Mind the Gap: An incomplete picture of statistics, statisticians, & statistics education

Matthew Beckman
Penn State University

June 25, 2023
Maleny, Australia

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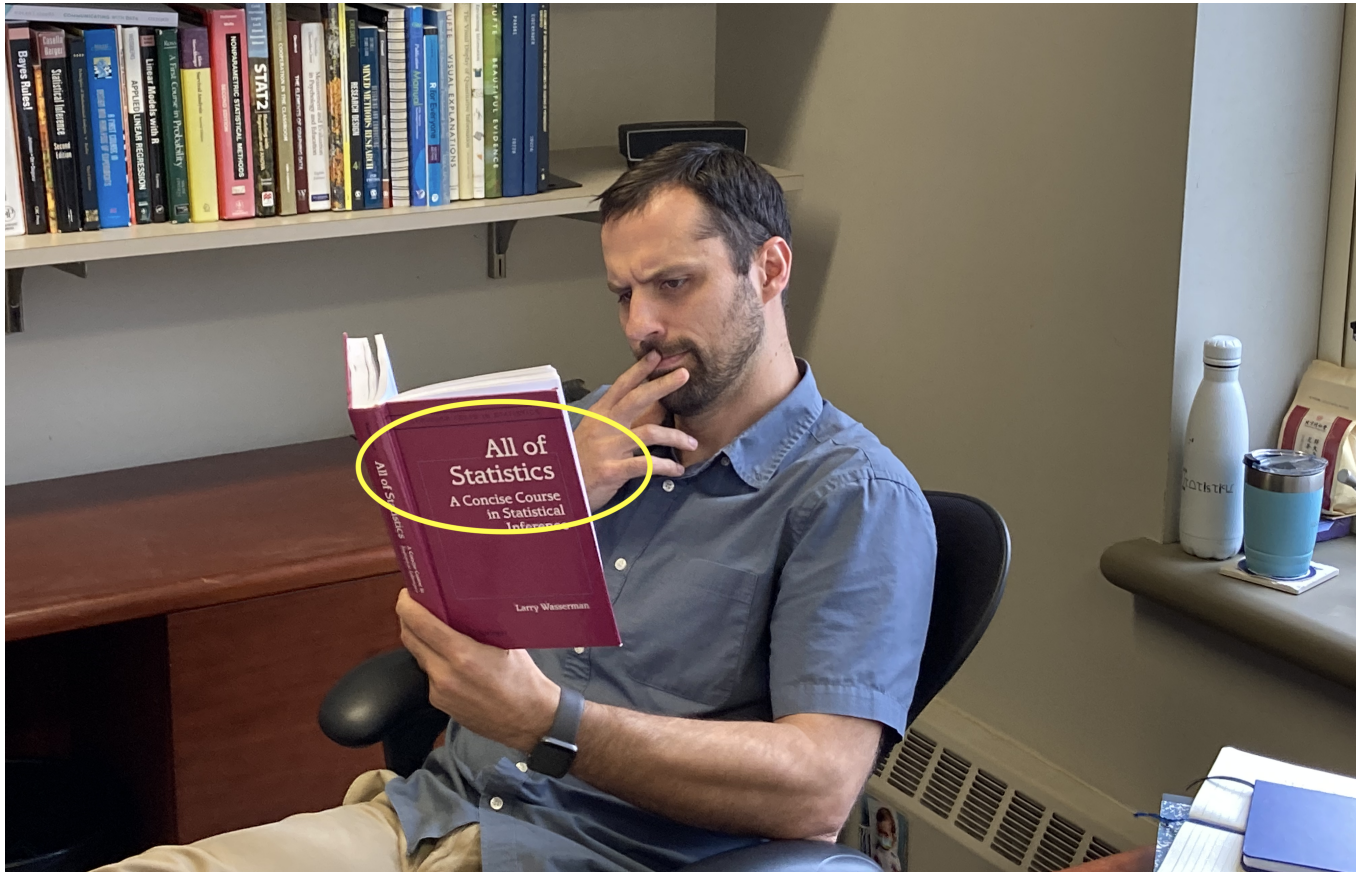

