infer

an R package for tidy statistical inference

Andrew Bray

infer.netlify.com

infer makes p-values easier to compute.

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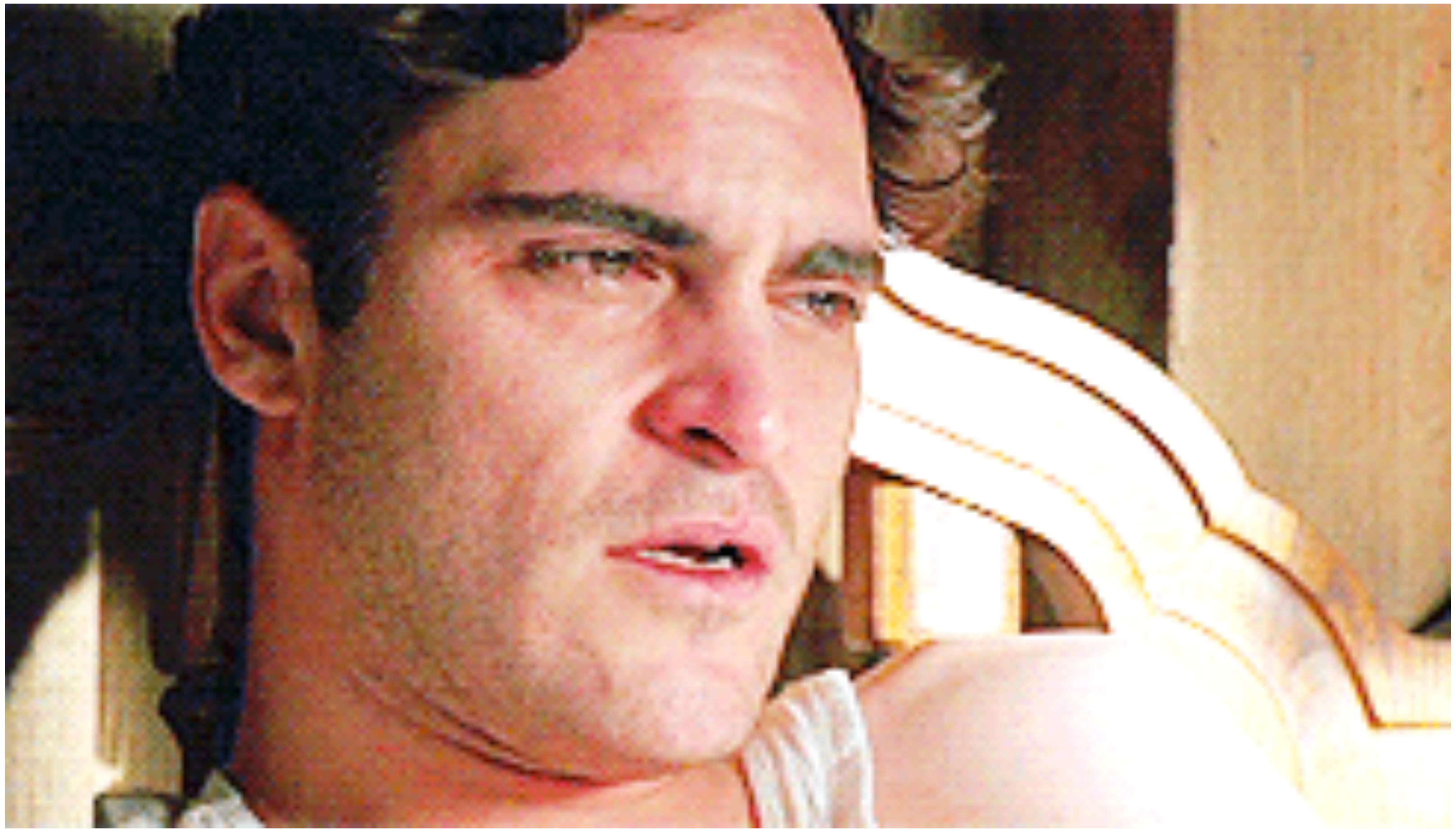

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statistical inference

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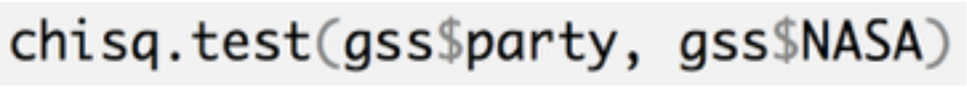
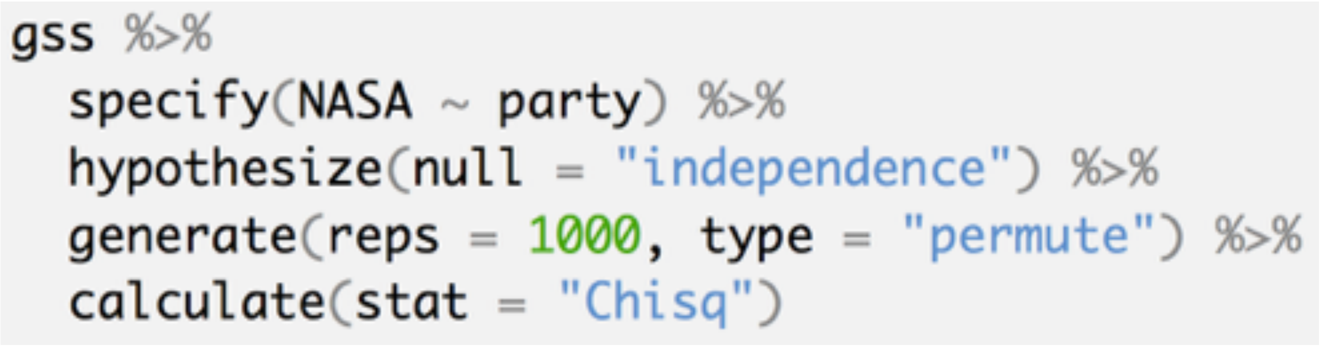


```
chisq.test(gss$party, gss$NASA)
```



```
gss %>%
  specify(NASA ~ party) %>%
  hypothesize(null = "independence") %>%
  generate(reps = 1000, type = "permute") %>%
  calculate(stat = "Chisq")
```

statistical
inference

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tidy and
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Case study: Is funding for space exploration a partisan issue?

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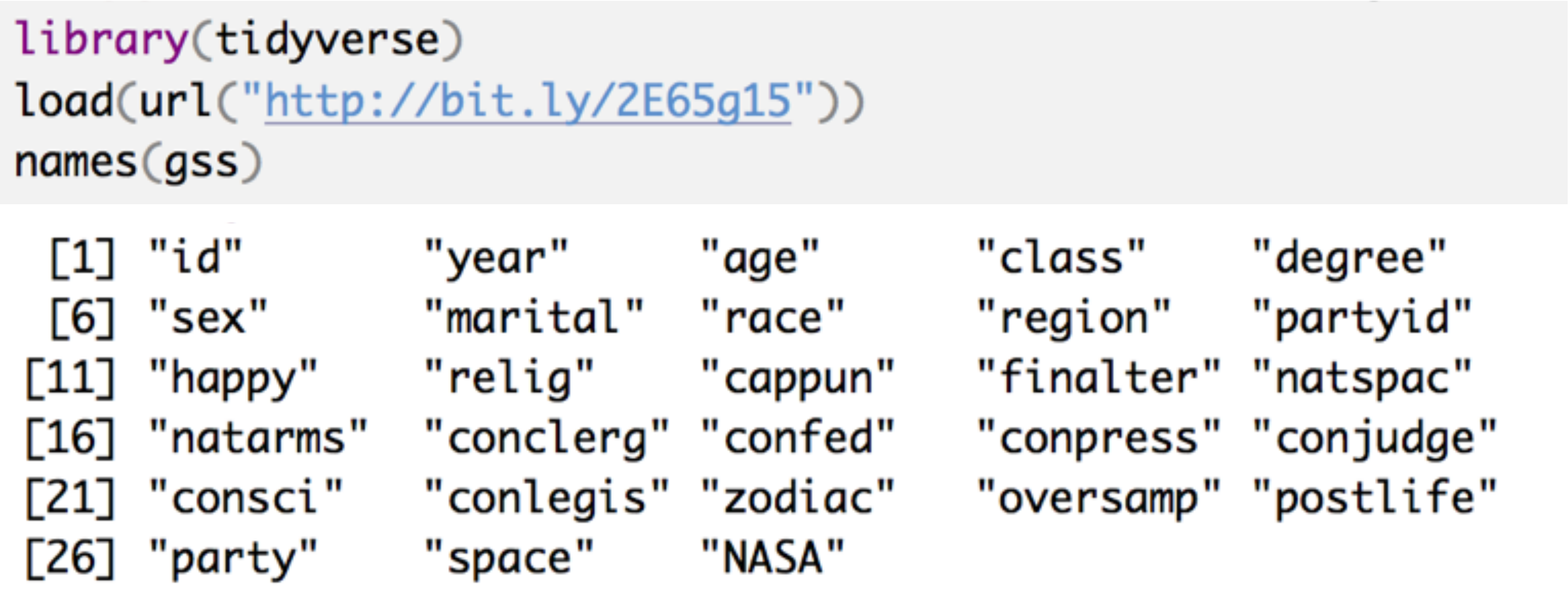

```
library(tidyverse)
load(url("http://bit.ly/2E65g15"))
names(gss)
```

```
 [1] "id"        "year"      "age"       "class"     "degree"   
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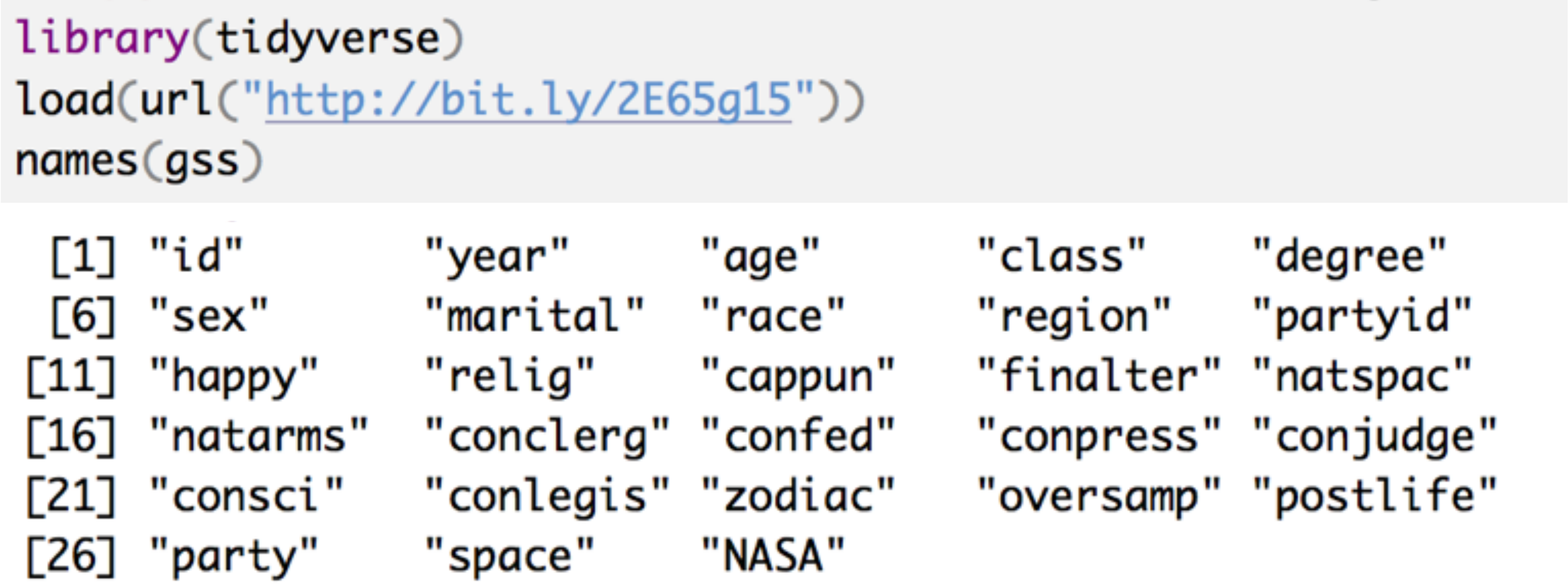

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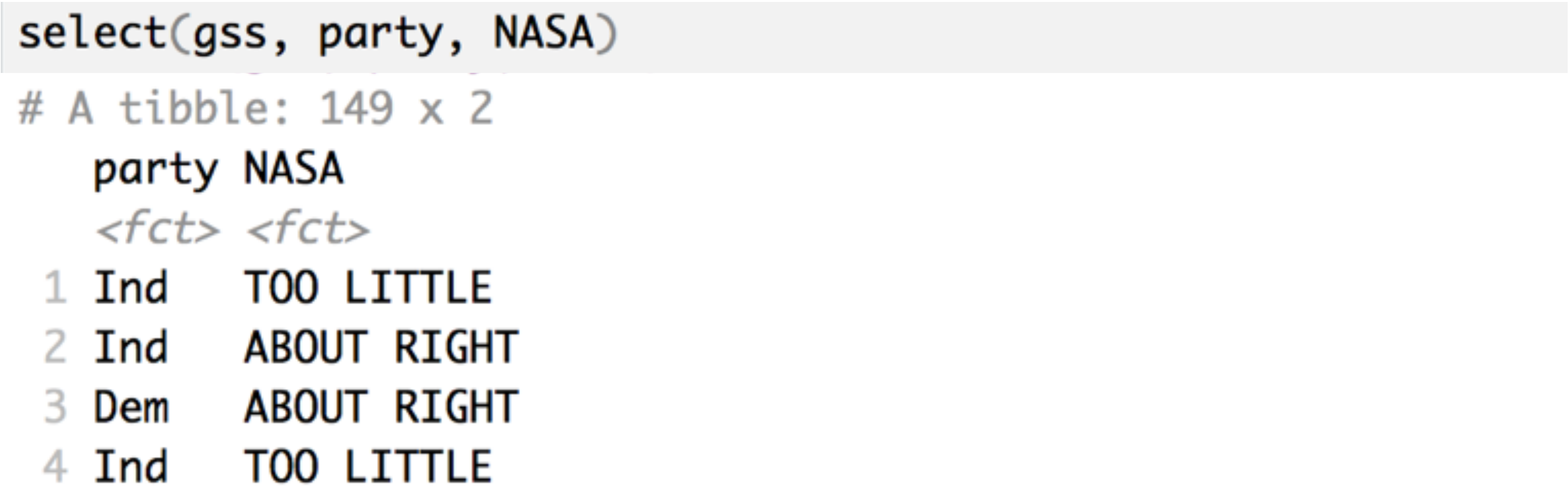

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select(gss, party, NASA)
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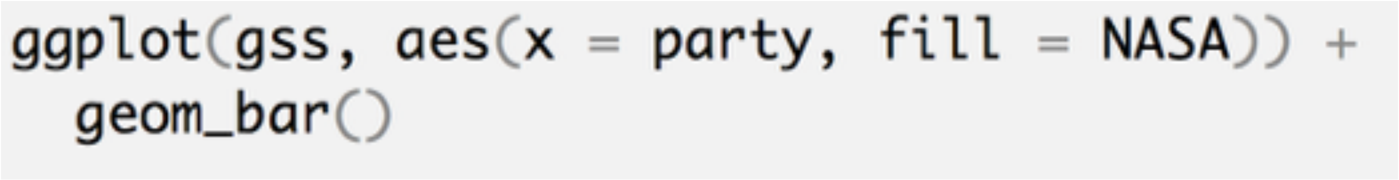

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ggplot(gss, aes(x = party, fill = NASA)) +
  geom_bar()
```

