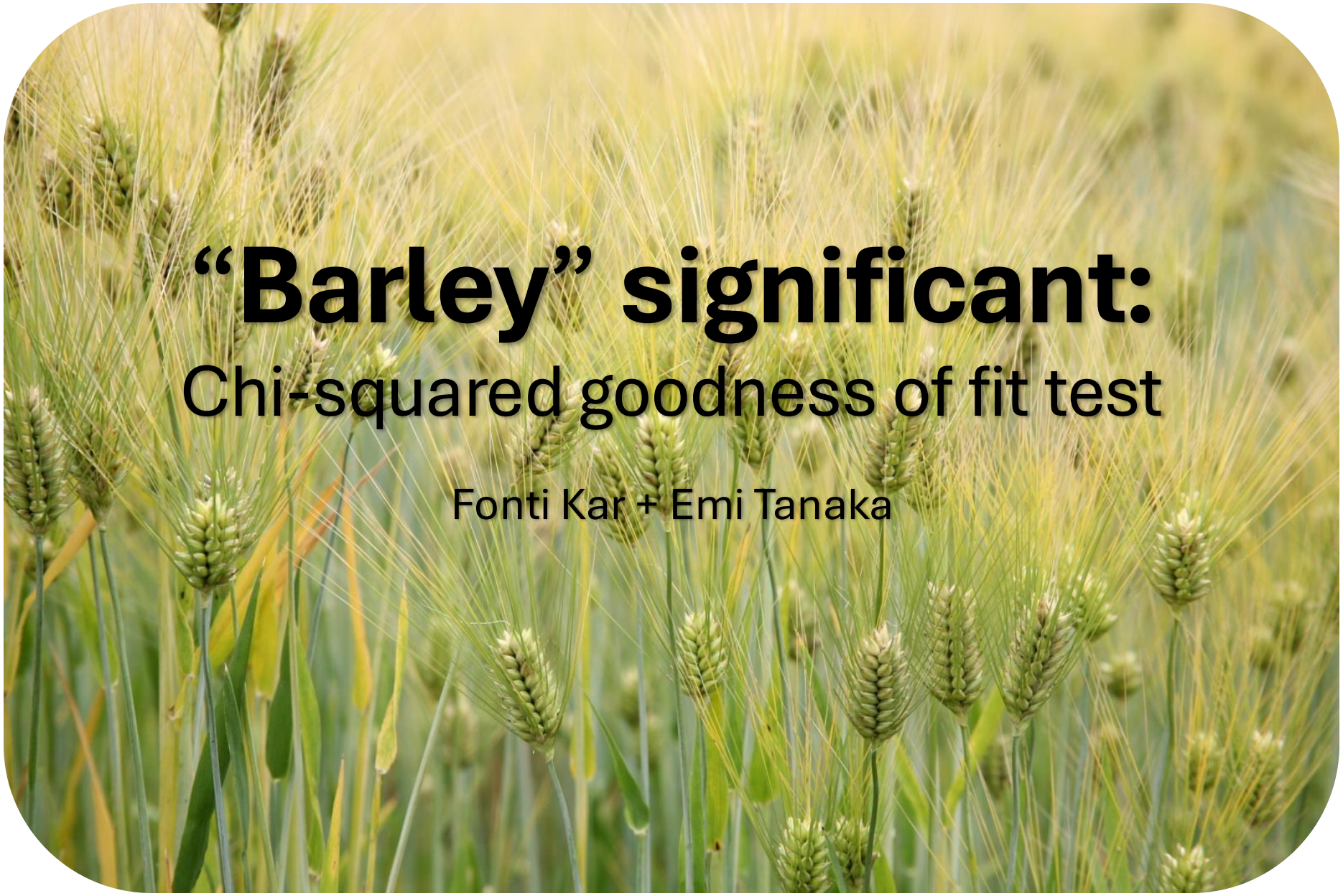

“Barley” significant:
Chi-squared goodness of fit test
Fonti Kar + Emi Tanaka

Outline

- Motivating example 
- Significance testing
  - Test statistic (Chi-squared goodness of fit)
  - Degrees of freedom
  - Significance level and critical value
  - *P*-value
- A sweet little exercise
- GTA x ZoomAgri


Cadbury
Favourites
TURKISH DELIGHT
Cadbury
Favourites
FUN & GAMES
VISIT
CADBURYFAVOURITES.COM
FOR FUN, GAMES
AND TRIVIA
Cadbury
Favourites
Cadbury
DAIRY M
Caramello
flake
Cadbury
crunc
Cad
Drea
℮ 265g

Shelley Down ▸ **Cadbury Dairy Milk**
Yesterday ·

Hiiii Cadbury
Was super excited to watch my son open his Favourites Easter Egg but had a bit of a WTF moment when we realised there were 7 Cherry Ripes and 1 Dairy Milk. I know Cherry Ripes get a bit of a tough time and you still need to force them upon us but the ratio seems a bit drastic!
Did you have a newbie working on the distribution line that day because surely this ain't right?!

Emma Hayes-Cooke, Lee Bright, Naima Maanaima and 3,268 others like this.

Top Comments

38 shares 398 comments

Cadbury Dairy Milk Thanks for your feedback. Whilst the process of the pieces going into the packet is randomised, it is not intentional that you would get that much of one particular product. Could you please PM us with the barcode, Best Before Date and batch code from the pack, as well as your address details, and we'll be in touch?

77 · 21 hrs

16 Replies · 2 hrs

How do we know when we have a leg to stand on?

38 shares 398 comments

Cadbury Dairy Milk Thanks for your feedback. Whilst the process of the pieces going into the …hat you …uct. …, Best Before Date and batch code from the pack, as well as your address details, and we'll be in touch?

77 · 21 hrs

16 Replies · 2 hrs

Cadbury's prevailing view vs. consumers

H_0 = Equal chance of drawing any brand of chocolate

Cadbury's prevailing view vs. consumers

H_0 = Equal chance of drawing any brand of chocolate

H_1 = ***Unequal*** chance of drawing any brand of chocolate

How well does the observed data fit the theory?

Test statistic

- A standardised, numeric ***summary*** our data
- Decide whether we have enough evidence to reject the default view (H_0)

Chi-squared test statistic

observed value

expected value

$$\chi^2 = \sum^{4} \frac{(O_i - E_i)^{2\,[2]}}{E_i\,[3]}$$

[1] Finding a difference or goodness of fit 😉

[2] Making it absolute

[3] Standardise differences by expected value

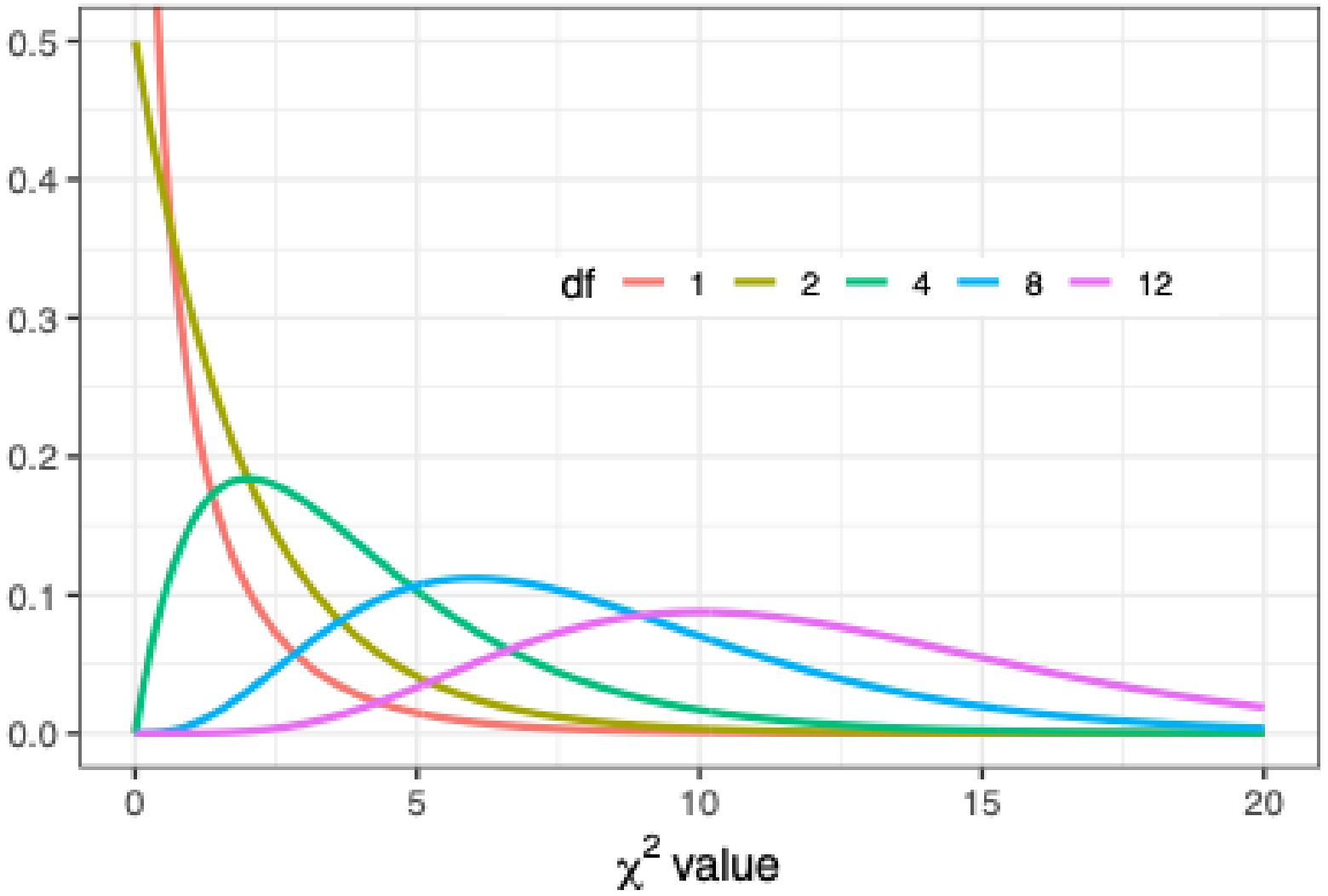
[4] Add them all up

Degrees of Freedom (k)