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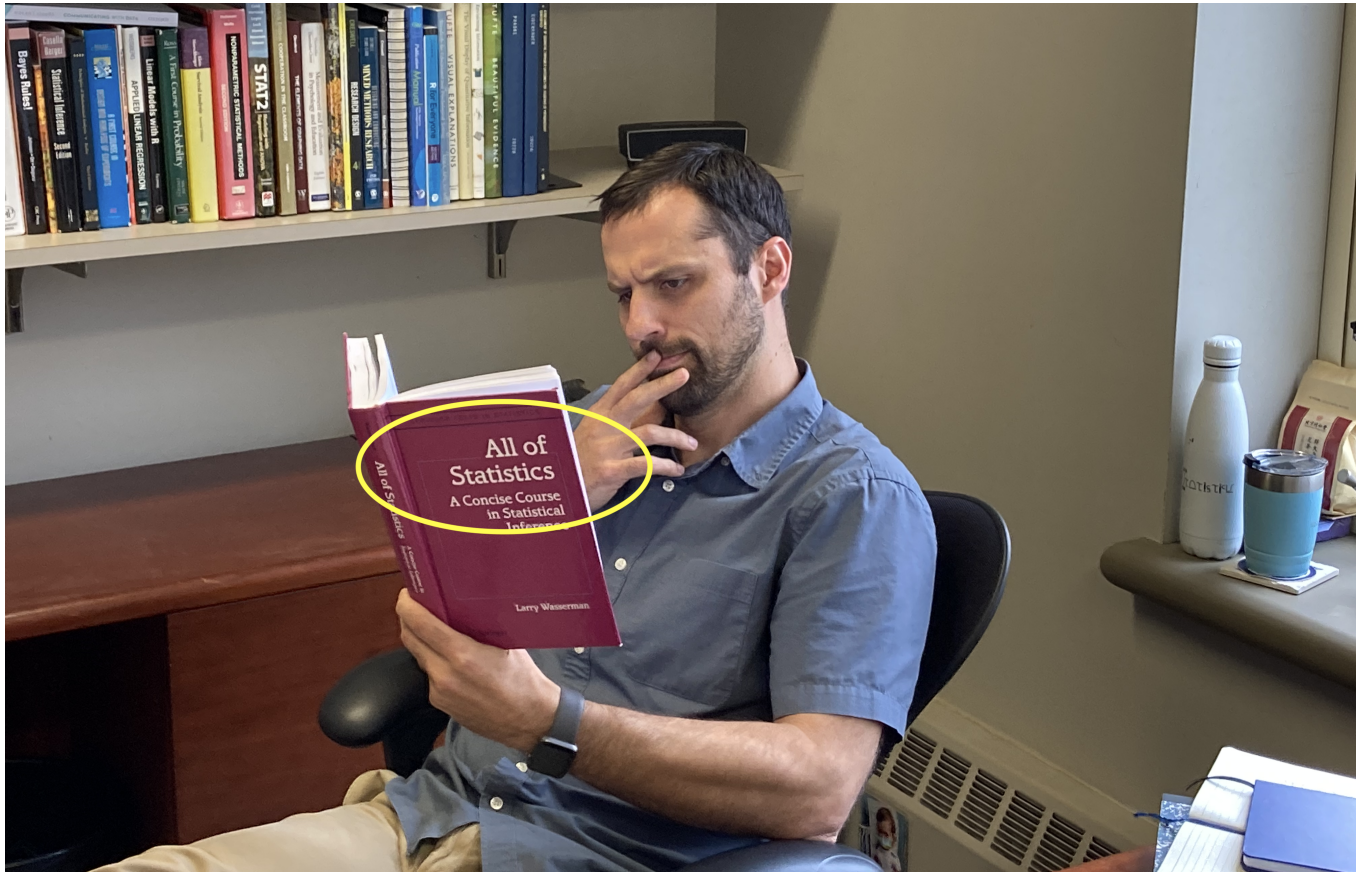
- . . . on "reconceptualising data and data-ing"



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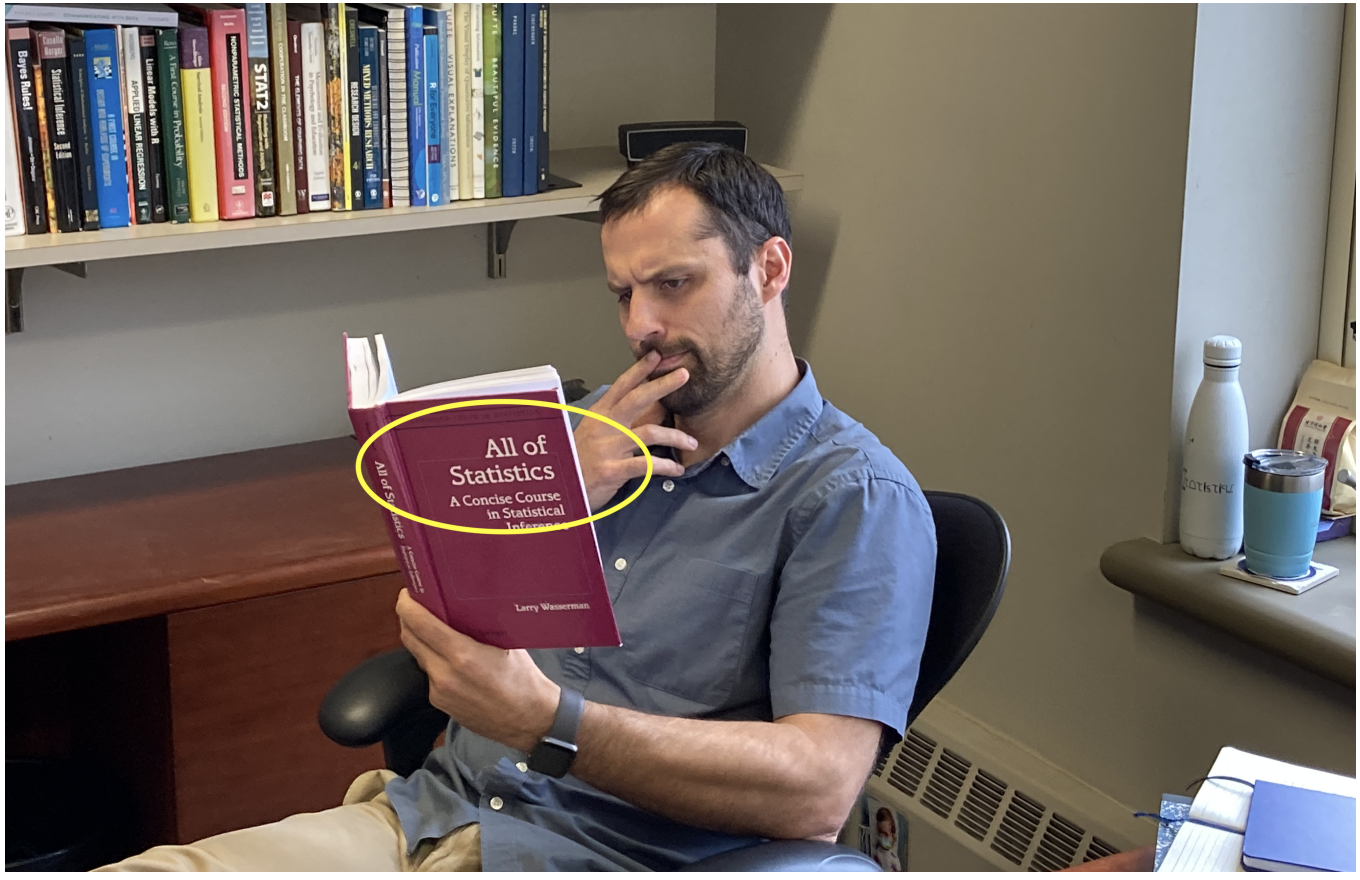