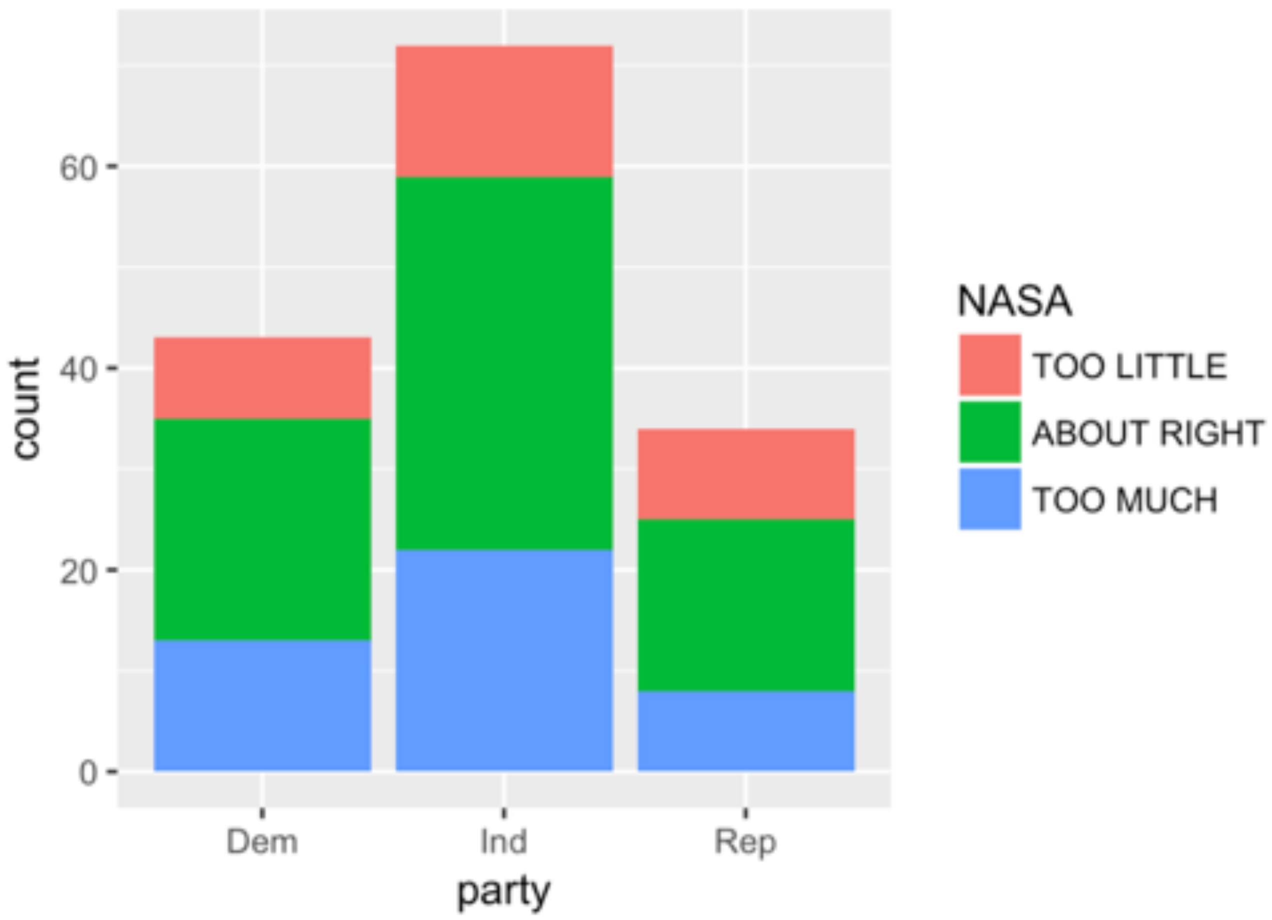

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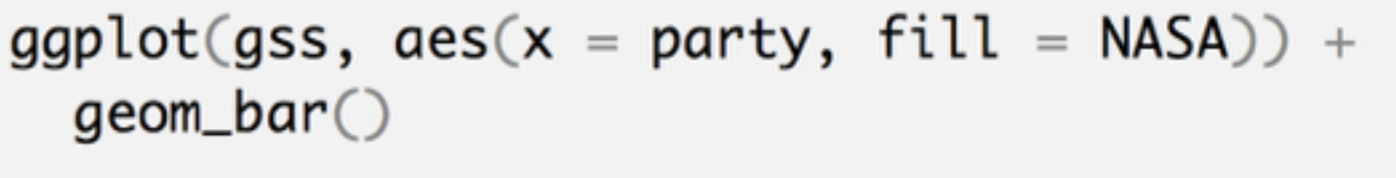

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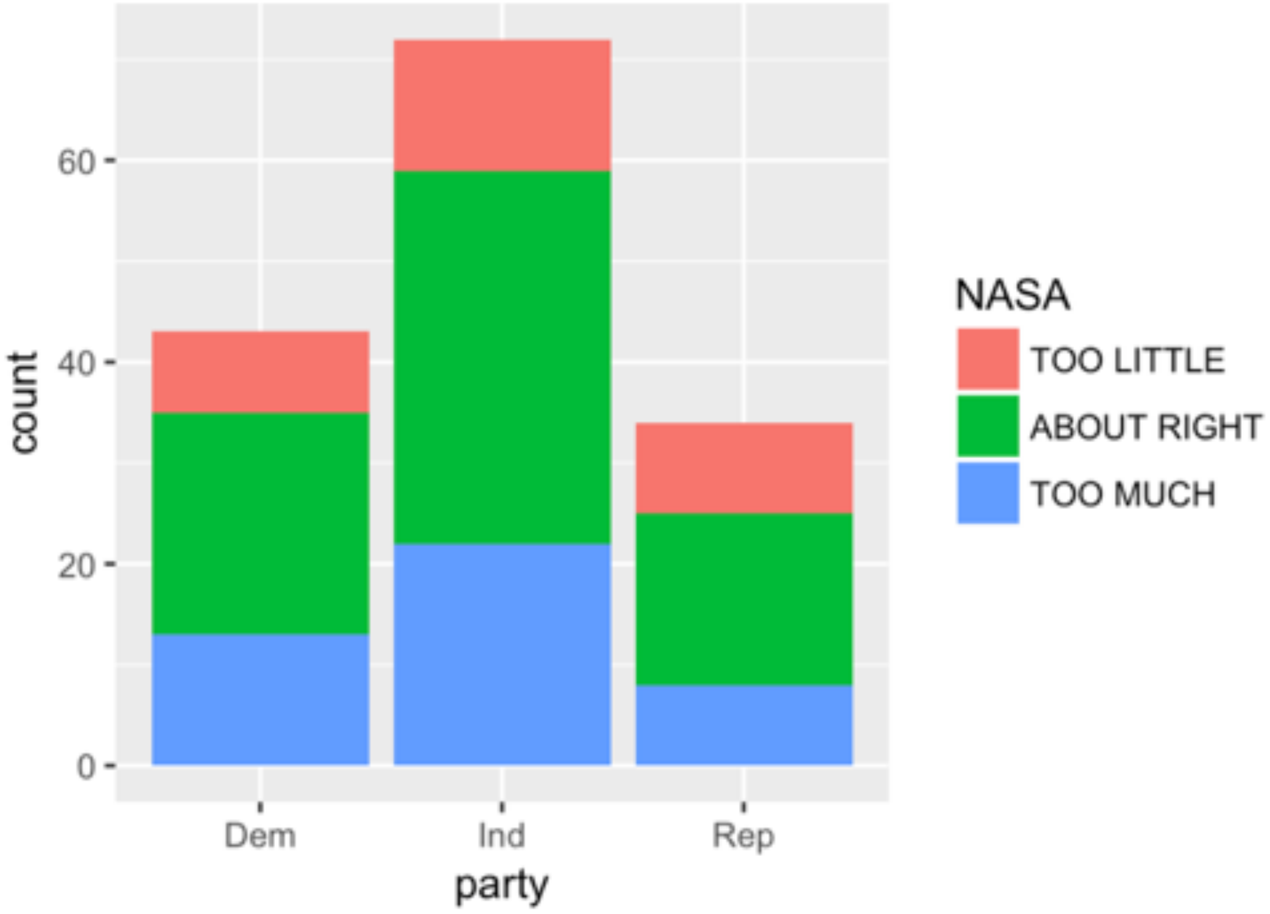

How can we test to see if the structure that we see is *significant*?

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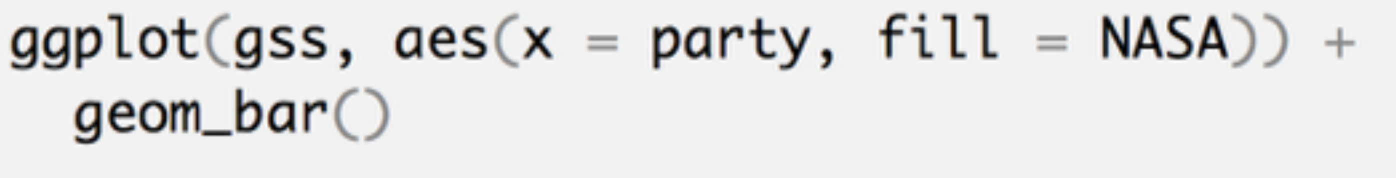