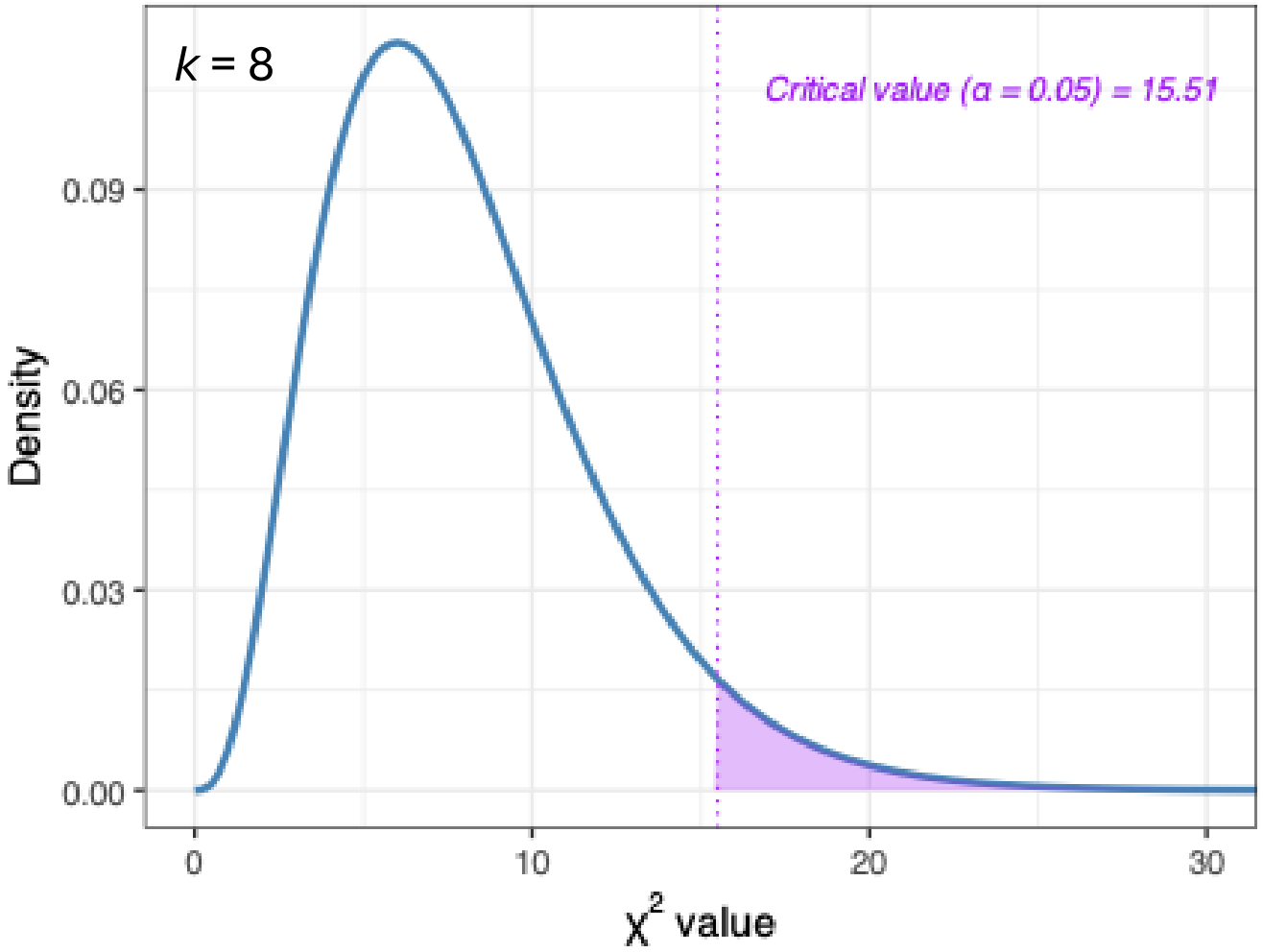
- *Independent, free* information in data
- Determines shape of χ^2 distribution

k = Number of categories - 1
= 9 brands - 1
= 8

Brand	Observed
Dream	1
Caramello	1
Dairy Milk	1
Moro	1
Flake	1
Boost	3
Cherry Ripe	2
Picnic	3
Turkish	2
TOTAL	**15**



Is what we observed extreme enough to cause a fuss?



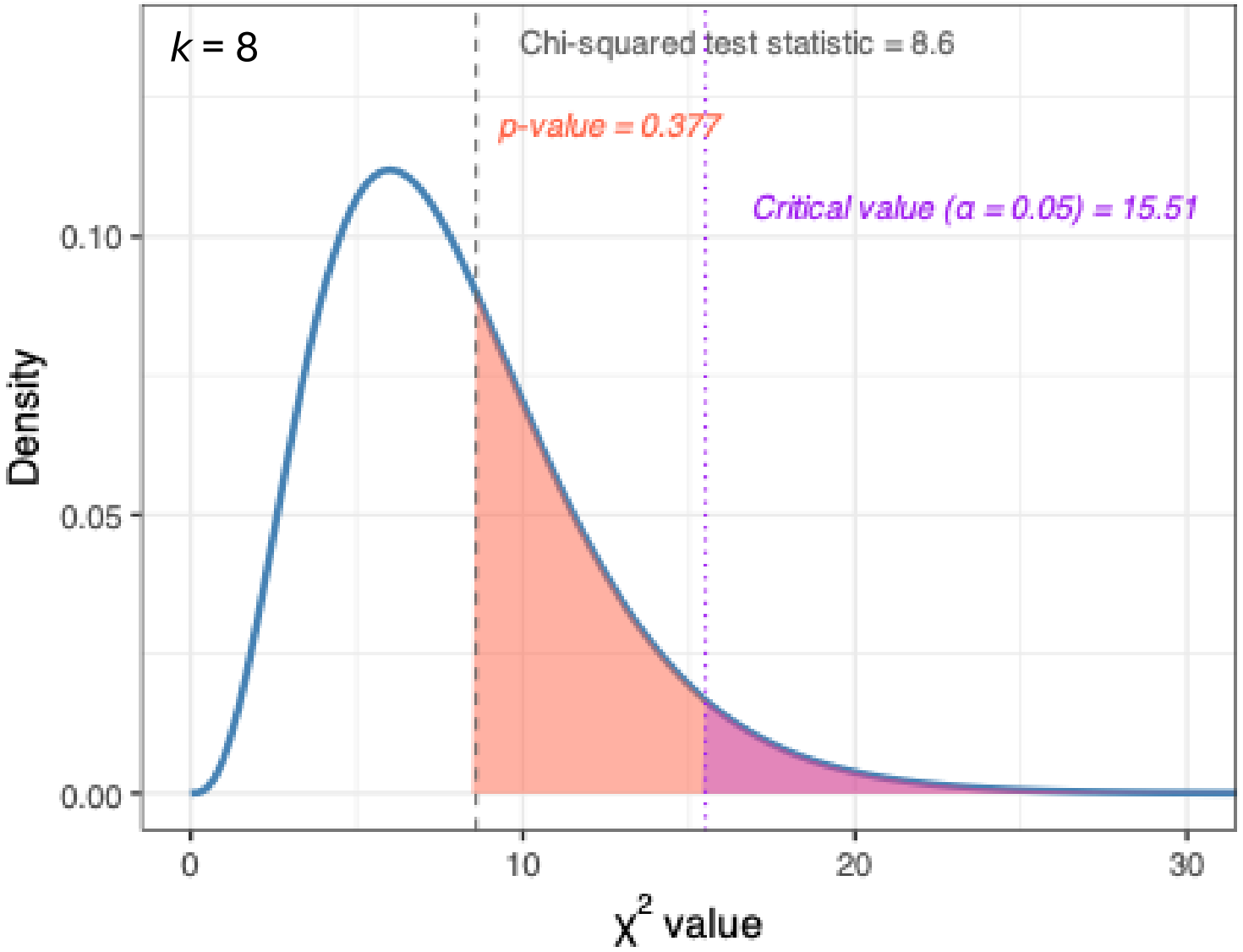
Significance level α

- how much probability we allow in the "rejection region"
- $\alpha = 0.05$
  - Balance of being too lenient vs. too cautious

Critical value

- A benchmark for us to determine whether our test statistic is extreme enough to reject the null.

Is what we observed extreme enough to cause a fuss?