Figure 1: Getting ready to "Provide the perspective of the discipline. . . " as promised in the SRTL announcement.

- . . . on "reconceptualising data and data-ing"
- "data-ing?"
- that wasn't in the book. . .

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- [*checks list of participants for “grammarian-in-residence”*]

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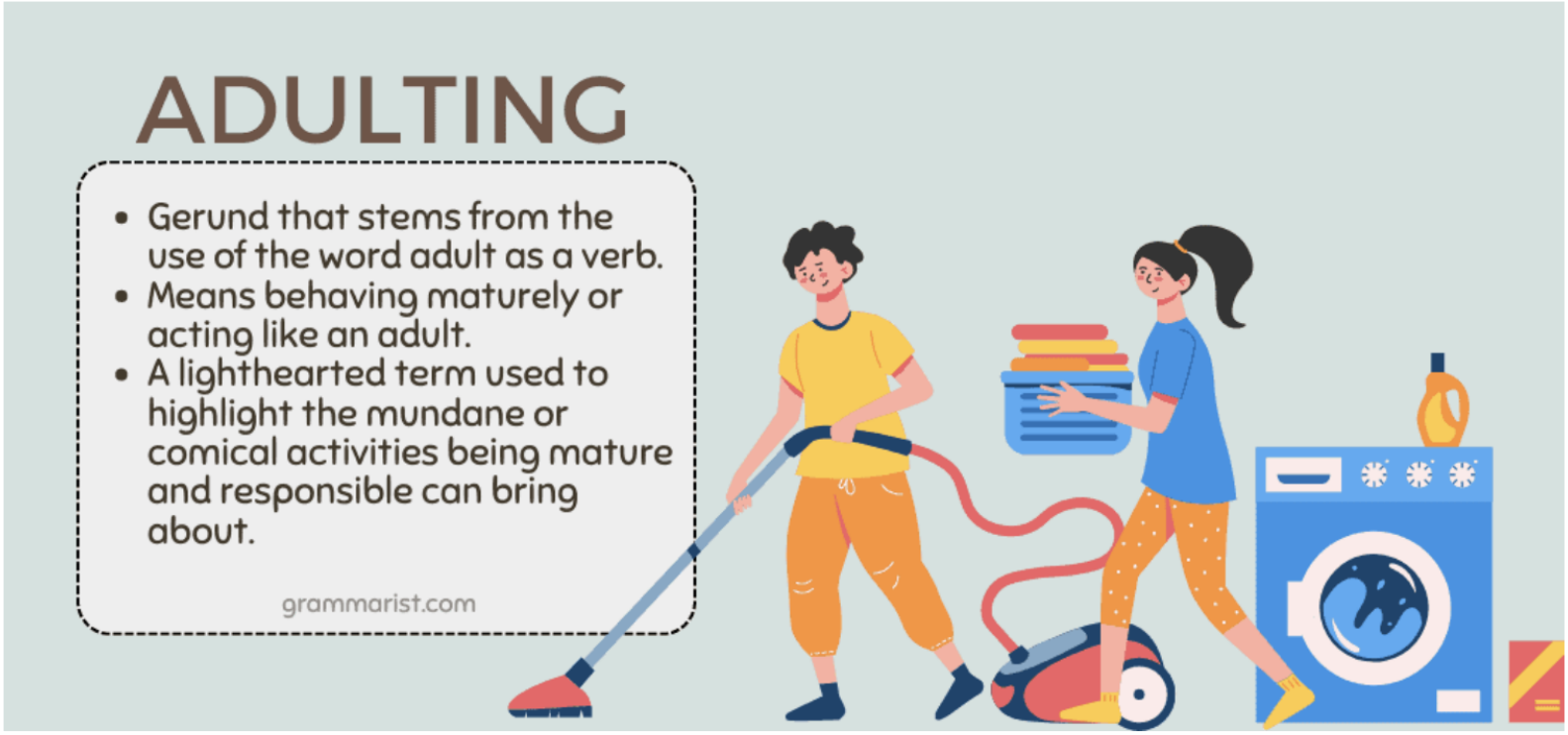
- [*checks list of participants for “grammarian-in-residence”*]
- but I’ve heard this kind of thing happens on Twitter