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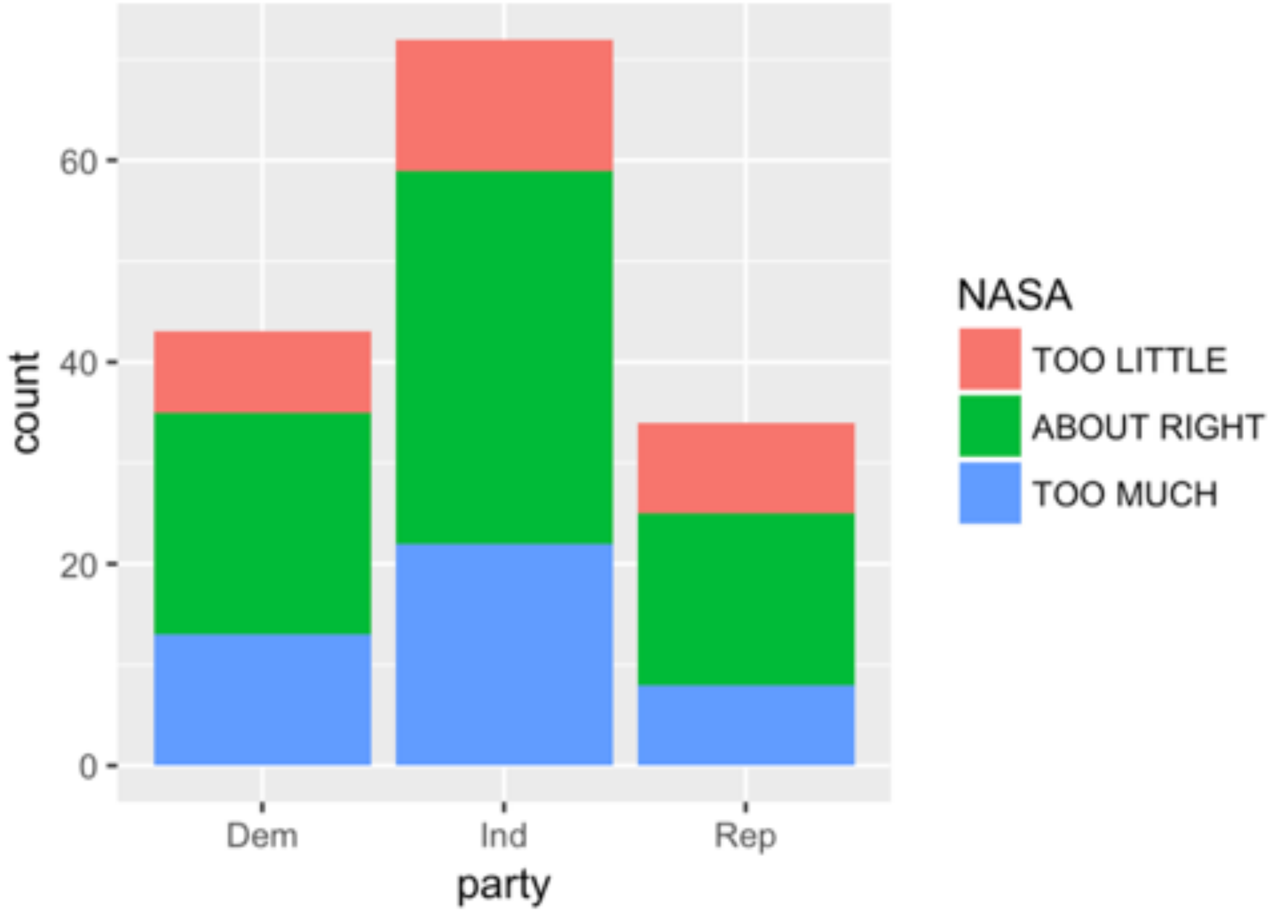
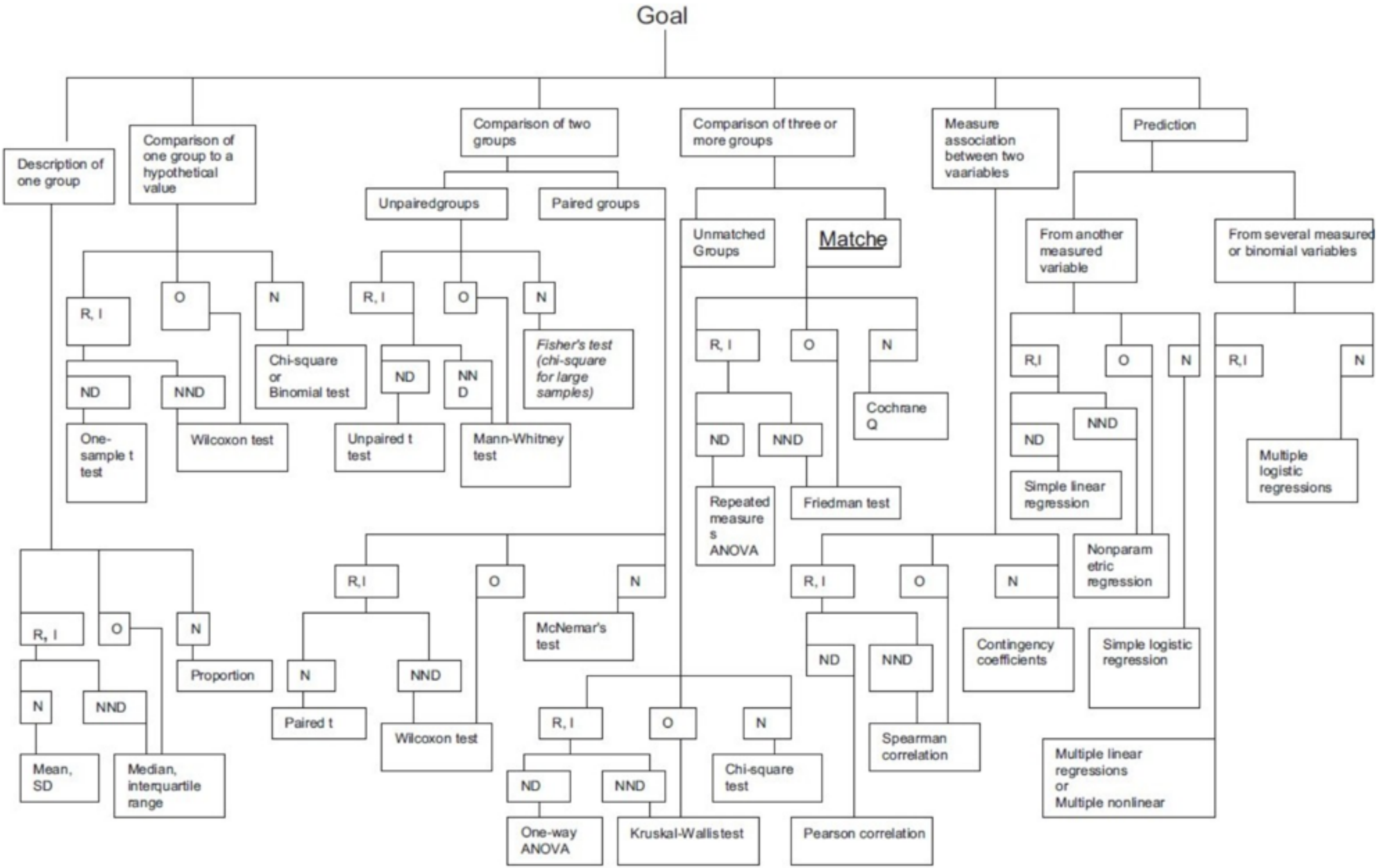


How can we test to see if the structure that we see is *significant*?

Run a hypothesis test!



Goal

Description of one group

R, I

N

Mean, SD

NND

Median, interquartile range

O

N

Proportion

Comparison of one group to a hypothetical value

R, I

ND

One-sample t test

NND

Wilcoxon test

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Chi-square or Binomial test

Comparison of two groups

Unpairedgroups

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ND

Unpaired t test

NN D

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Fisher's test (chi-square for large samples)

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McNemar's test

Comparison of three or more groups

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R, I

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One-way ANOVA

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Cochrane Q

Measure association between two vaariables

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ND

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Spearman correlation

O

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Contingency coefficients

Prediction

From another measured variable

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ND

Simple linear regression

NND

Nonparam etric regression

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Simple logistic regression

From several measured or binomial variables

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Multiple linear regressions or Multiple nonlinear

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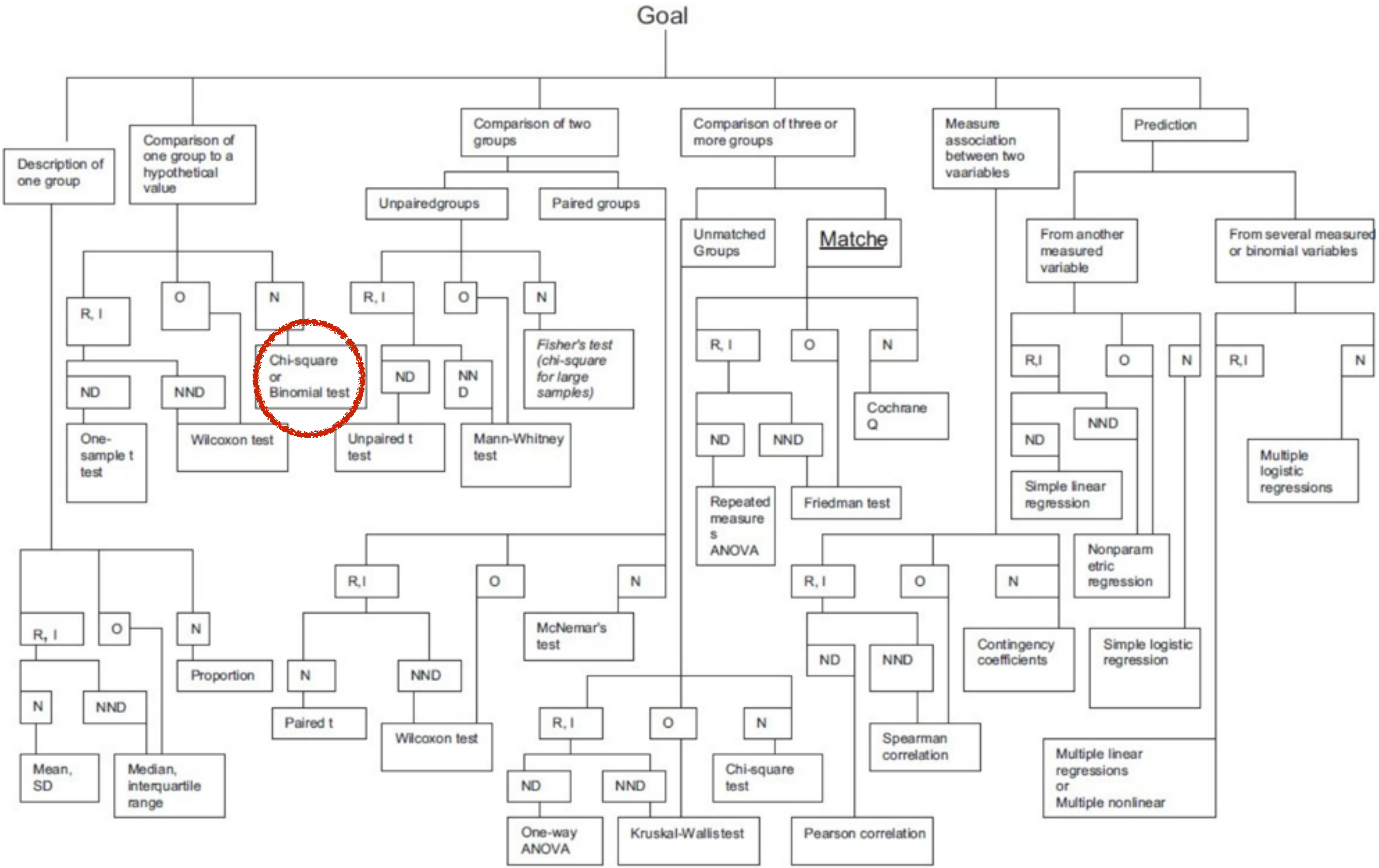
Multiple logistic regressions

Journal of Pharmacological Negative Results, DOI: 10.4103/0976-9234.75708



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Optimistic effort I

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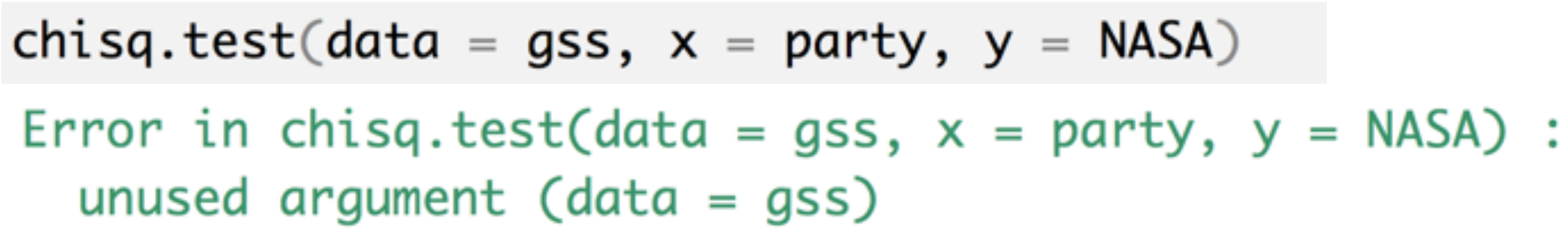

```r
chisq.test(data = gss, x = party, y = NASA)
```

```
Error in chisq.test(data = gss, x = party, y = NASA) :
  unused argument (data = gss)
```

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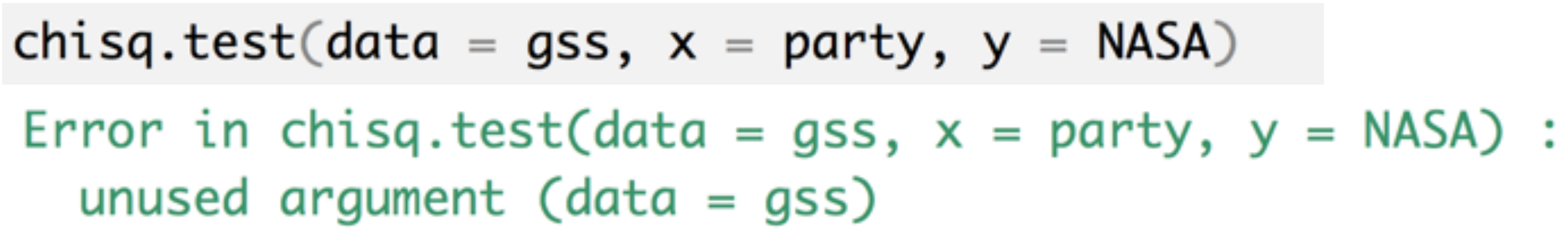