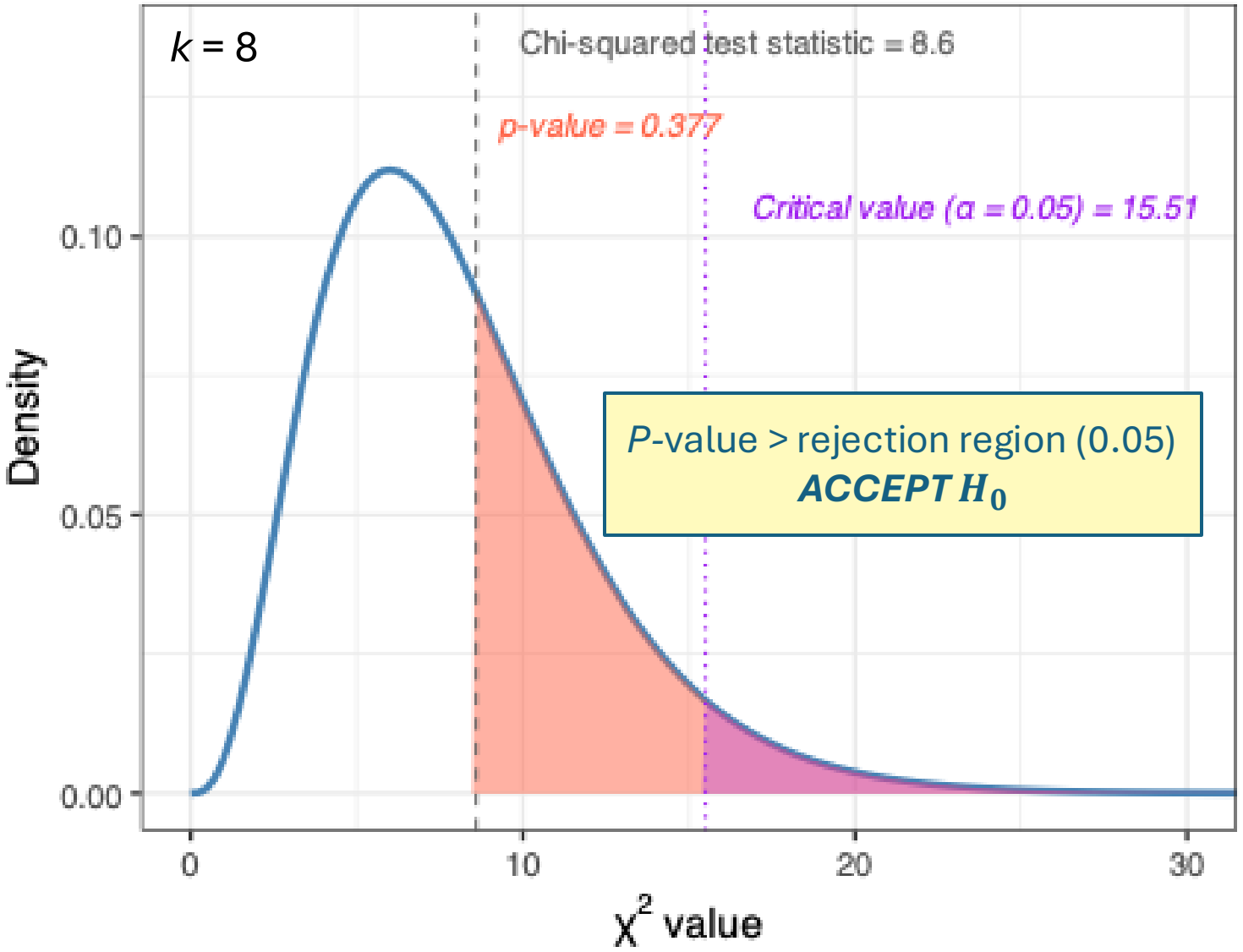
Compare our *test statistic* to the *critical value*

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

p-value

- Probability of observing test statistic, if the H_0 were true

Is what we observed extreme enough to cause a fuss?



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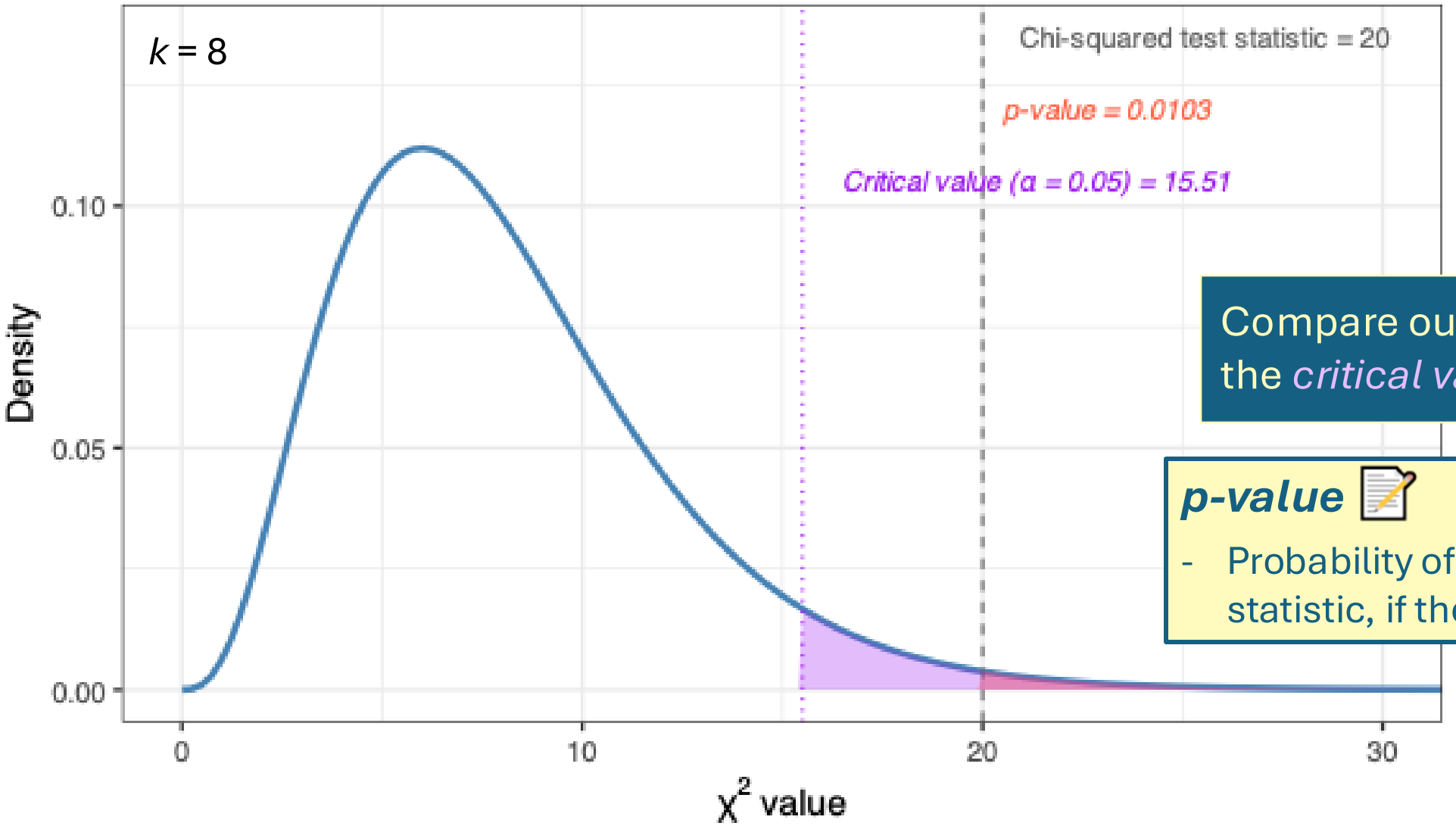
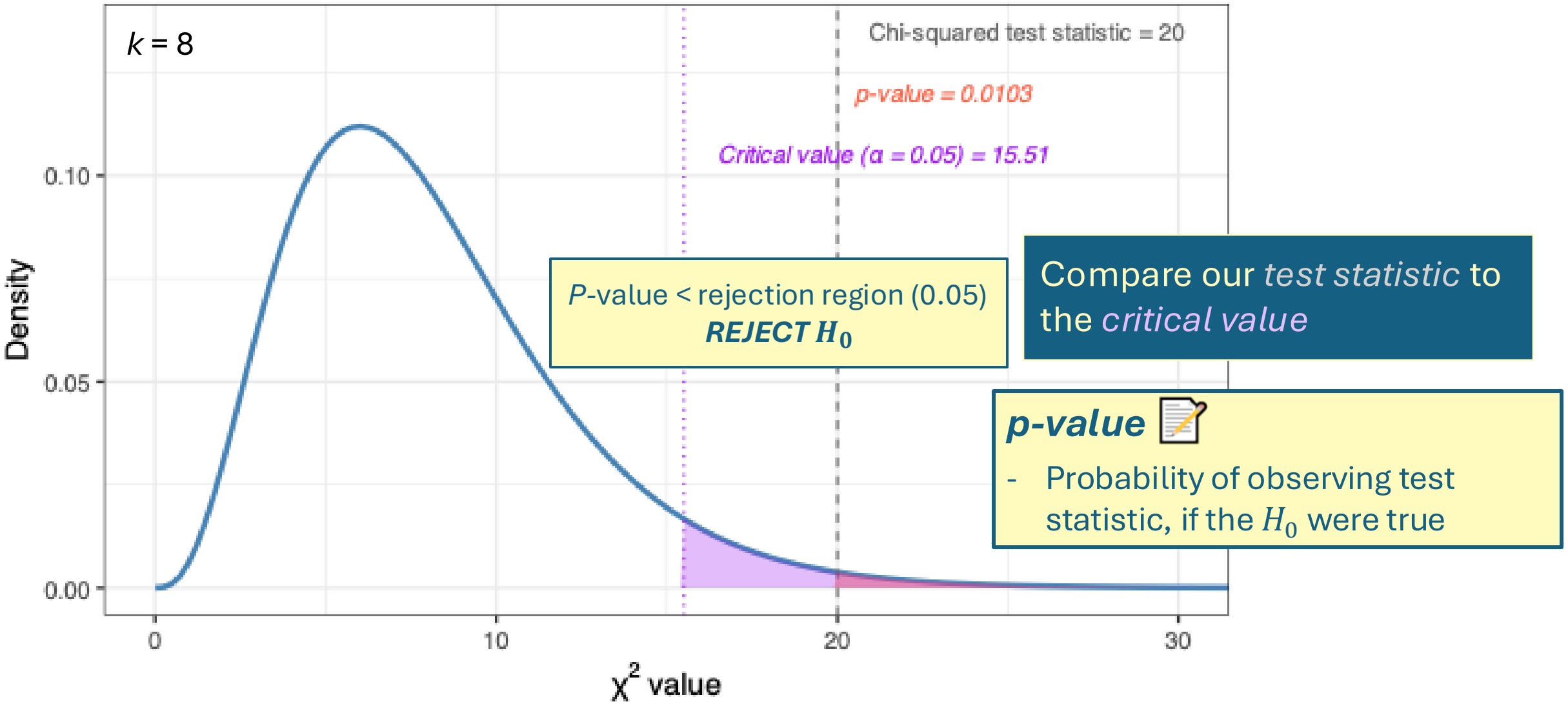