ADULTING

What Is the Meaning of Adulting?



Adulting is a fairly new gerund that stems from the use of the word adult as a verb. A gerund is a verb form ending in -ing that acts as a noun. *Adulting* simply means behaving maturely or acting like an adult.

Figure 2: image credit: Grammarist. URL: https://grammarist.com/new-words/adulting/

But “Data” as a verb?

- I’ve heard of *data verbs*, just not “data” *as* a verb

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- Amelia McNamara helpfully pointed out (to my surprise) this too has precedent!

But “Data” as a verb?

- I’ve heard of *data verbs*, just not “data” *as* a verb
- Amelia McNamara helpfully pointed out (to my surprise) this too has precedent!
- Who would do such a thing?

Jer Thorp

Roman Makhmutov

Jer Thorp is an artist, a writer, and a teacher. He was the first data artist in residence at *The New York Times*, is a *National Geographic* Explorer, and served as the innovator in residence at the Library of Congress in 2017 and 2018. He lives under the Manhattan Bridge with his family and his awesome dog, Trapper John, MD. *Living in Data* is his first book. You can sign up for email updates here.

Coming around...

- "the pair data and data-ing refers to a similar conceptualization of the relation between sample and sampling, or model and modeling, where the first is the statistical concept and the second refers to the process of engaging or reasoning with this concept."

Coming around. . .

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- *This* resonates with me

Coming around...

- "the pair data and data-ing refers to a similar conceptualization of the relation between sample and sampling, or model and modeling, where the first is the statistical concept and the second refers to the process of engaging or reasoning with this concept."

- *This* resonates with me

- and it's starting to sound familiar...

What perspective can I offer?

The birth of an academic

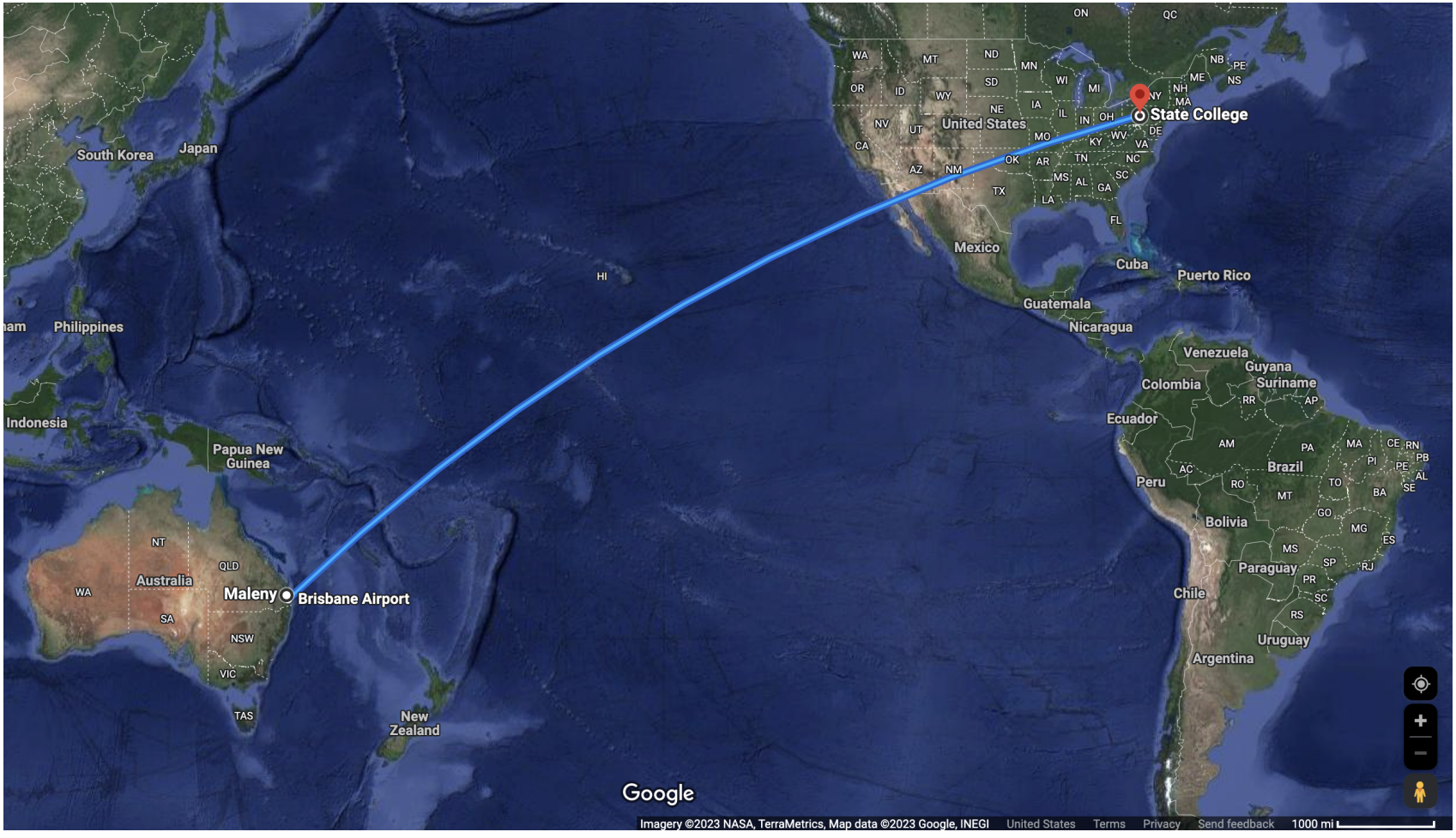
Figure 4: (Academic) offspring of Joan Garfield & Bob delMas enters the world (of Statistics Education)