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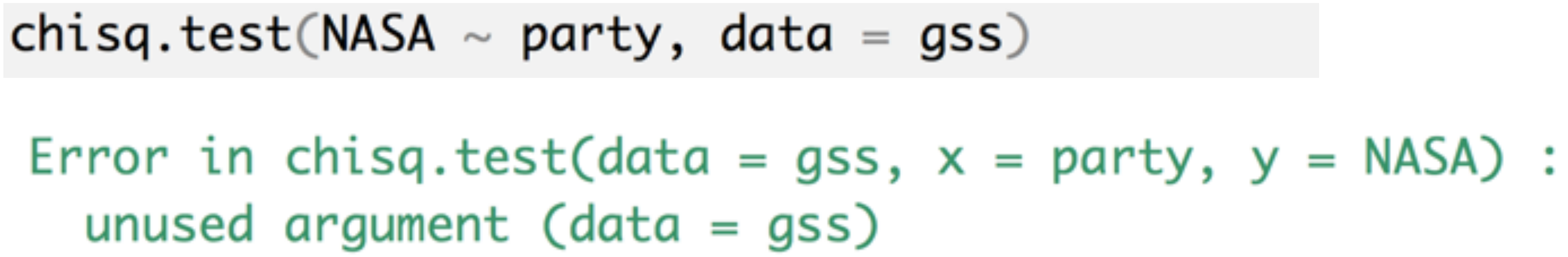
. . . optimistic effort II



```
chisq.test(NASA ~ party, data = gss)
```

```
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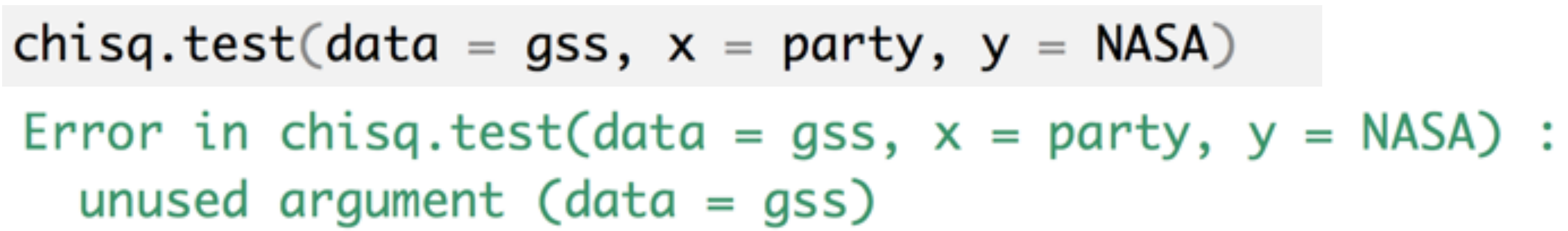
Optimistic effort I



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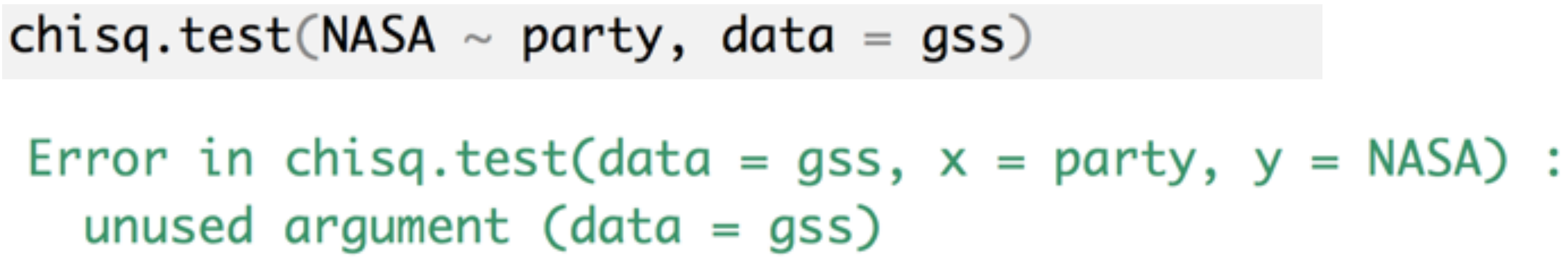

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chisq.test(NASA ~ party, data = gss)

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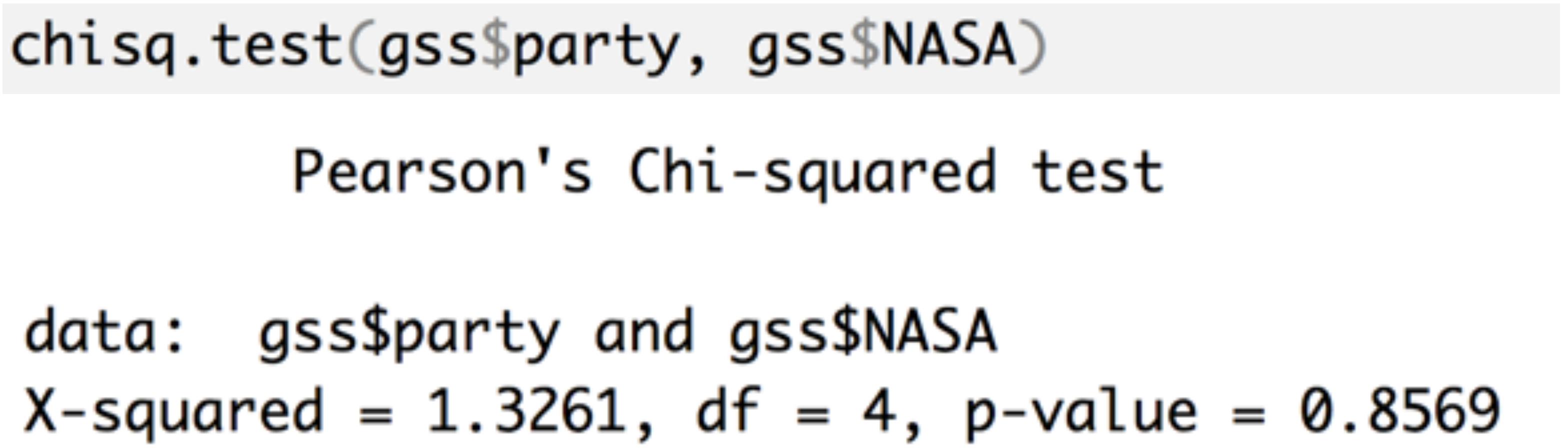
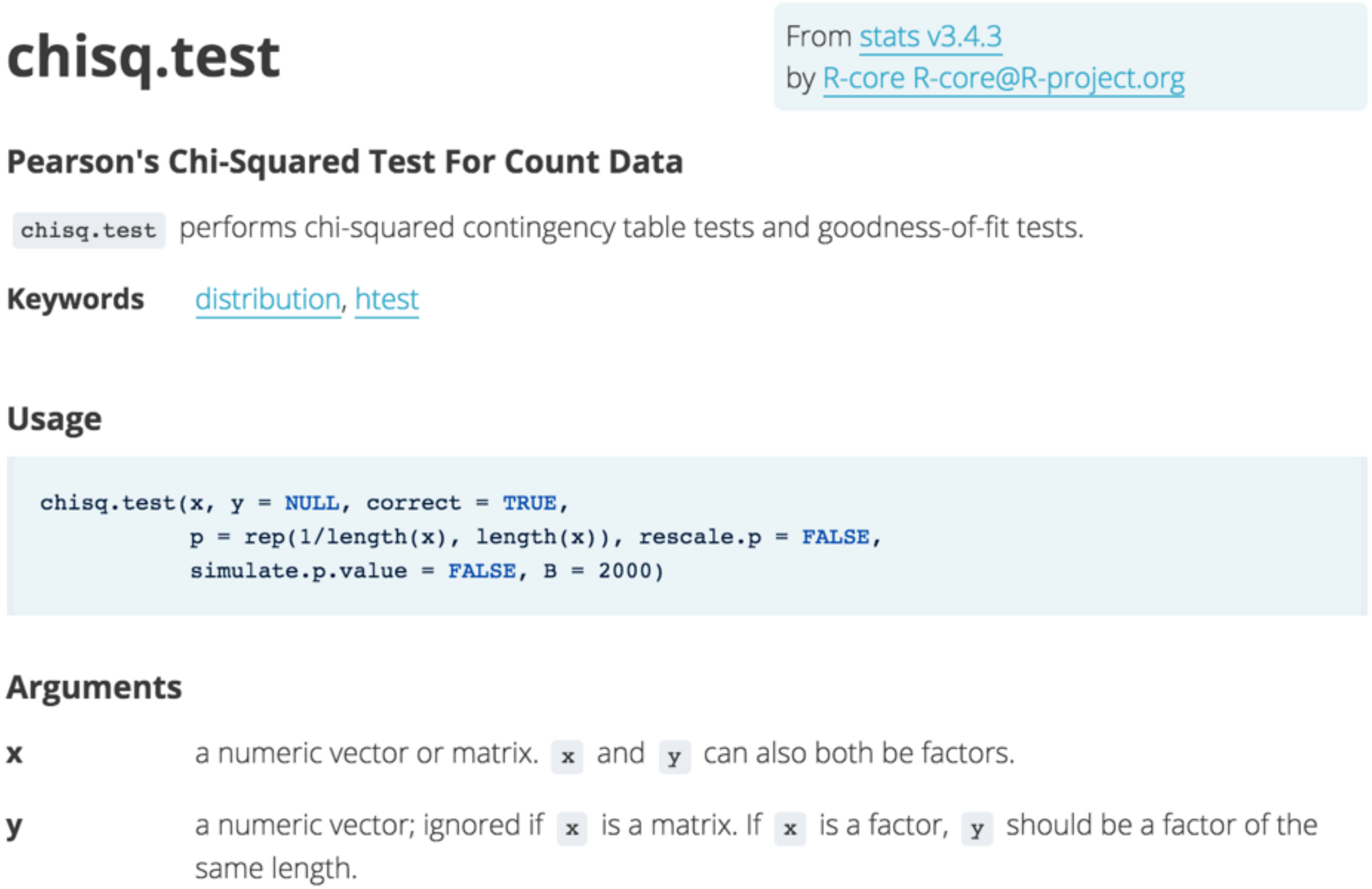
...after looking at the help file



```
chisq.test(gss$party, gss$NASA)

        Pearson's Chi-squared test

data:  gss$party and gss$NASA
X-squared = 1.3261, df = 4, p-value = 0.8569
```



chisq.test

From stats v3.4.3
by R-core R-core@R-project.org

Pearson's Chi-Squared Test For Count Data

`chisq.test` performs chi-squared contingency table tests and goodness-of-fit tests.

Keywords distribution, htest

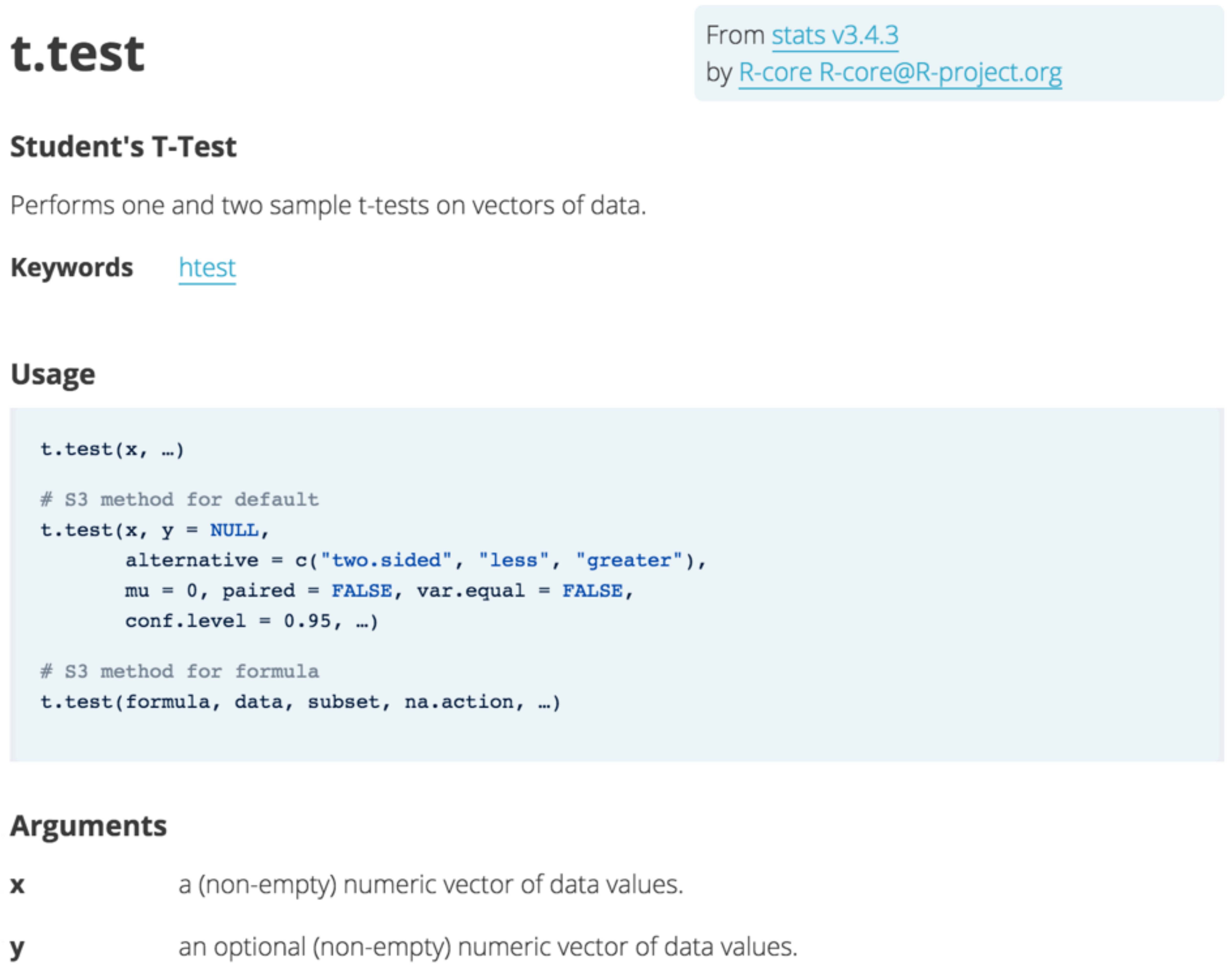
Usage