Compare our *test statistic* to the *critical value*

p-value

- Probability of observing test statistic, if the H_0 were true

Is what we observed extreme enough to cause a fuss?



P-value < rejection region (0.05)
REJECT H_0

Compare our *test statistic* to the *critical value*

p-value

- Probability of observing test statistic, if the H_0 were true

Put it to practice

H_0 = Equal chance of drawing any brand of chocolate

H_1 = ***Unequal*** chance of drawing any brand of chocolate

Chi-squared test statistic

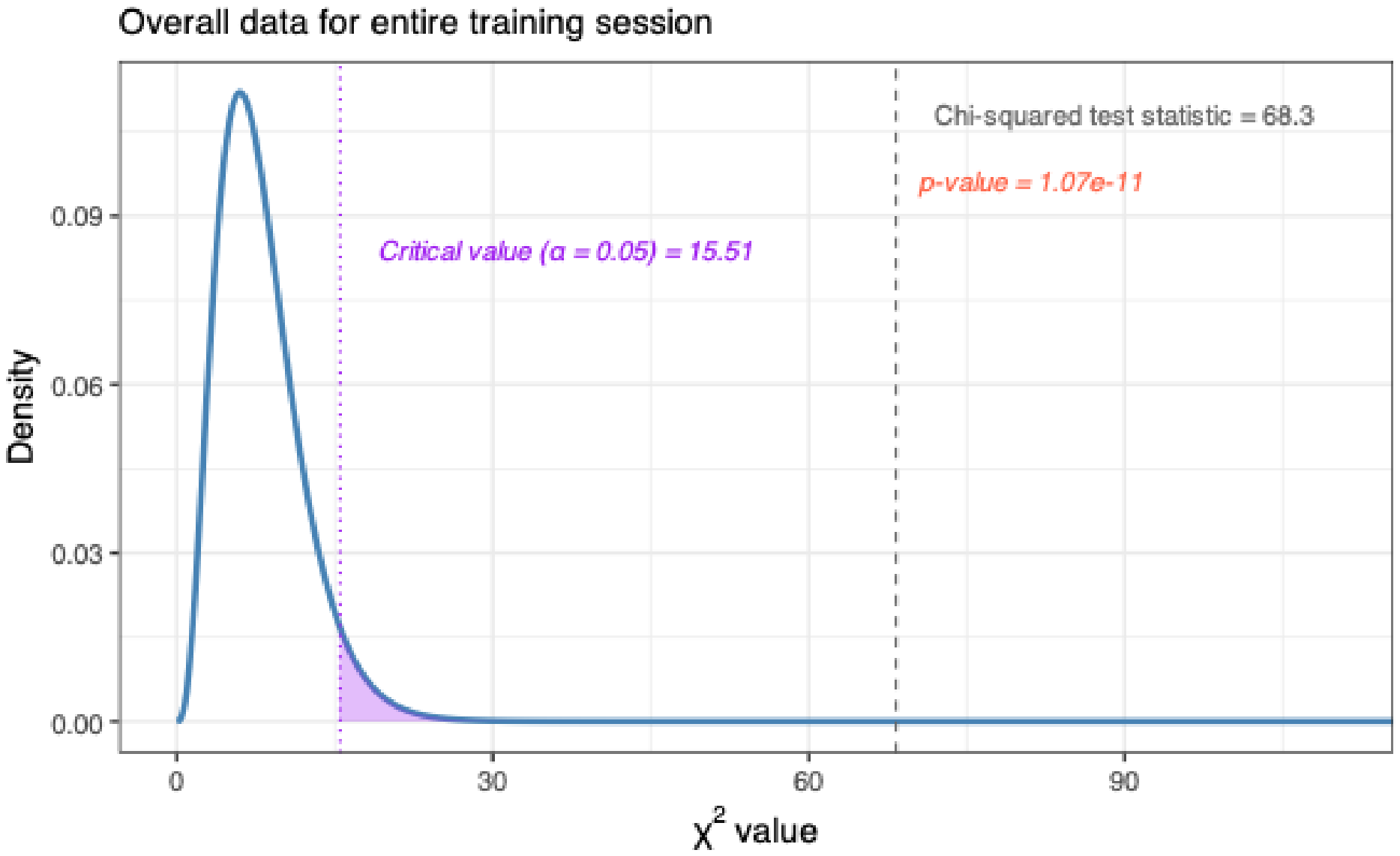
observed value

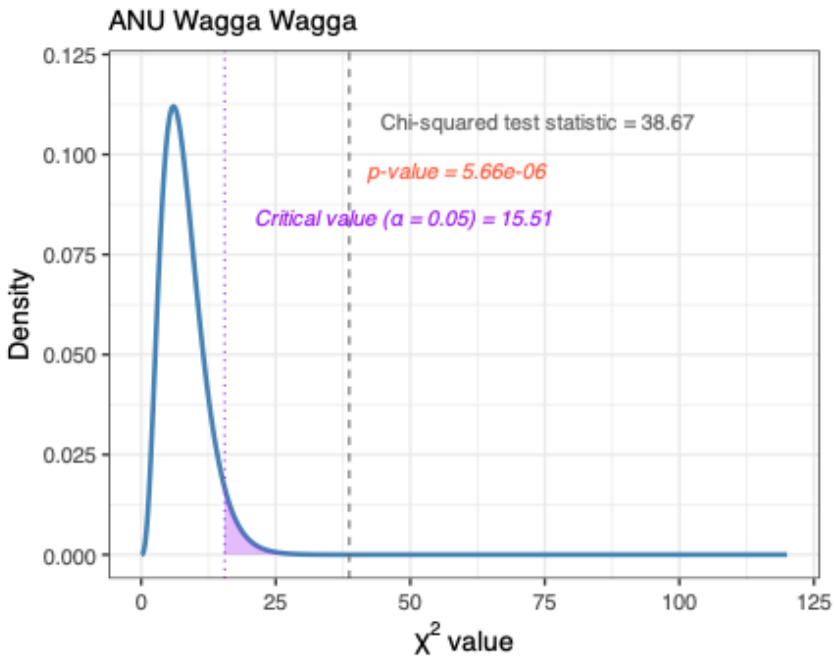
expected value

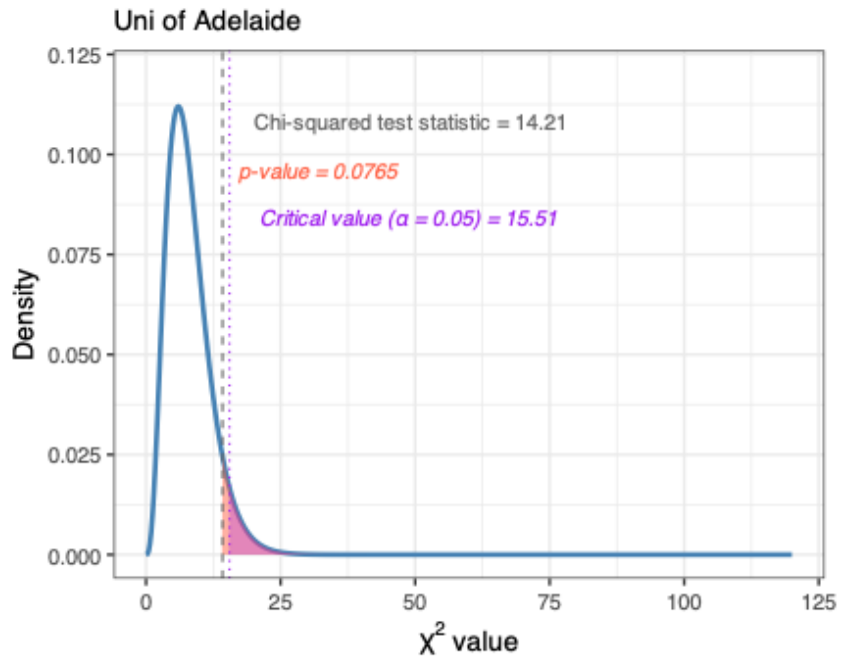
$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

