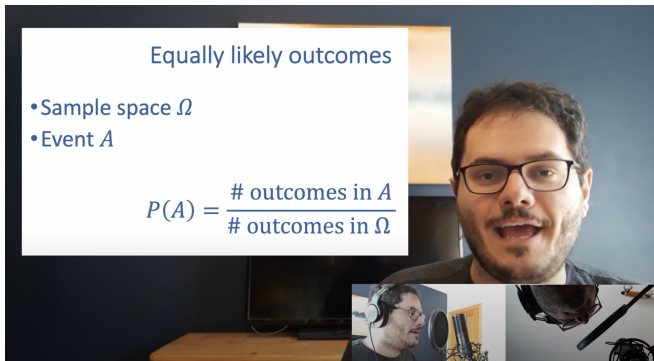
Experience with music

Summary Song 1

Probability

Dr Rafael Moral

Experience with music



Equally likely outcomes

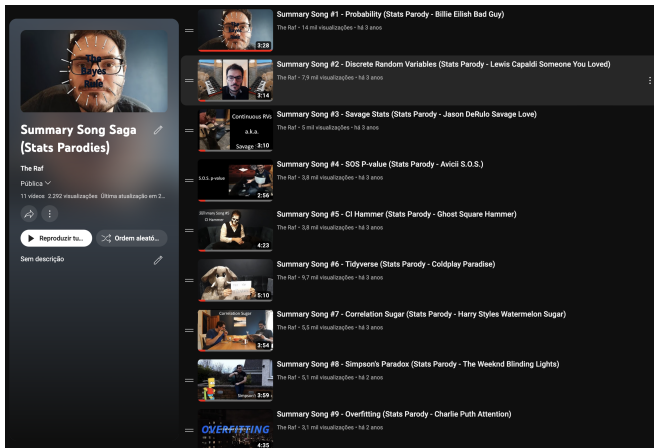
- Sample space Ω
- Event A

$$P(A) = \frac{\# \text{ outcomes in } A}{\# \text{ outcomes in } \Omega}$$

Experience with music



Experience with music



tinyurl.com/rafamoral

What I learned so far

- It works very well for some people
- It doesn't work at all for others
- Some are indifferent
- This is my style; it doesn't mean it'll work in any situation
- Be open to be criticised, look for feedback, but *don't quit being yourself*

How I work

Step	Average time taken to complete	Main challenges
1. Defining theme/original song	1 – 2h	The themes are typically defined in advance; song choice is based on popularity and how well statistics-oriented lyrics could be fitted to it
2. Writing lyrics	1 – 3 h	Sometimes the lyrics come naturally to me; depending on the song, it is difficult to fit the exact number of syllables into the verses
3. Creating backing track	30 min – 5 h	When high-quality backing tracks are available online, it is much more straightforward; sometimes I have to play every instrument to create a backing track (e.g. It's Exponential)
4. Audio recording/mixing	5 – 10 h	Depending on the style of the song, it takes more time to reproduce all vocal melodies, especially backing vocals; there is a learning curve to audio mixing and mastering
5. Writing storyline	2 – 4 h	Sometimes the storyline is very clear; other times it takes a while to come up with something interesting
6. Video recording	5 – 12 h	Redoing shots until there are no mistakes; preparing props and animals
7. Video editing	5 – 10 h	There is a learning curve when working with DaVinci Resolve
8. Video captioning	2 – 4 h	Sometimes captioning has to be redone if there are minor changes to the original video
9. Video upload and dissemination	30 min	I find it difficult to create the best caption to promote the material. Dr Niamh Cahill has been helping me, especially with the Twitter posts. Dr Catherine Hurley has been especially helpful disseminating the material to other classes.
Overall	22 – 50 h	

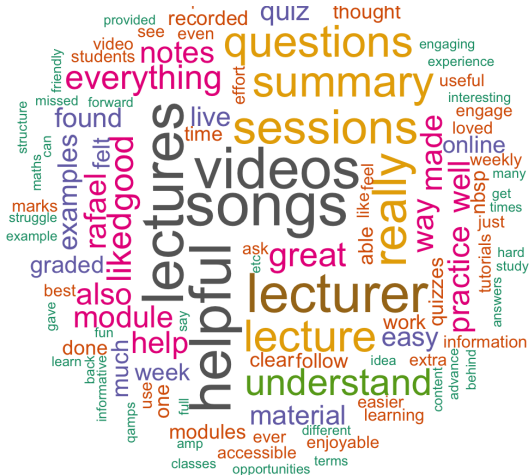
Assessment

The summary songs helped me understand/memorise/learn concepts of the module better.