```
chisq.test(x, y = NULL, correct = TRUE,
           p = rep(1/length(x), length(x)), rescale.p = FALSE,
           simulate.p.value = FALSE, B = 2000)
```

Arguments

x a numeric vector or matrix. `x` and `y` can also both be factors.

y a numeric vector; ignored if `x` is a matrix. If `x` is a factor, `y` should be a factor of the same length.



t.test

From stats v3.4.3
by R-core R-core@R-project.org

Student's T-Test

Performs one and two sample t-tests on vectors of data.

Keywords htest

Usage

```
t.test(x, …)

# S3 method for default
t.test(x, y = NULL,
       alternative = c("two.sided", "less", "greater"),
       mu = 0, paired = FALSE, var.equal = FALSE,
       conf.level = 0.95, …)

# S3 method for formula
t.test(formula, data, subset, na.action, …)
```

Arguments

x a (non-empty) numeric vector of data values.

y an optional (non-empty) numeric vector of data values.

statistical inference

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Two paradigms

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Mathematical Approximation

- Chi-squared
- Student t
- Normal

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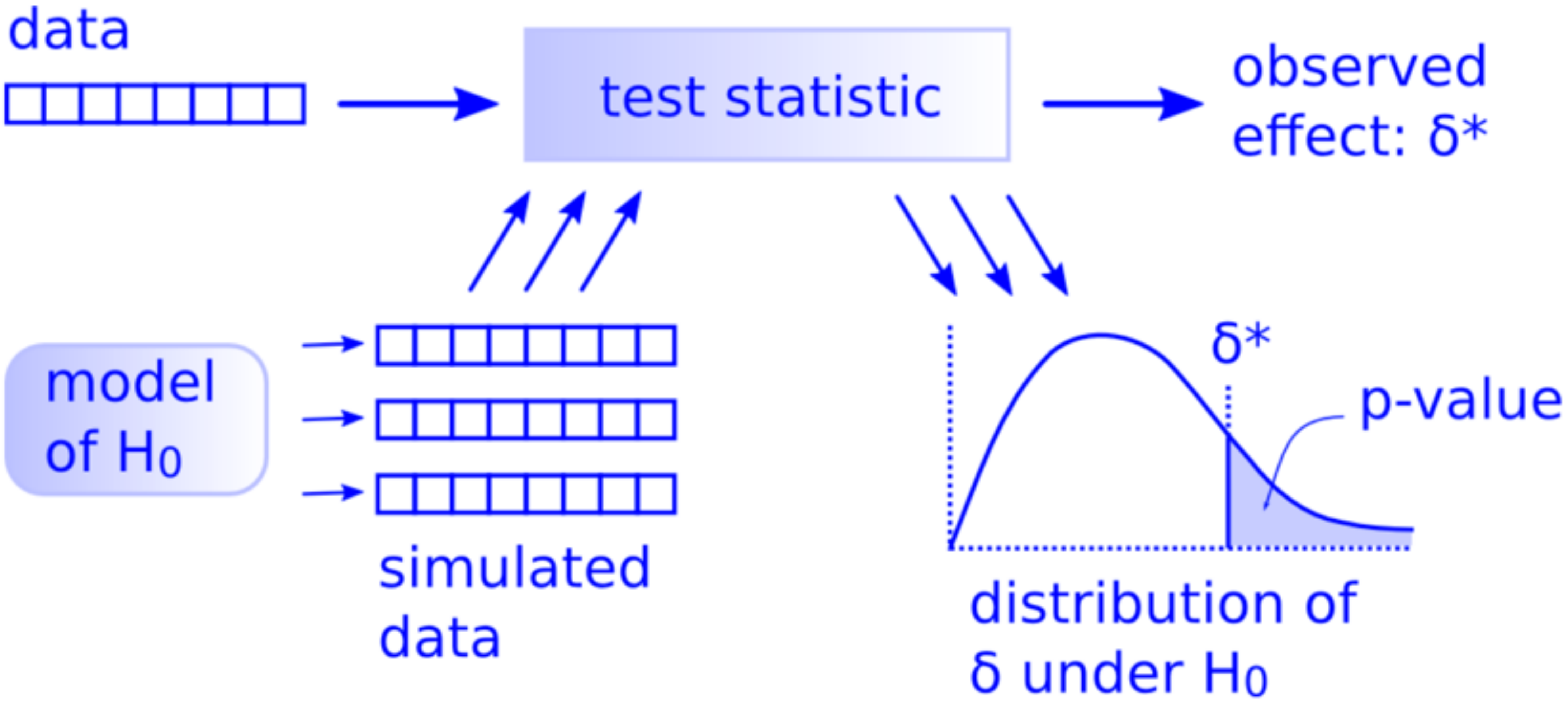
There is only one test

- Allen Downey



Simulation through Permutation