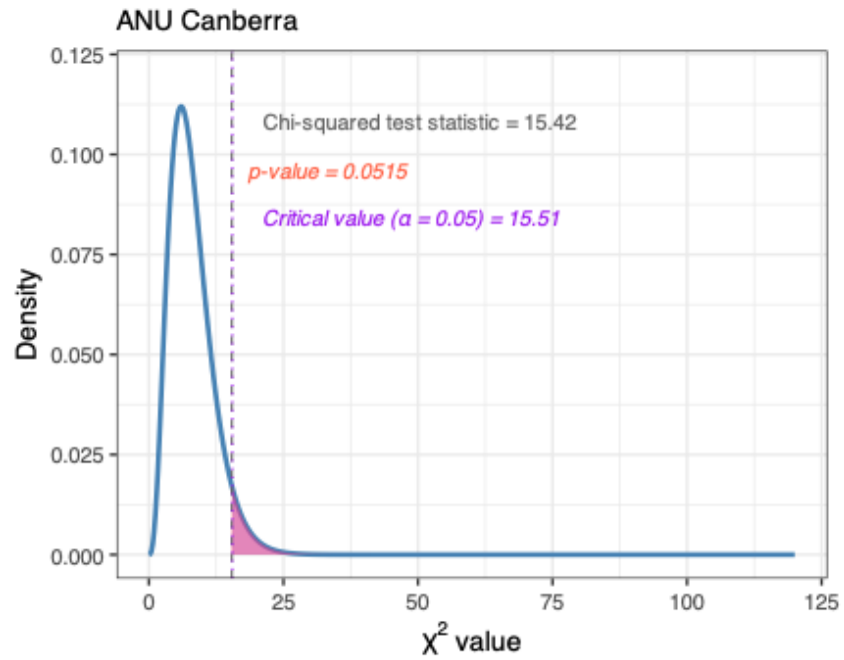
Let's have a go! 🤓 **(10 mins)**

Open your boxes and enter the data!


Overall data for entire training session
Chi-squared test statistic = 68.3
p-value = 1.07e-11
Critical value (α = 0.05) = 15.51
Density
0.09
0.06
0.03
0.00
0
30
60
90
χ² value

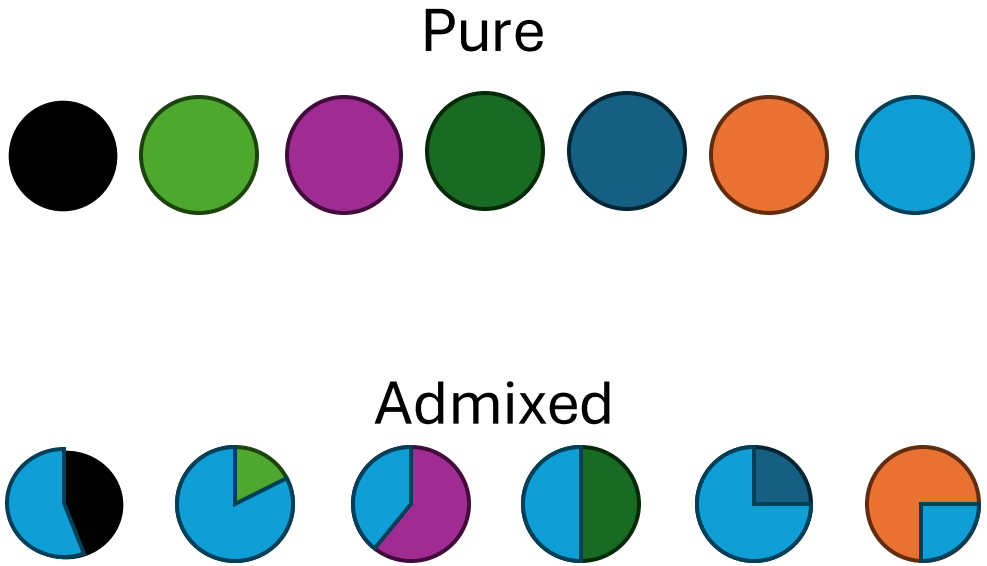

ANU Wagga Wagga
Chi-squared test statistic = 38.67
p-value = 5.66e-06
Critical value (α = 0.05) = 15.51
Density
0.125
0.100
0.075
0.050
0.025
0.000
0
25
50
75
100
125
X2 value


Uni of Adelaide
Chi-squared test statistic = 14.21
p-value = 0.0765
Critical value (α = 0.05) = 15.51
Density
0.125
0.100
0.075
0.050
0.025
0.000
0
25
50
75
100
125
X2 value


ANU Canberra
Chi-squared test statistic = 15.42
p-value = 0.0515
Critical value (α = 0.05) = 15.51
Density
0.125
0.100
0.075
0.050
0.025
0.000
0
25
50
75
100
125
X2 value

ZOOMAGRI methods

- 10 devices
- 7 barley varietals
- 24 samples
  - 12 x Pure
  - 12 x Admixed



GRAIN TRADE AUSTRALIA

What is the **efficacy** and consistency of the ZoomAgri devices in detecting the correct barley varietal(s)?