- if any of you know me, it's probably thanks to my ~~parents~~ PhD advisors Joan Garfield & Bob delMas

The birth of an academic

Figure 4: (Academic) offspring of Joan Garfield & Bob delMas enters the world (of Statistics Education)

- if any of you know me, it's probably thanks to my ~~parents~~ PhD advisors Joan Garfield & Bob delMas
- there's plenty more to my upbringing before I ever got involved with Statistics Education, including lots that has almost nothing to do with academia!


State College
Maleny
Brisbane Airport
United States
South Korea
Japan
Philippines
Indonesia
Papua New Guinea
Australia
New Zealand
Mexico
Cuba
Puerto Rico
Guatemala
Nicaragua
Venezuela
Guyana
Suriname
Colombia
Ecuador
Peru
Brazil
Bolivia
Paraguay
Chile
Argentina
Uruguay
Google
Imagery ©2023 NASA, TerraMetrics, Map data ©2023 Google, INEGI
United States
Terms
Privacy
Send feedback
1000 mi

Rebellious phase

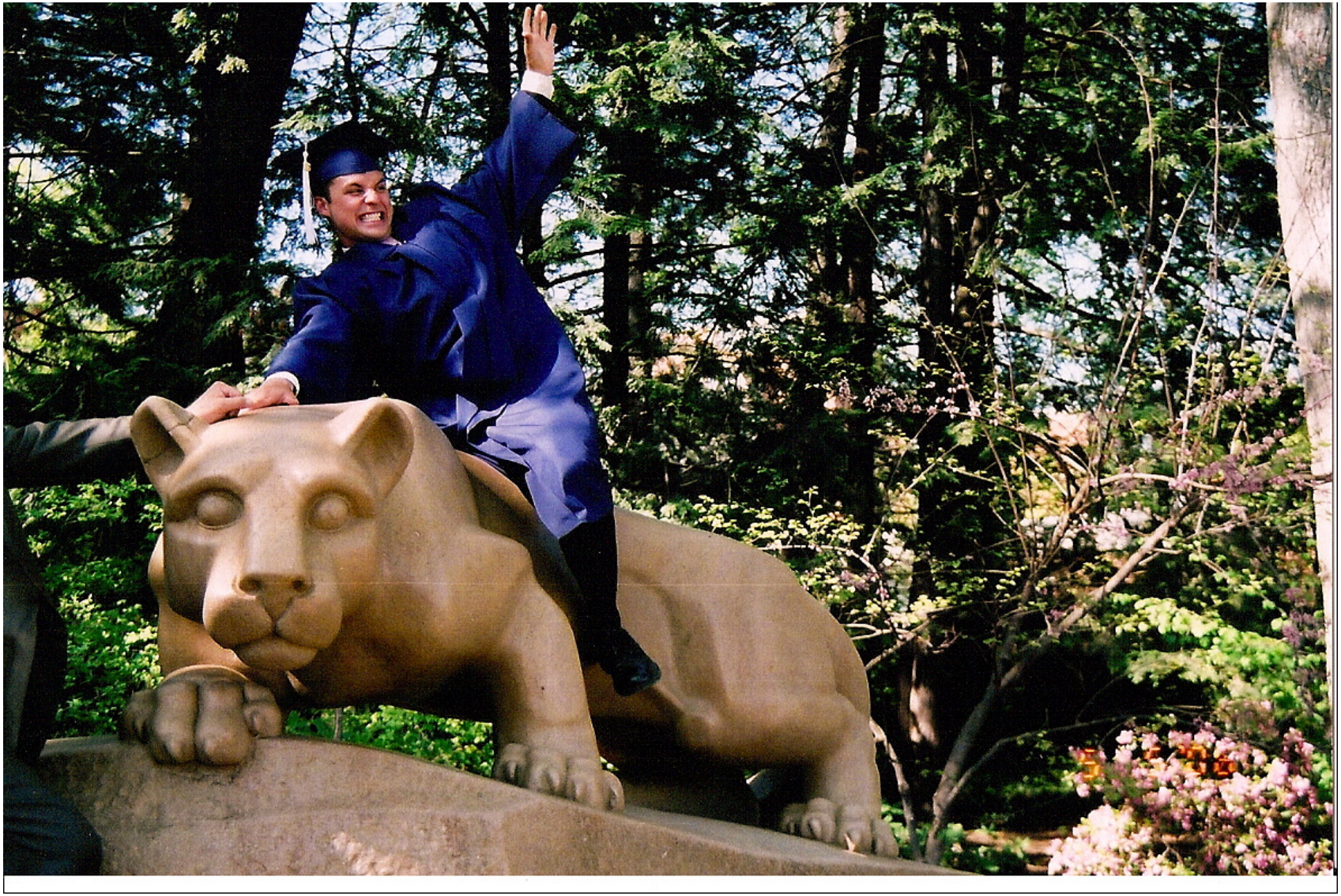


Figure 5: Who knows...

Social life

Figure 6: Sneaking onto the football field with a friend.

My actual Mum & Dad

Figure 7: Marian & Don Beckman

Got an education. . .

Getting more serious. . .

Figure 8: Met my wife in Minnesota and began a career in statistics.

8 years as statistician

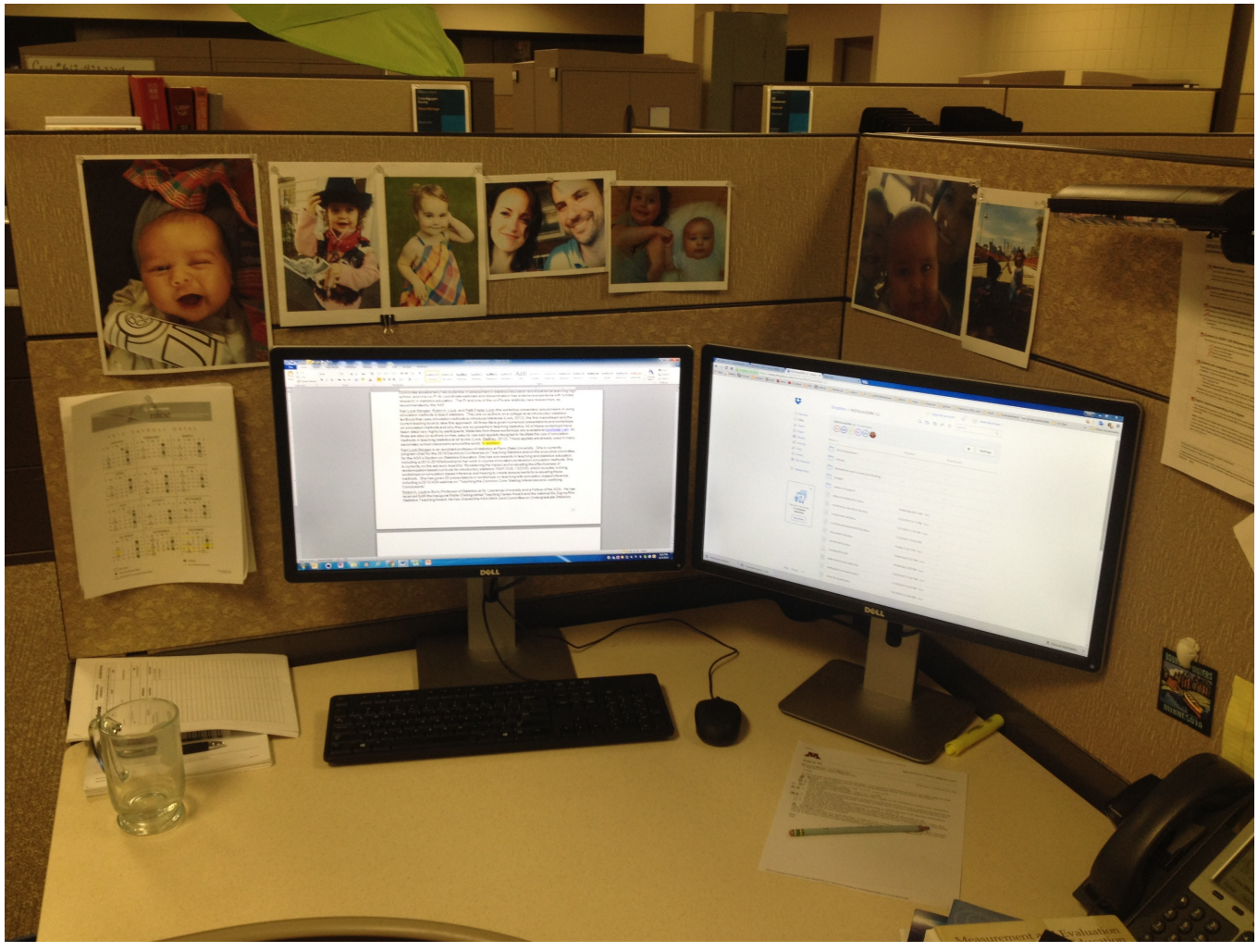


Figure 9: Where the magic happens. . .