If we live in world where these variables are totally unrelated, the ties between variables are arbitrary, so they might just as well have been shuffled.

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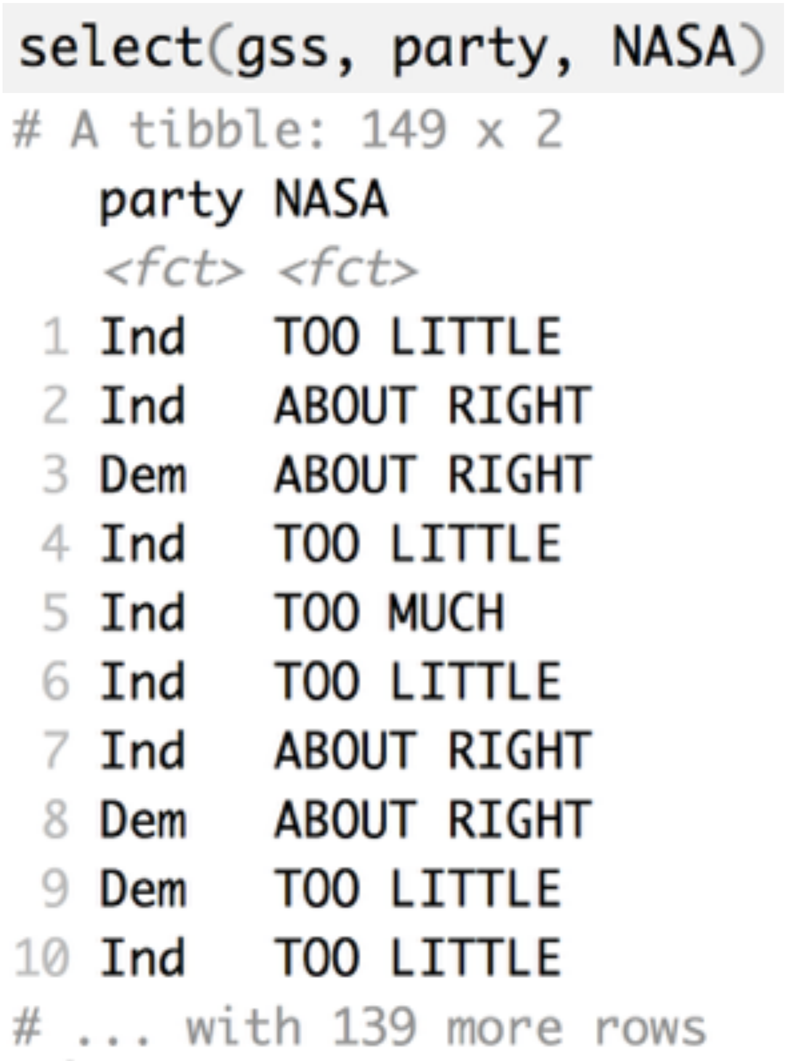

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 4 Ind   TOO LITTLE
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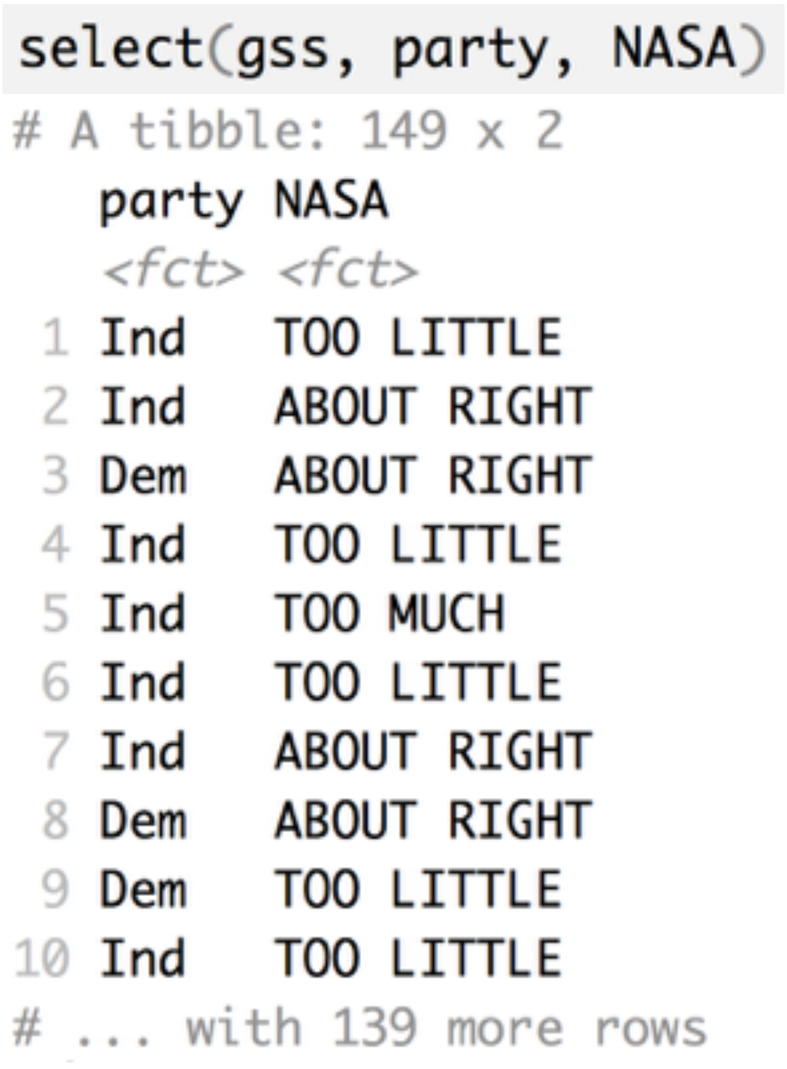

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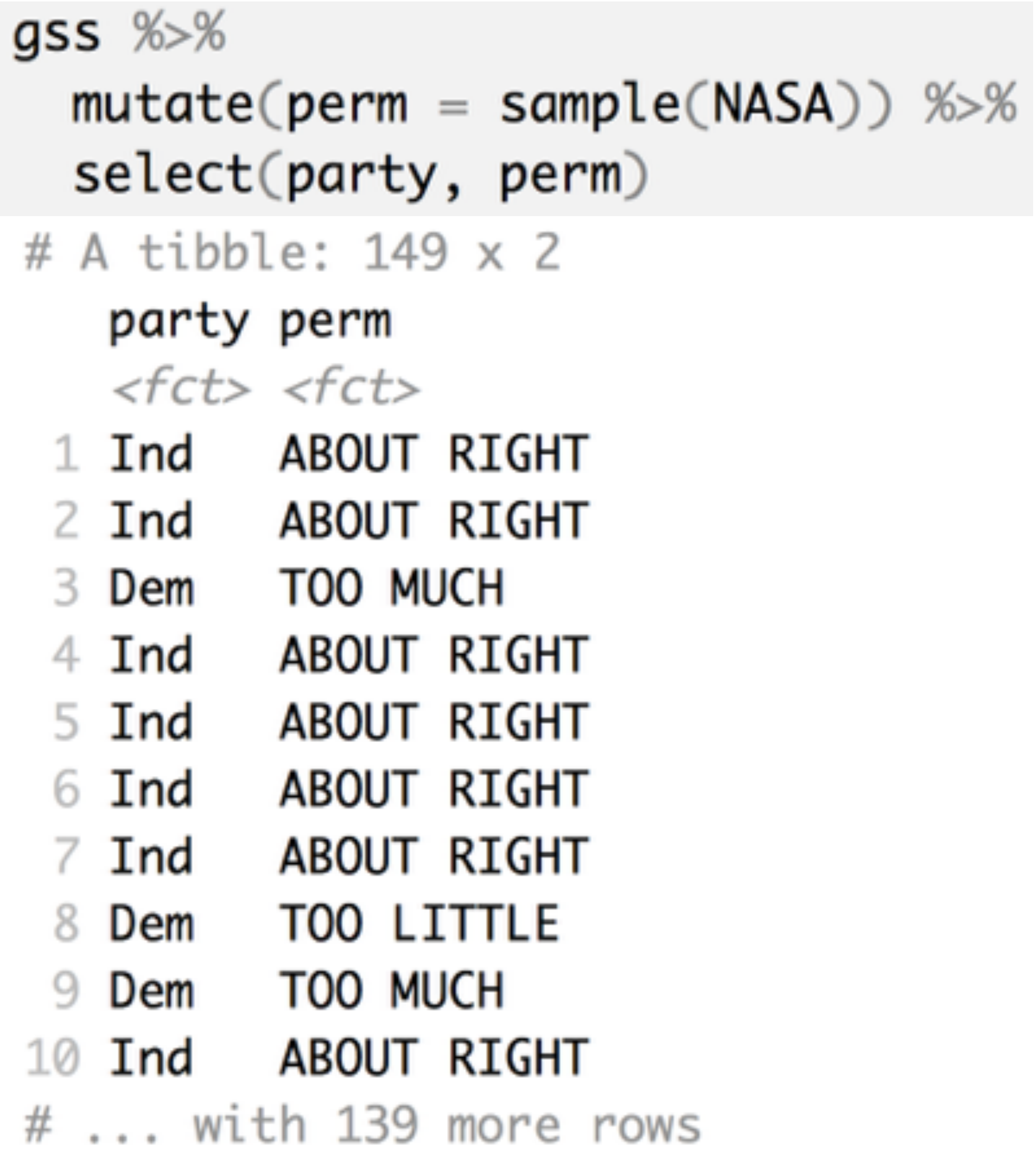

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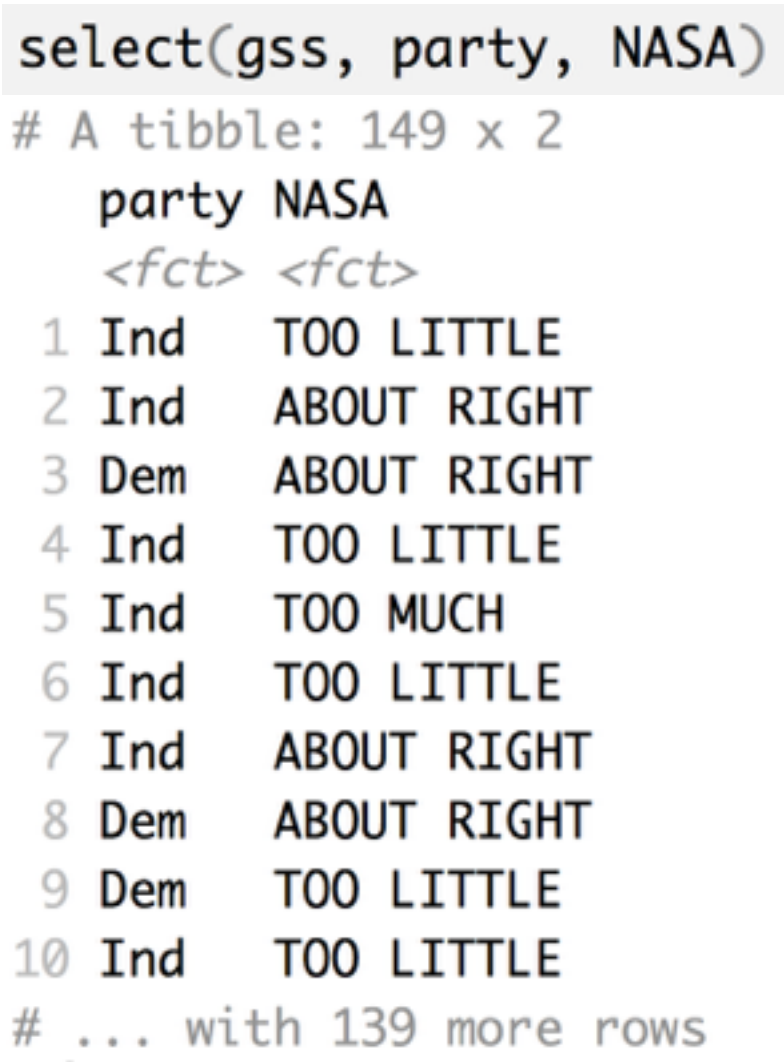

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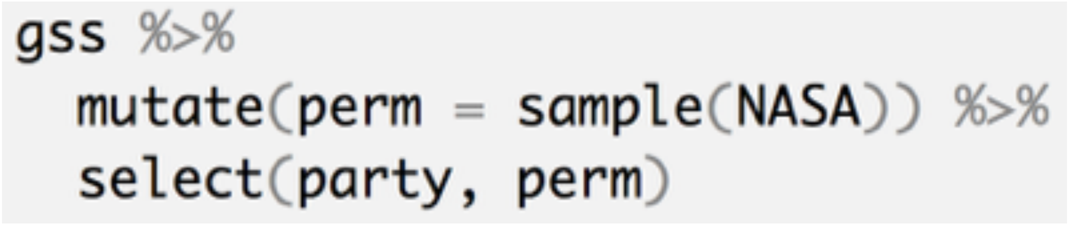

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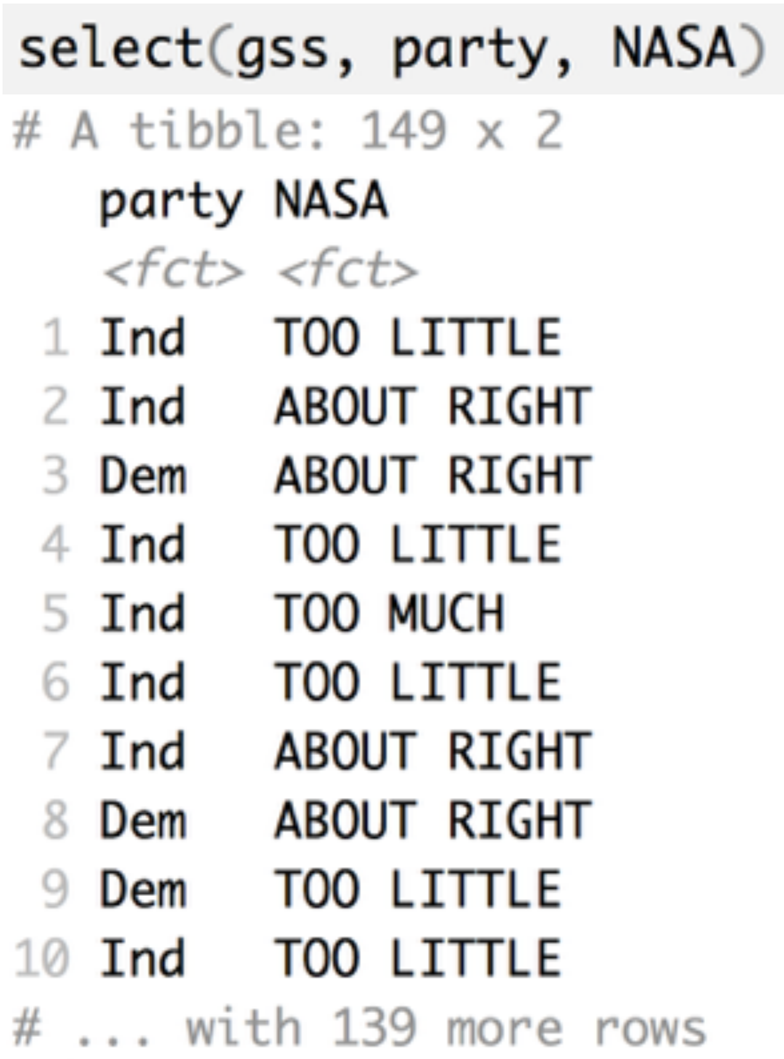

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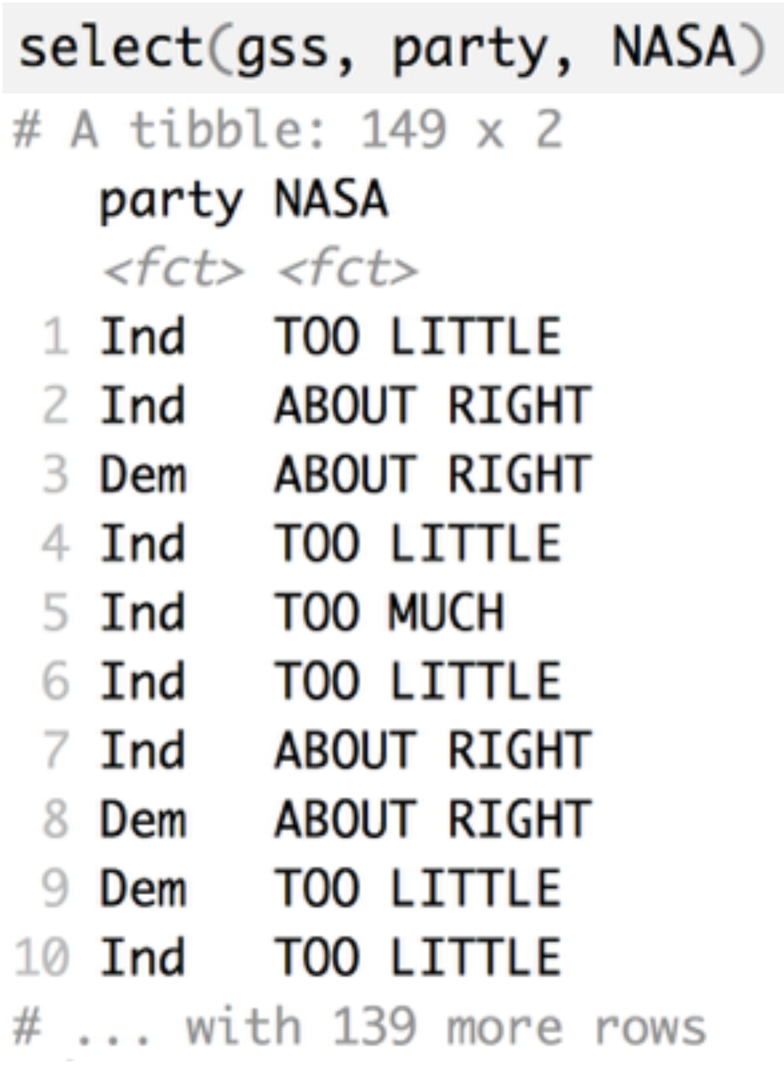

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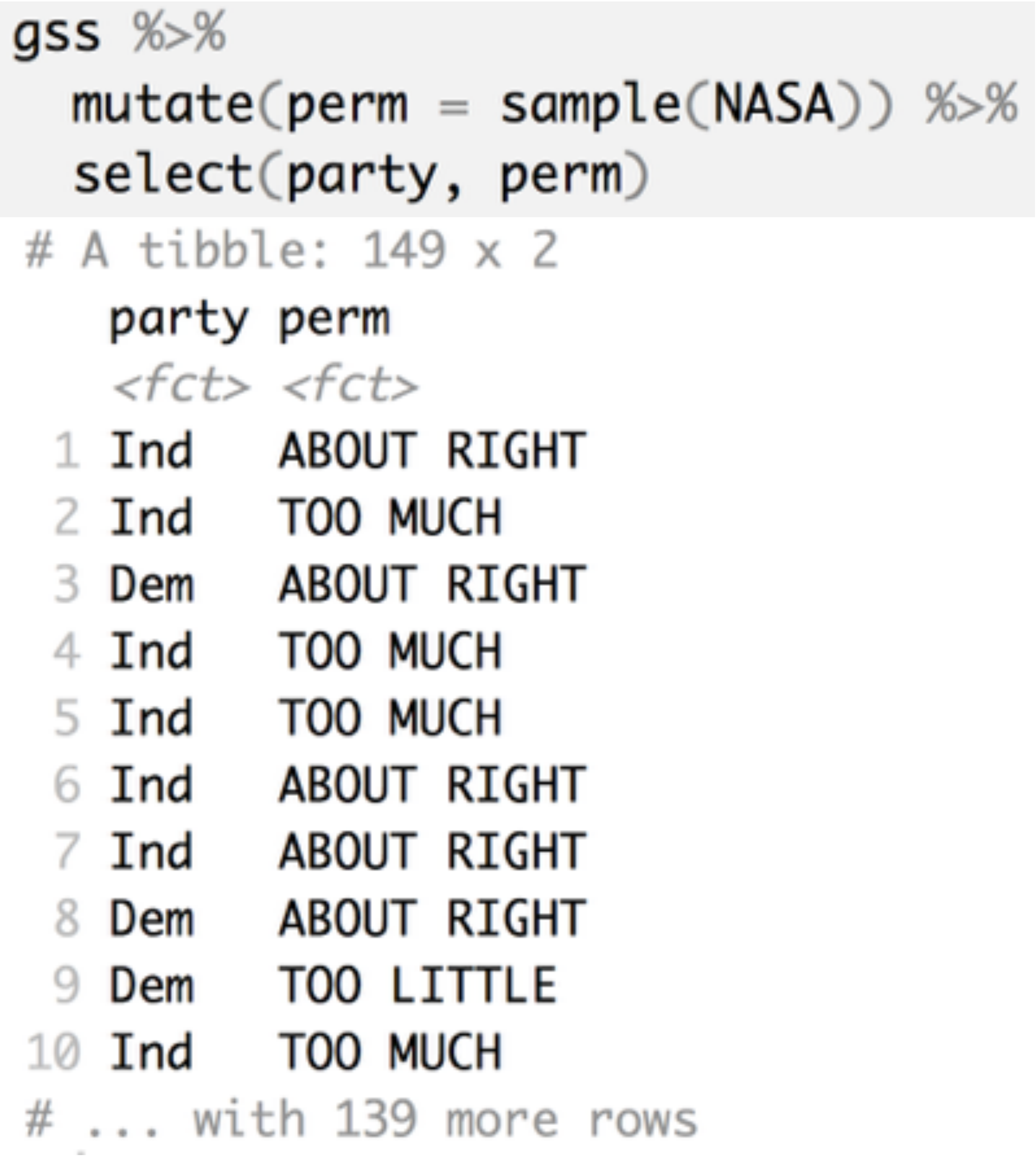

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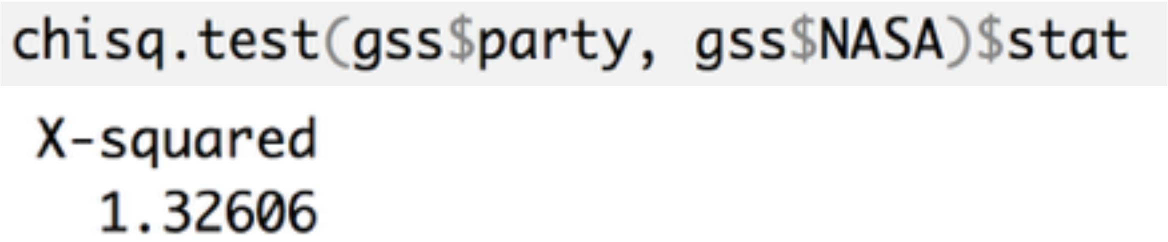

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chisq.test(gss$party, gss$NASA)$stat
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 X-squared 
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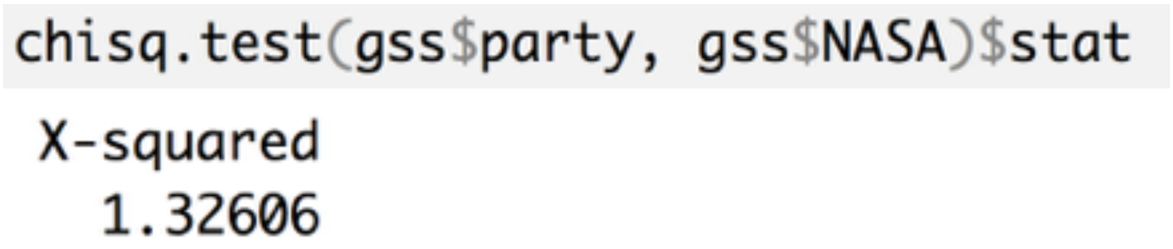

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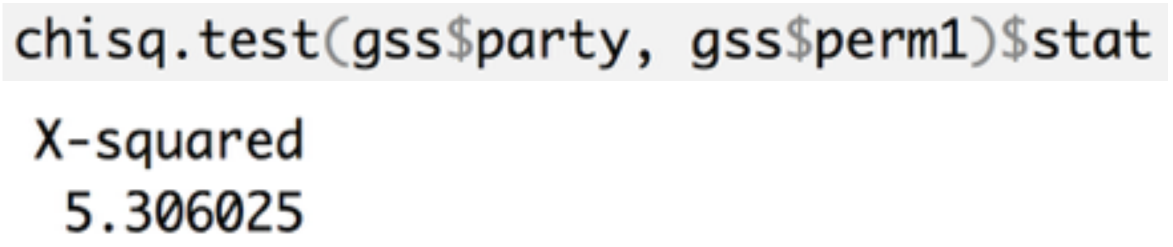