Testing at different levels

By evaluation

Expected

Observed

Device 1

Device 2

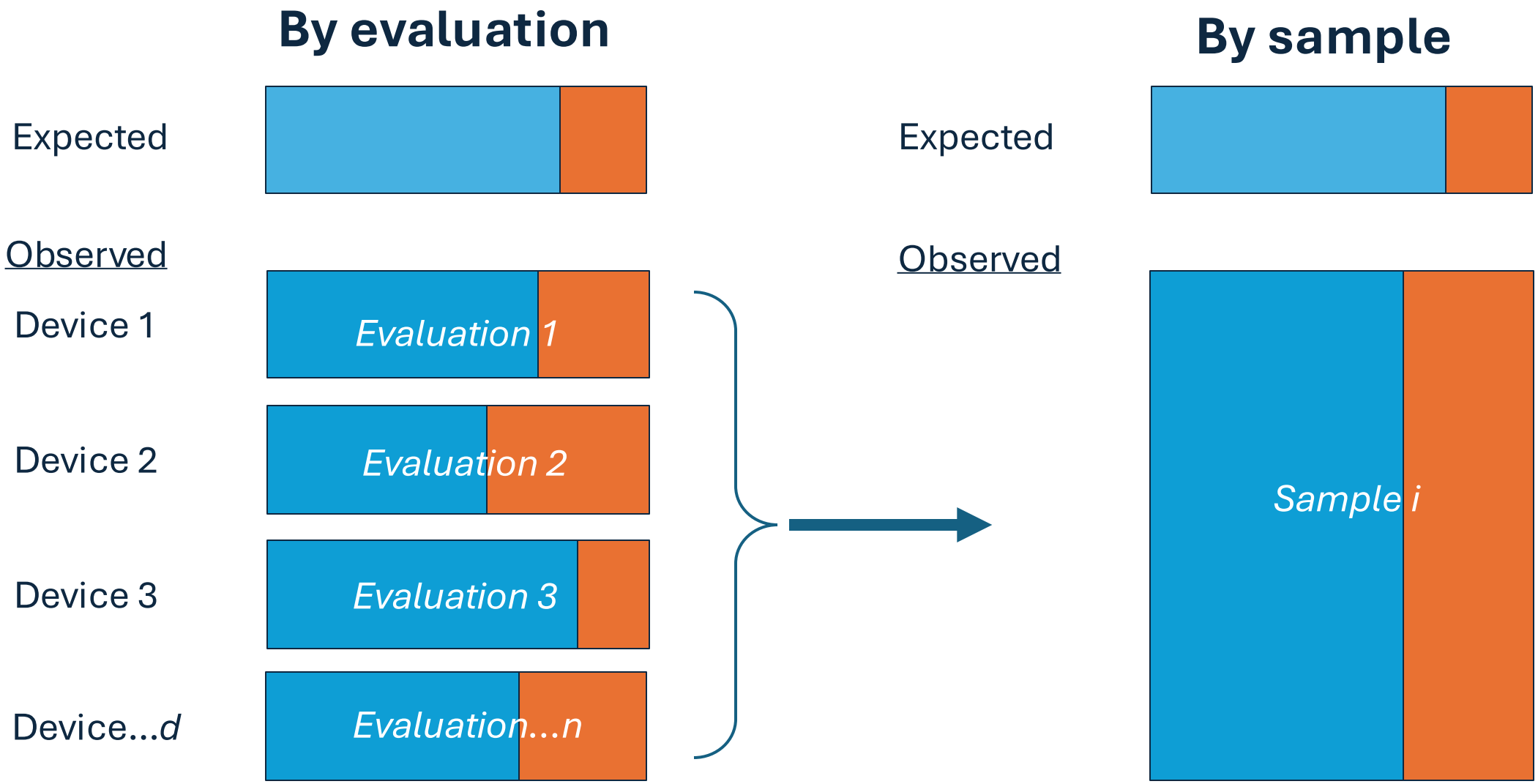
Device 3

Device…*d*

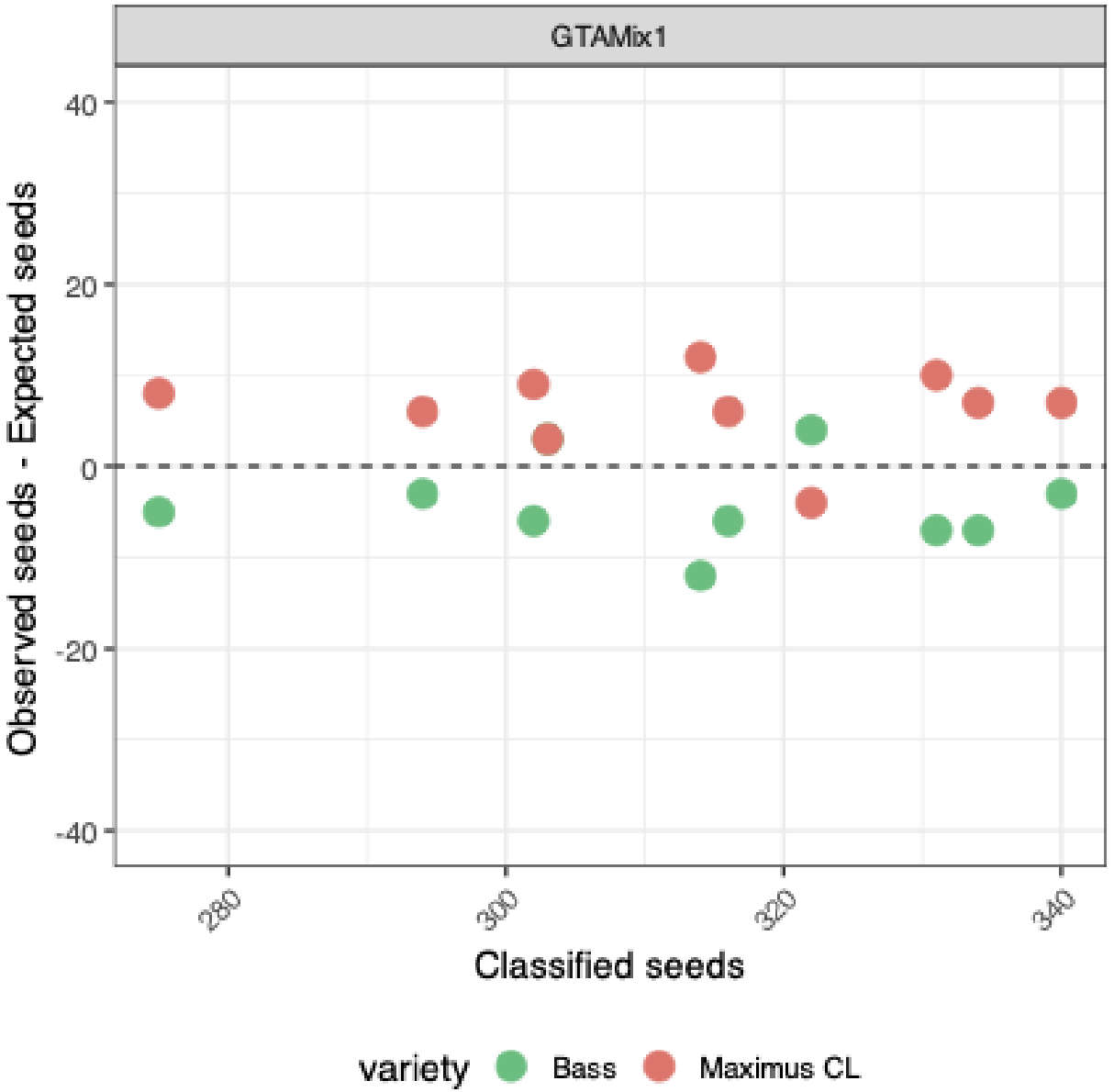
By sample

Expected

Testing at different levels



Let’s visualise the differences



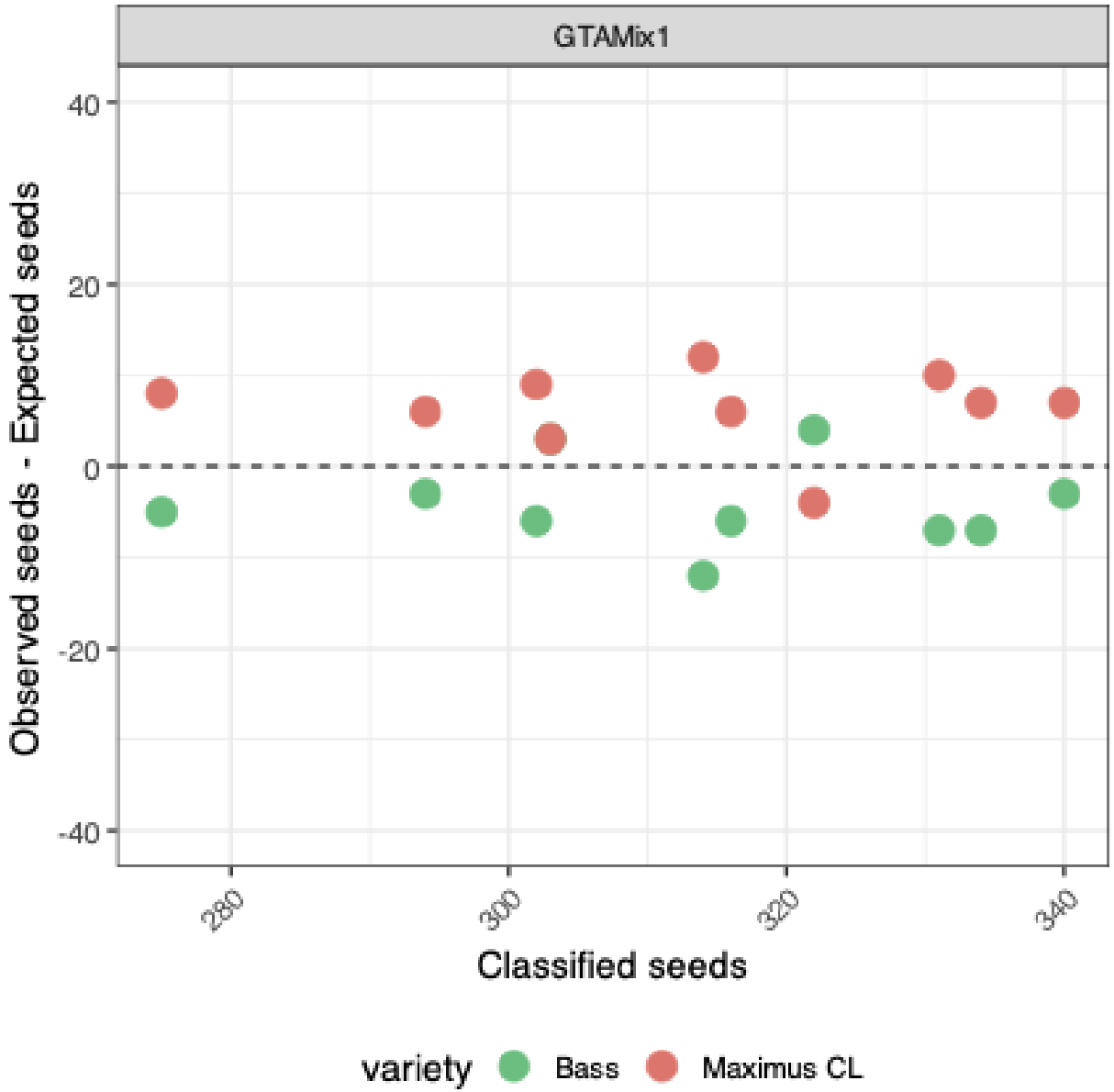
Data viz 🎨