Response	Average	Total
Strongly Agree	 47%	47
Agree	 39%	39
Disagree	 9%	9
Strongly Disagree	 4%	4
Total responses to question	 100%	99/99

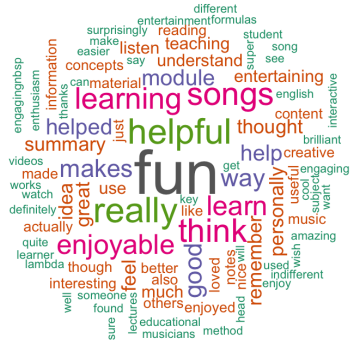
Assessment

What aspects of this module did you like?



Assessment

What are your thoughts about the use of music to teach/learn Statistics?



Assessment

- The songs were helpful
- stuck in my head
- It's easier to learn with without having to read too much
- Its an interesting way to learn, a nice change from the monotony of lectures/assignments
- How can the module be improved: more summary songs!!! (and more pet footage)!!!
- the C.I. song is a banger. Rafael should do a Brazilian song :)
- show Luna more.
- One of my friends (in a different course in a different college) even referenced one of the songs when we talked about football. He said "Its like your lecturer in that song, just because they score when he's playing doesn't mean he's the reason."
- **I found it enjoyable and it was a great way to bond with the class.**

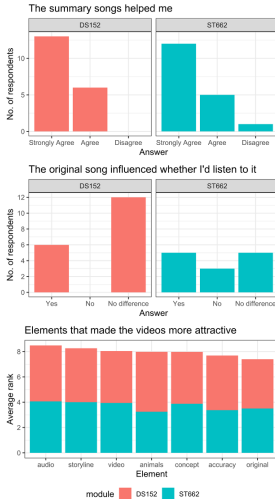
Assessment

- Very helpful in summarising the content
- It is brilliant, makes maths fun
- made it fun, and easier to memorize
- Very helpful, it makes the module enjoyable to learn and doesn't make the module feel like a chore
- This is an extremely effective teaching method and I thank you sincerely for catering to the auditory learner. This is something not a lot of educators incorporate and I'm personally benefiting from this.
- **I really struggle with maths and actually for once found maths enjoyable and not something that is scary or unachievable**
- **it motivated me to watch the lectures to be able to understand the material covered in texts of the songs!**

Assessment

- didn't help me sorry
- I did not watch any of them so I have no input
- **might take a while for me to get used to it**

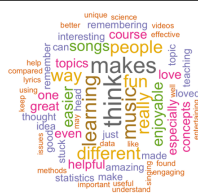
Assessment



Aspects you liked



Thoughts on use of songs



Student participation



Student participation



Student participation



Student participation



Demonstration: The Discrete Random Variables Song

The binomial distribution is a sum of Bernoullis

But only if they're independent and they all have the same p

Y is discrete proportion of n

Here the letter p means probability

It's easy to say the mean is np

And so the variance is $np \times (1 - p)$

Demonstration: The Discrete Random Variables Song

We've got the Bernoulli

We've got the Poisson

They're discrete

That's why I wrote this song

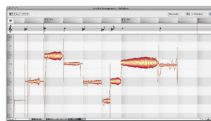
There's the binomial

But when Y is a count

$$P(Y = x) = \frac{e^{-\lambda} \lambda^x}{x!}$$

Equipment and software

- Audio interface: Focusrite Scarlett 2i2
- Microphone: Behringer B1
- Digital Audio Workstation: Logic Pro
- Pitch correction: Melodyne
- Video editing software: DaVinci Resolve (free!)
- Camera: phone + cheap tripod



But for the first six videos I didn't have any of that!

- Audio interface: none
- Microphone: Tonor USB with pre-amp
- Digital Audio Workstation: GarageBand (free for Mac)
- Pitch correction: Melodyne (free for 30 days)
- Audio editing software: Audacity (free!)
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-
- What if I can't sing or play anything?
 - A: backing tracks + melodyne (or call a friend) + play the recording

VOICES



<https://www.causeweb.org/voices/home>

Acknowledgments



Summary

- Hooks are great to grab students' attention
- Authentic stories stick
- Provide evidence that you are approachable
- Develop practices that teach how to learn by honing students' abstraction, analysis, and synthesis skills
- A magic trick or a song can go a long way. . .

Now grab a deck of cards!

- The odds of this happening by chance alone are 1 in 208

Now grab a deck of cards!

- The odds of this happening by chance alone are 1 in 208
- This trick uses 3 principles in magic:
 - 1 Equivoque
 - 2 Force
 - 3 Multiple outs

Thank you!