Ecolab, Inc.

Figure 10: Image credit: Patrick Kennedy, Star Tribune[2]

- Started out at Ecolab working in R&D (+ Eng)
- Interned with a small team of staff statistical consultants
- Typical data for data-ing: Lots of design & analysis of experiments
- Assist teaching in-house statistics courses for Engineers, Mgmt, scientists, etc (Intro, DOE, MSA, SPC, RDSA)

[2]Kennedy, P., (6 Feb 2023). Ecolab now selling products at Home Depot — the first time available at retail stores. Star Tribune. URL: https://www.startribune.com/ecolab-now-selling-products-at-home-depot-the-

Medtronic, PLC

Figure 11: Medtronic Headquarters. image credit: https://asiapac.medtronic.com/xp-en/about.html

- World's largest medical technology company
- Hired due to commitment to government regulators!
- Data for Data-ing: verbatim complaints from call center, manufacturing lines, *some* clinical, sales & registration data, engineering diagnostics from in-house returned product analysis, lots more!

Medtronic, PLC

Figure 12: Medtronic Headquarters. image credit: https://asiapac.medtronic.com/xp-en/about.html

- "What happens when a competent statistician gets released into a sea of engineers?"

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Nonin Medical. Inc

Figure 13: image credit: Michael Heisson[3]

- Senior Biostatistican ("only" statistician. . .)
- Internal & external collaborations (e.g., anesthesiology research, clinical trial design, etc)
- Data for Data-ing: all of it.

[3]Lee, E., (4 Oct 2022). The Best Pulse Oximeter for Home Use. New York Times Wirecutter. URL: https://www.nytimes.com/wirecutter/reviews/best-pulse-oximeter-for-home-use/

Back to Medtronic!?

- Back to Medtronic for a lame duck session
- Goals: clean up special projects, train new statisticians (& business analysts) and help automate my own job away (!)
- Next Stop: Penn State!
- When I was a few years younger, people gave me puzzled looks when I described my background. . .

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- Life hack: I earned my PhD *while* working full-time

Personal reflections from industry

- I began to notice gaps between my expectations/assumptions for my contributions at work and the reality of my experiences on the job...
- *Expectation*: UMN Statistics Dept filled my toolbox with advanced methods & fancy models... that's what they'll expect me to do at work.

- *Mind the gap*: At work, I generally used 10-20% of the fancy things I learned in those courses

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- Lots of the fancy methods that I needed at work, I *learned* at work. This is a common refrain among professional statisticians.

Personal reflections from industry

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- **Bad** reason this gap might emerge: management may not understand how statisticians best contribute to the organization[4]

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- **Bad** reason this gap might emerge: management may not understand how statisticians best contribute to the organization[4]

- **Good** reason this gap might emerge: (coming up later. . .)

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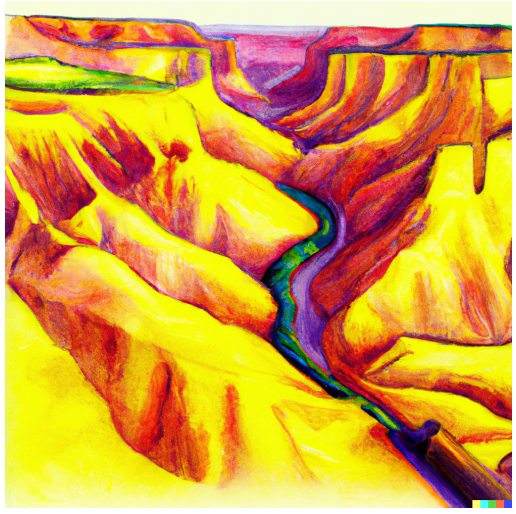

Figure 15: image created with assistance of DALL · E 2 by Open AI

- Role of statisticians at work
- Public perception of Statistics
- Student perception of EDA
- Opportunities for research

Mind the gap: In the public

statistics vs Statistics

Mind the gap: EDA

Perceived value vs potential contribution of EDA[5]

[5] Exploratory Data Analysis

Mind the gap: EDA

- My solution?

Mind the gap: EDA

- My solution?
- my students need a framework for a careful EDA

Mind the gap: EDA

- My solution?
- my students need a framework for a careful EDA
- with an acronym to help remember it

EDA Framework (1st attempt)

Get in "B-E-D" with your data

- **B**ecome acquainted with the data

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- **D**iscover features in the data that impact modeling decisions

EDA Framework (2nd attempt)

. . . not a great acronym

Let's just reuse "EDA" instead

- **Examine the data source(s)**: data provenance, variable types, coding, missingness, summary statistics/plots;

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- p.s. Lonneke's work included a concise summary of literature that I think improves upon the "E" step!

Mind the gap: Opportunity for research?