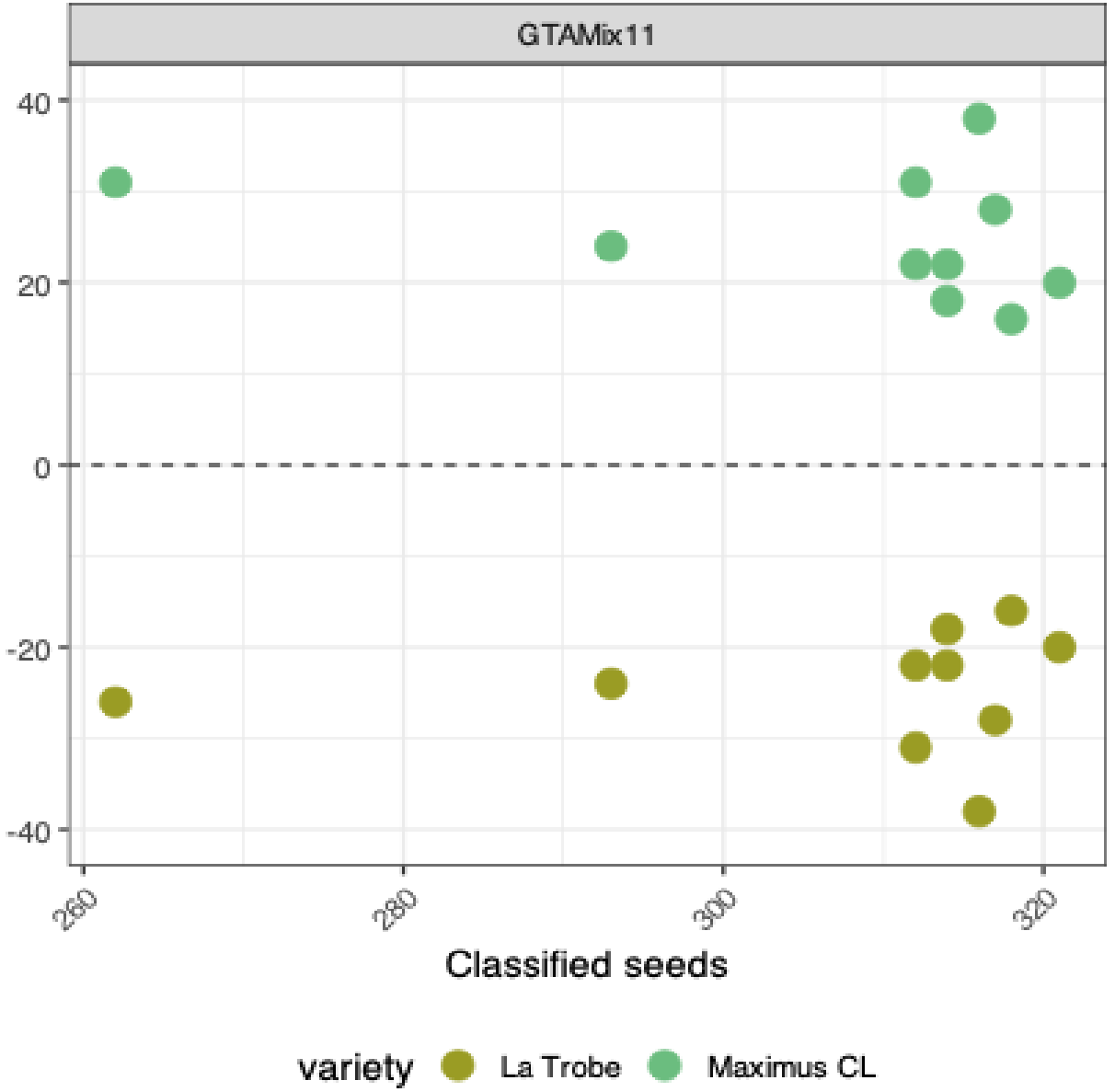
- Middle, **horizontal line** is our **benchmark**
- **Distance** from middle is relative to **discrepancy**
- **Scatterplot** to show how **discrepancy** **changes** with classified seeds

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

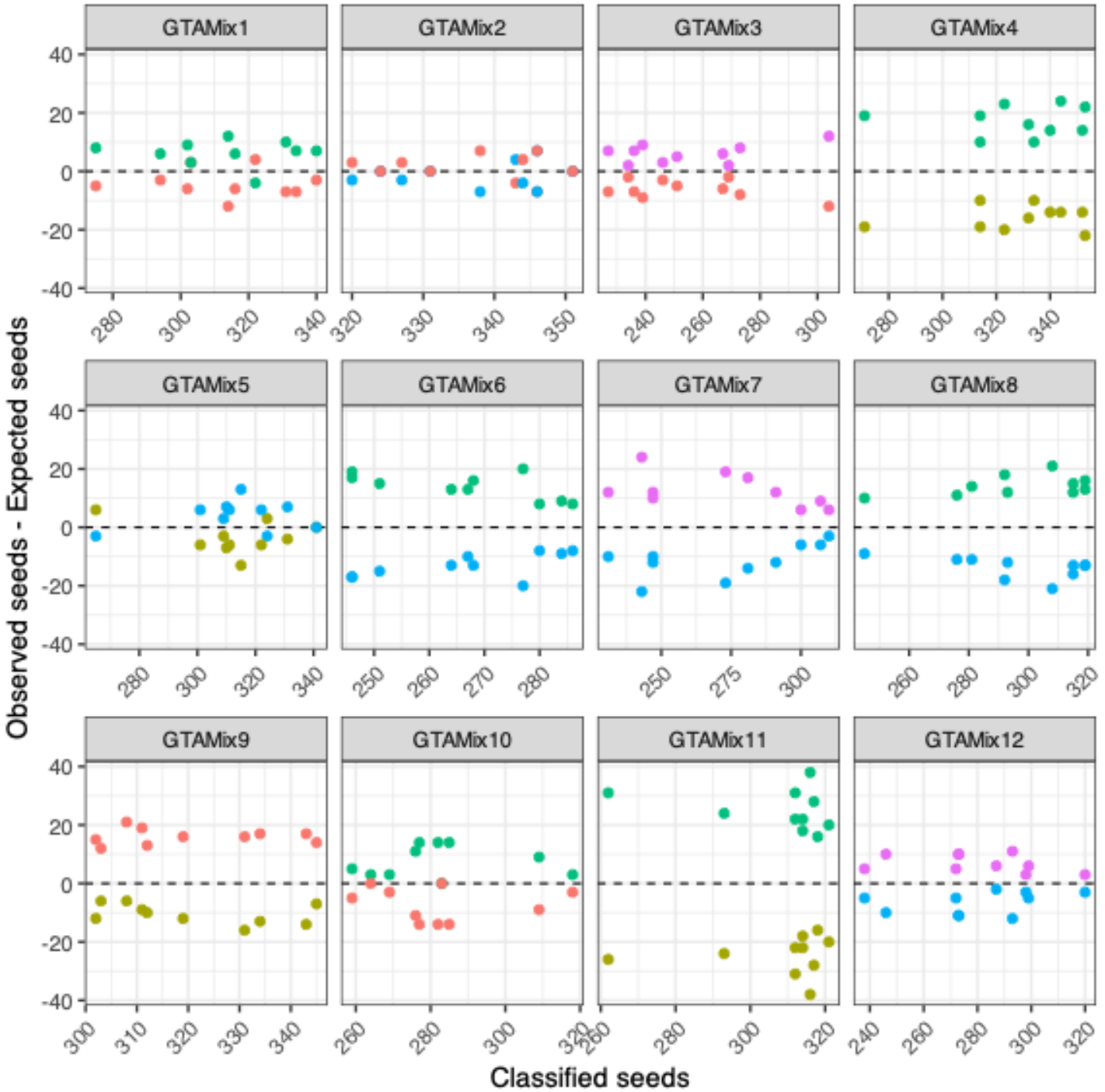
What would their χ^2 look like?