```
chisq.test(gss$party, gss$perm1)$stat
 X-squared
  5.306025
```

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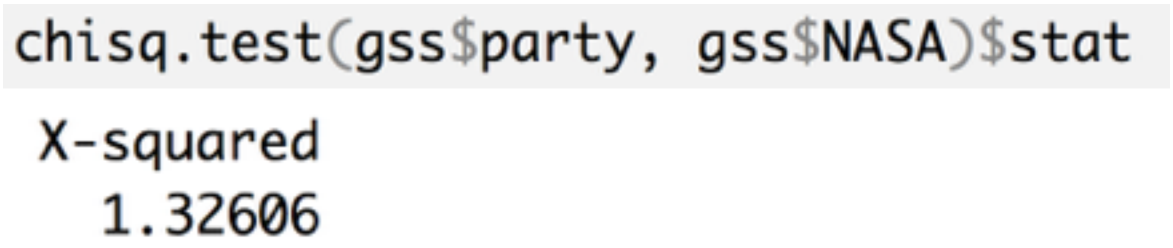

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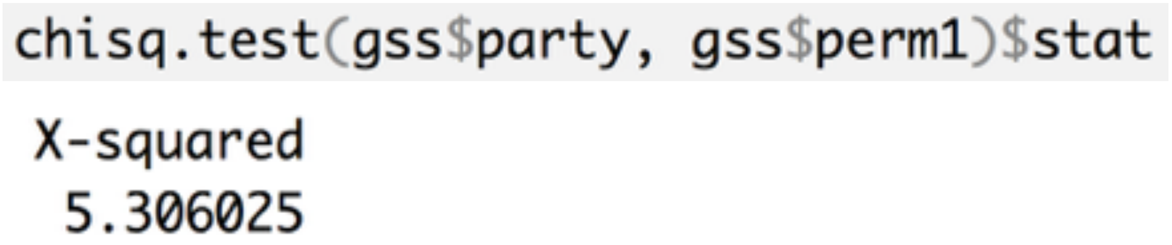
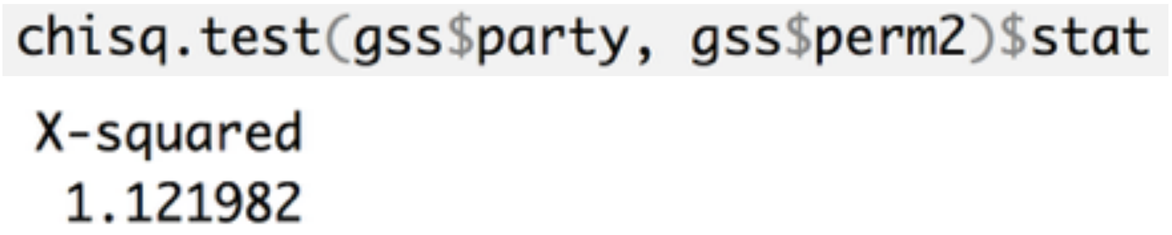


```
chisq.test(gss$party, gss$perm1)$stat
```

```
X-squared
 5.306025
```

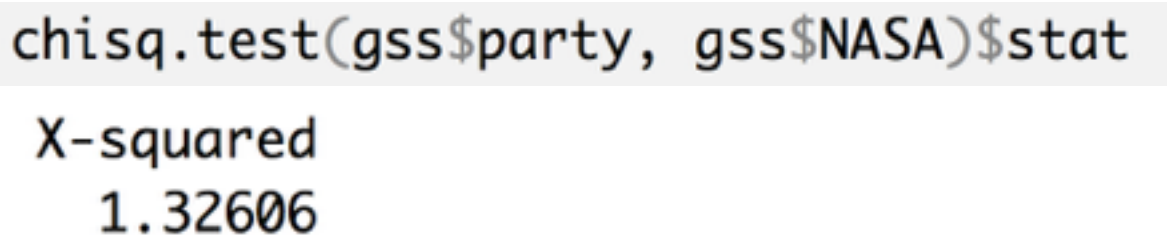


```
chisq.test(gss$party, gss$perm2)$stat
```

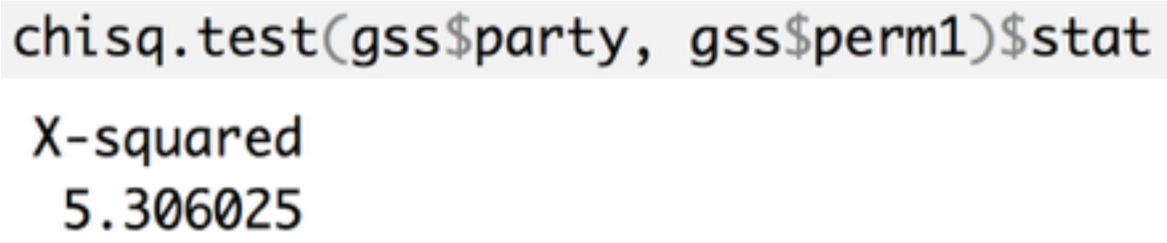
```
X-squared
 1.121982
```

Test statistic

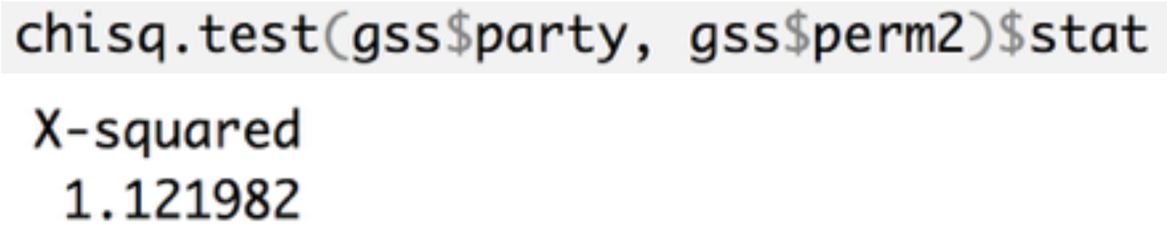
Chi-squared statistic: a measure of the difference between your data and what you would expect if the null hypothesis were true.



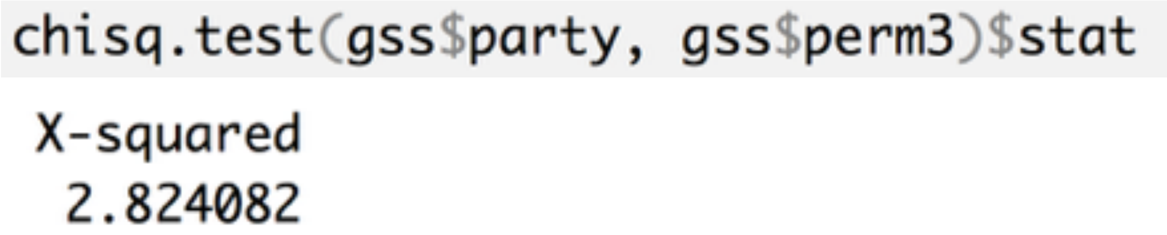
```
chisq.test(gss$party, gss$NASA)$stat
 X-squared
   1.32606
```



```
chisq.test(gss$party, gss$perm1)$stat
 X-squared
  5.306025
```



```
chisq.test(gss$party, gss$perm2)$stat
 X-squared
  1.121982
```

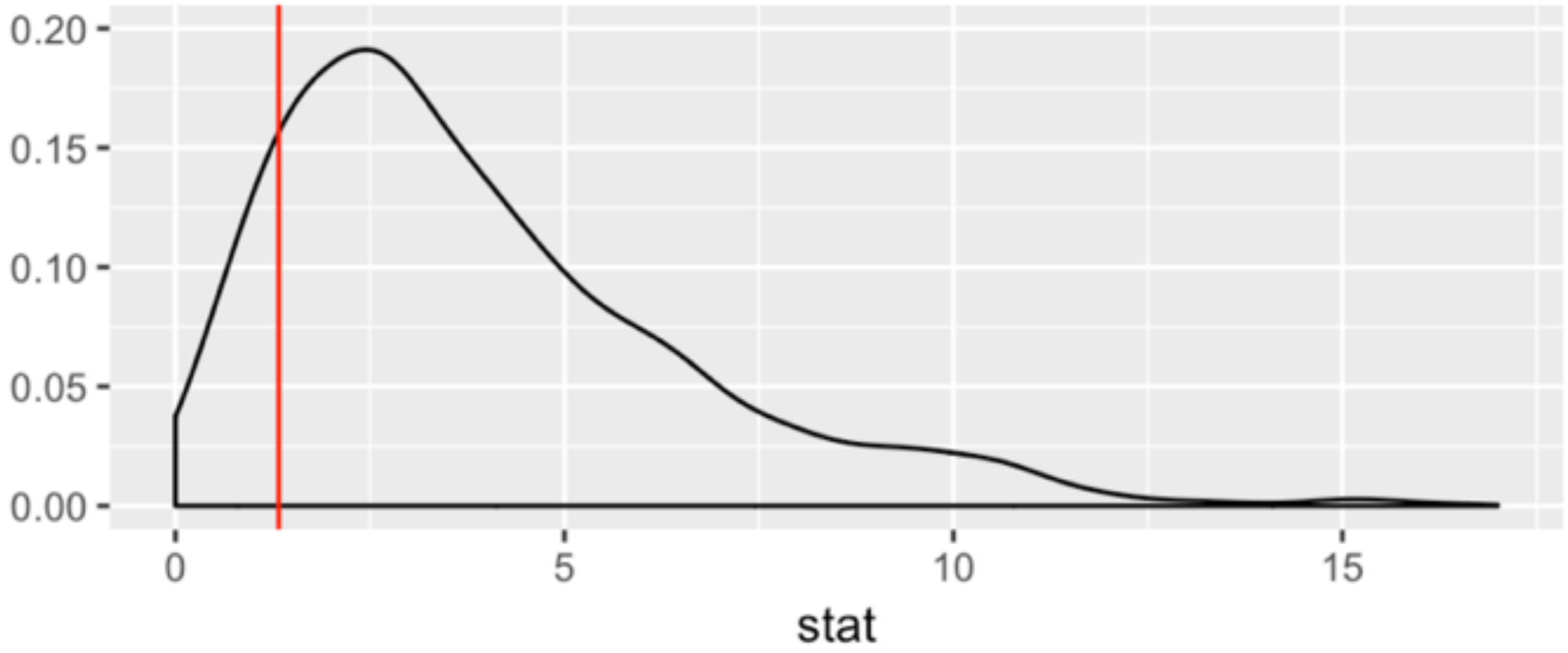