Mind the gap: Statistical Thinking

International Statistical Review (1999), **67**, 3, 223–265, Printed in Mexico
© International Statistical Institute

Statistical Thinking in Empirical Enquiry

C.J. Wild and M. Pfannkuch

Department of Statistics, University of Auckland, Private Bag 92019, Auckland, New Zealand

This paper had its genesis in a clash of cultures. Chris Wild is a statistician. Like many other statisticians, he has made impassioned pleas for a wider view of statistics in which students learn "to think statistically" (Wild, 1994). Maxine Pfannkuch is a mathematics educator whose primary research interests are now in statistics education. Conception occurred when Maxine asked "What ***is*** statistical thinking?" It is not a question a statistician would ask. Statistical thinking is the touchstone at the core of the statistician's art. But, after a few vague generalities, Chris was reduced to stuttering.

Figure 16: Opening vignette from one of my all-time favorite papers.[6]

[6]Wild, C. J., Pfannkuch, M. (1999). Statistical thinking in empirical enquiry. International Statistical Review, 67(3), pp 223-265.

Thinking Statistically

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- Disciplined approach to problem solving & critical thinking

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- *Bad* reason: management unclear what contribution statisticians offer to the organization

- **Good reason**: perhaps my colleagues recognized that *statistical thinking transfers*

- Disciplined approach to problem solving & critical thinking
- Due consideration for uncertainty, alternate explanations, and practical implications

Mind the gap: Data & Data-ing

"the pair data and data-ing refers to a similar conceptualization of the relation between sample and sampling, or model and modeling, where the first is the statistical concept and the second refers to the process of engaging or reasoning with this concept."

- So, why verb the noun??

Mind the gap: Data & Data-ing

"the pair data and data-ing refers to a similar conceptualization of the relation between sample and sampling, or model and modeling, where the first is the statistical concept and the second refers to the process of engaging or reasoning with this concept."

- So, why verb the noun??
- Maybe because a verb for the action we're describing *doesn't exist*!

What *IS* data-ing?

- Something new to be explored?

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- Something familiar by another name?

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What *IS* data-ing?

- Something new to be explored?
- Something familiar by another name?
- An intersection?
- A superset?
- What about Gapminder? Dollar Street? Factfulness?

What actions might data-ing include?

- data collection (Yannik & Susanne)
- variable creation/recognition (Amelia & Sibel)
- modeling and interpretation of data (Lucia)
- data cleaning (Many SRTL-ers)

More engaging and reasoning with data

- Andee & Michal probe evaluation of which data **needed** to achieve the scientific purposes?

- Carl & Kym evoke notions about data and empowering students to uncover rich (multivariate) stories
- Alyssa seeks to examine the interface between computational thinking and data-ing
- What if we favor an algorithmic rather than inferential "culture"?[7]
- Ronit challenges us to consider "big data-ing"

More engaging and reasoning with data

- Andee & Michal probe evaluation of which data **needed** to achieve the scientific purposes?

- Proxy variables when we encounter a gap in the available (or accessible) data to achieve the scientific purpose of our analysis–really important part of "data-ing" as an applied statistician, but these are motivated by the scientific domain

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[7] Laney, D. (2001). 3D data management: Controlling data volume, velocity and variety. In: Meta Group.

How well-defined is "data"

- Is "messy" data well-defined?
  - any deviation from tidy data[8]?
  - Amelia & Kym discuss intuition of data cards
- What is "big data"??[9]
  - Volume? Velocity? Variety?[10]
  - Does "messier" make it "bigger"
  - Is the distinction absolute or relative?
  - how will this make "big data-ing" different?
- Jill & Lonneke discuss consuming and evaluating evidence–and implications of data-ing when engaged with forms of evidence more broadly concieved than has been typical for classical data analysis

[8] Wickham, H. (2014). Tidy data. Journal of Statistical Software, 59(10). DOI: 10.18637/jss.v059.i10

[9] Kitchin, R., & McArdle, G. (2016). What makes Big Data, Big Data? Exploring the ontological characteristics of 26 datasets. *Big Data & Society, 3*(1).

[10] Laney, D. (2001). 3D data management: Controlling data volume, velocity and variety. In: Meta Group.


RESTRANT FORUM
RFDASE REDALARART

References

- Batty, M. (2015). Data about cities: Redefining big, recasting small. Paper prepared for the Data and the City workshop, Maynooth University, 31 August–1 September 2015. URL: http://www.spatialcomplexity.info/files/2015/08/Data-Cities-Maynooth-Paper-BATTY.pdf
- Breiman, L. (2001). Statistical modeling: The two cultures. *Statistical science, 16*(3), 199-231.
- Deming, W. E. (2000). *Out of the Crisis*. MIT Press.
- Kitchin, R., & McArdle, G. (2016). What makes Big Data, Big Data? Exploring the ontological characteristics of 26 datasets. *Big Data & Society, 3*(1).
- Laney, D. (2001) 3D data management: Controlling data volume, velocity and variety. In: Meta Group. URL: https://studylib.net/doc/8647594/3d-data-management--controlling-data-volume--velocity--an...
- Tukey, J. (1977). *Exploratory Data Analysis*. Vol 2.
- Wickham, H. (2014). Tidy data. *Journal of Statistical Software, 59*(10). DOI: 10.18637/jss.v059.i10
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