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

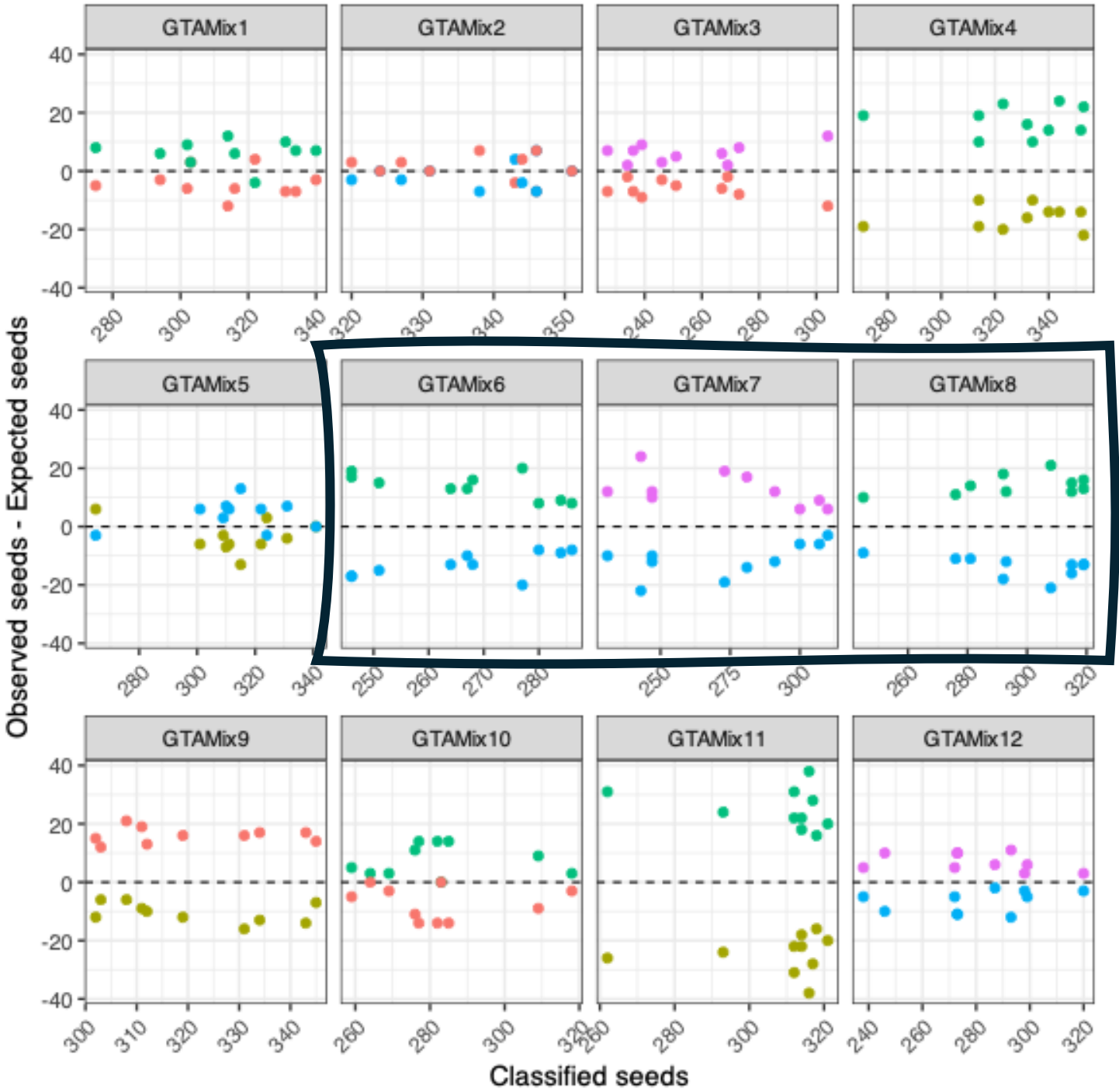




Across all samples

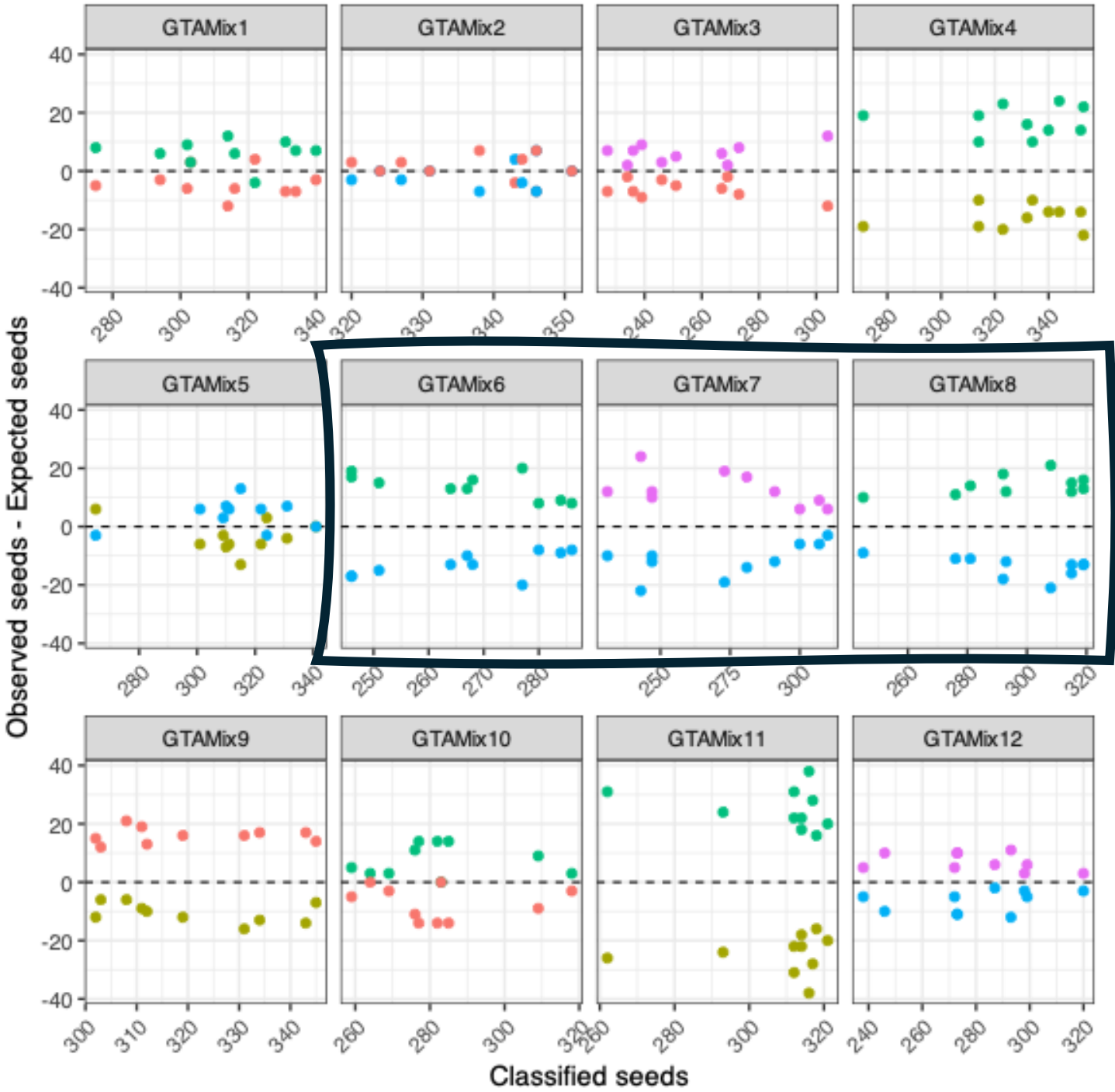


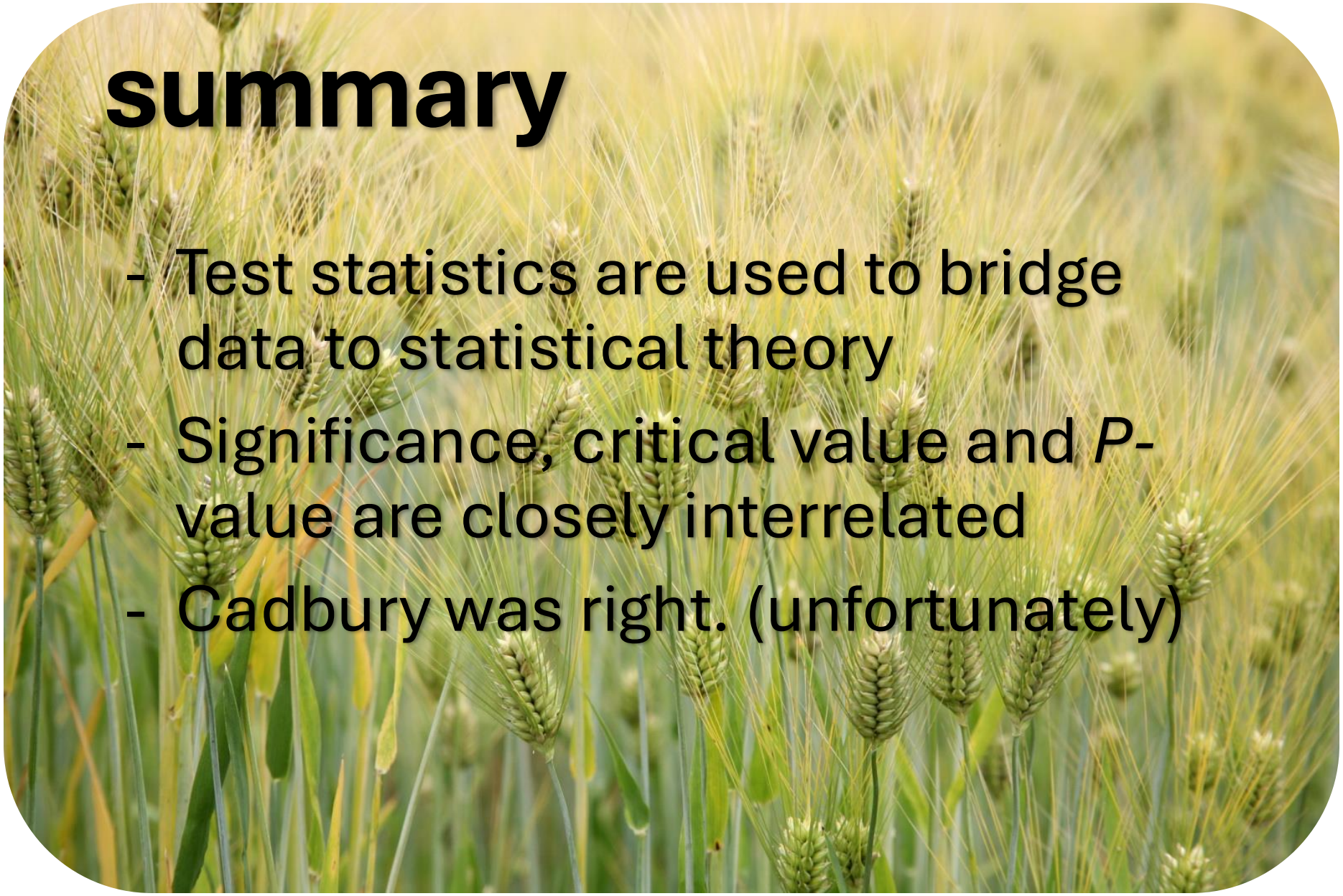
Across all samples



Across all samples

Sample code	Variety mixture	X^2	df	p-value	
GTAMix5	La Trobe (75%), Planet (25%)	6.82	10	0.742	
GTAMix6	Maximus CL (75%), Planet (25%)	38.82	10	<0.001	***
GTAMix7	Spartacus CL (70%), Planet (30%)	31.12	10	<0.001	***
GTAMix8	Planet (70%), Maximus CL (30%)	33.10	10	<0.001	***





summary

- Test statistics are used to bridge data to statistical theory
- Significance, critical value and *P*-value are closely interrelated
- Cadbury was right. (unfortunately)