```
chisq.test(gss$party, gss$perm3)$stat
 X-squared
  2.824082
```

Distribution of statistic

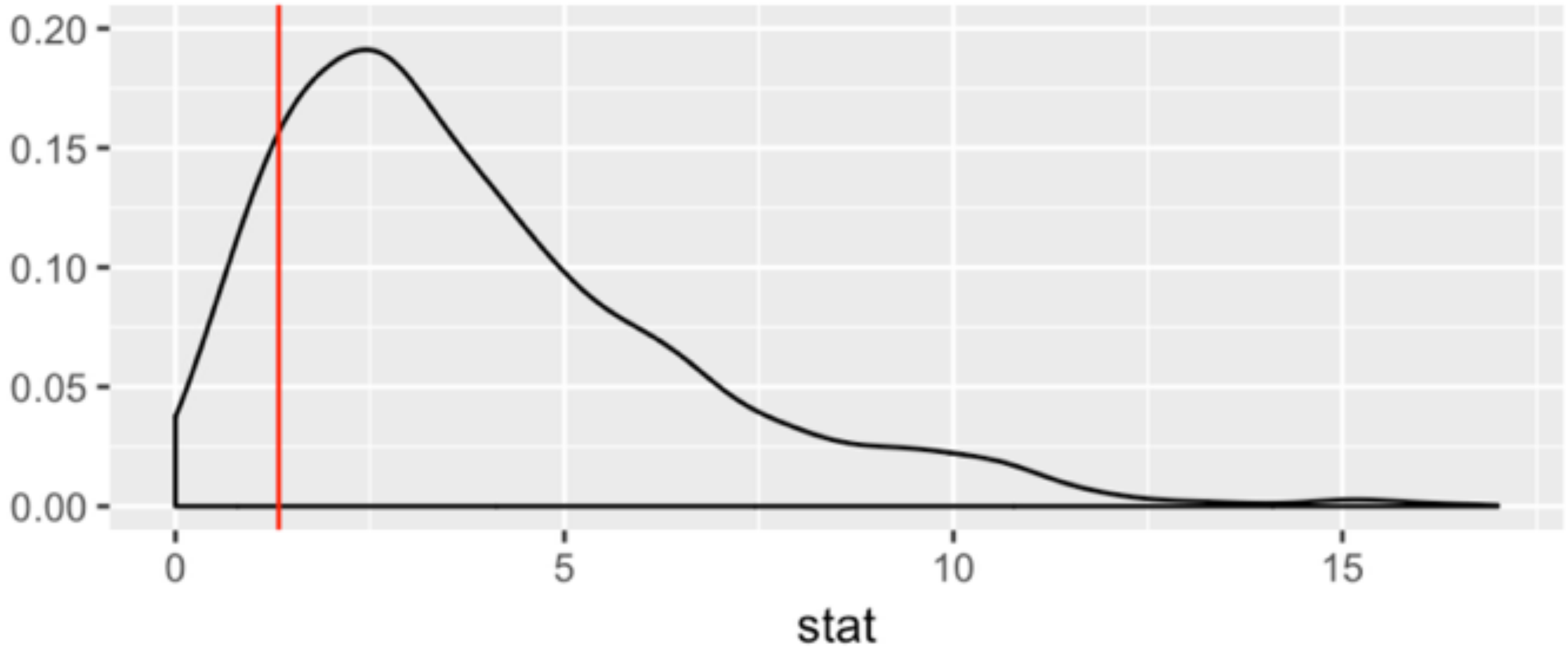
Distribution of statistic

via permutation



Distribution of statistic

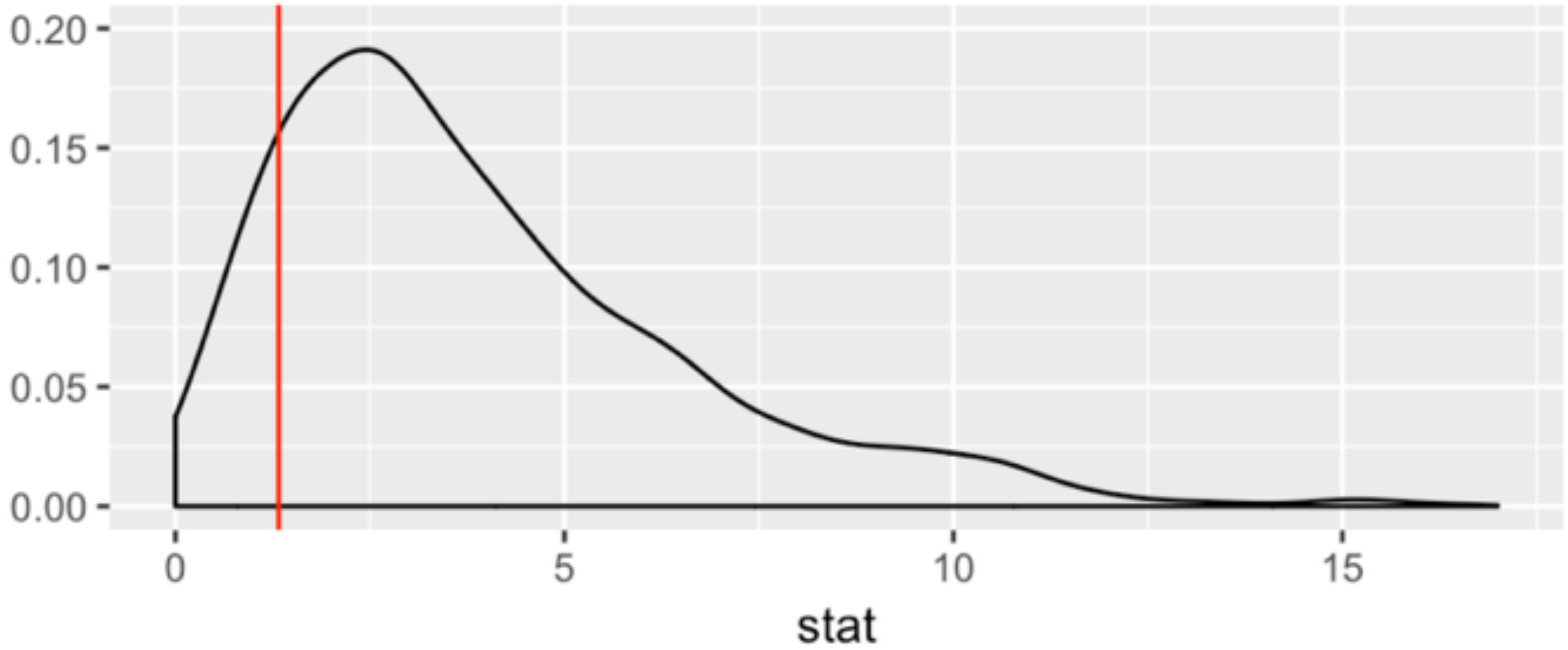
via permutation



Question: Is funding for space exploration a partisan issue?

Distribution of statistic

via permutation

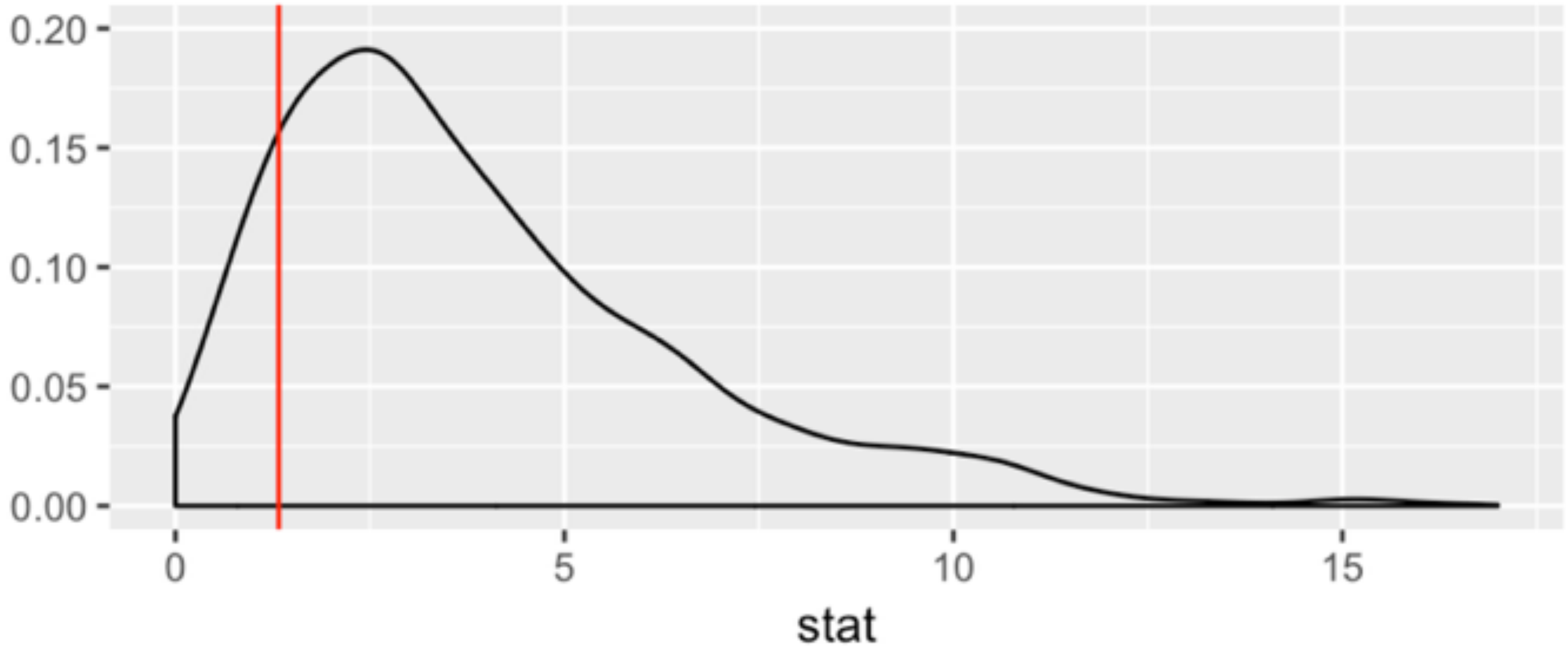


Question: Is funding for space exploration a partisan issue?

Answer: The GSS data is consistent with the model that there is no association between party and space funding.

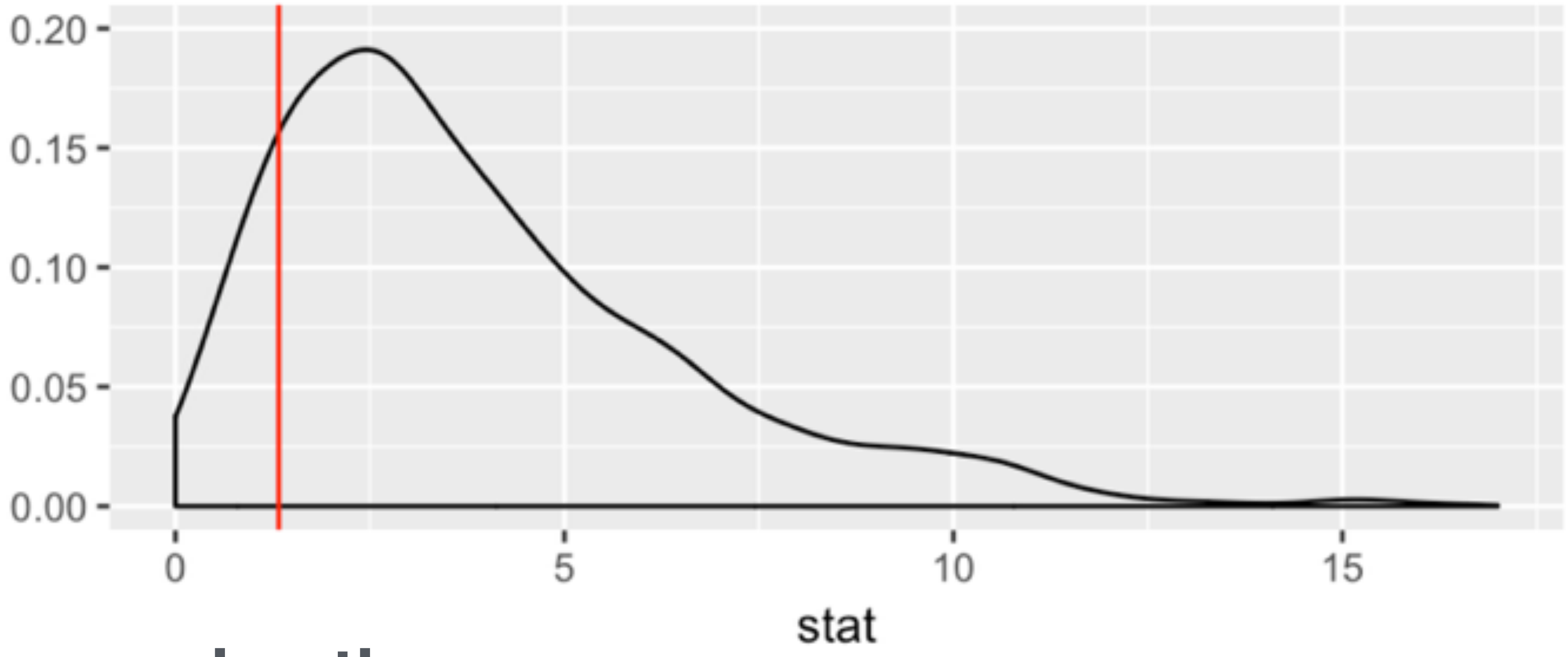
Distribution of statistic

via permutation

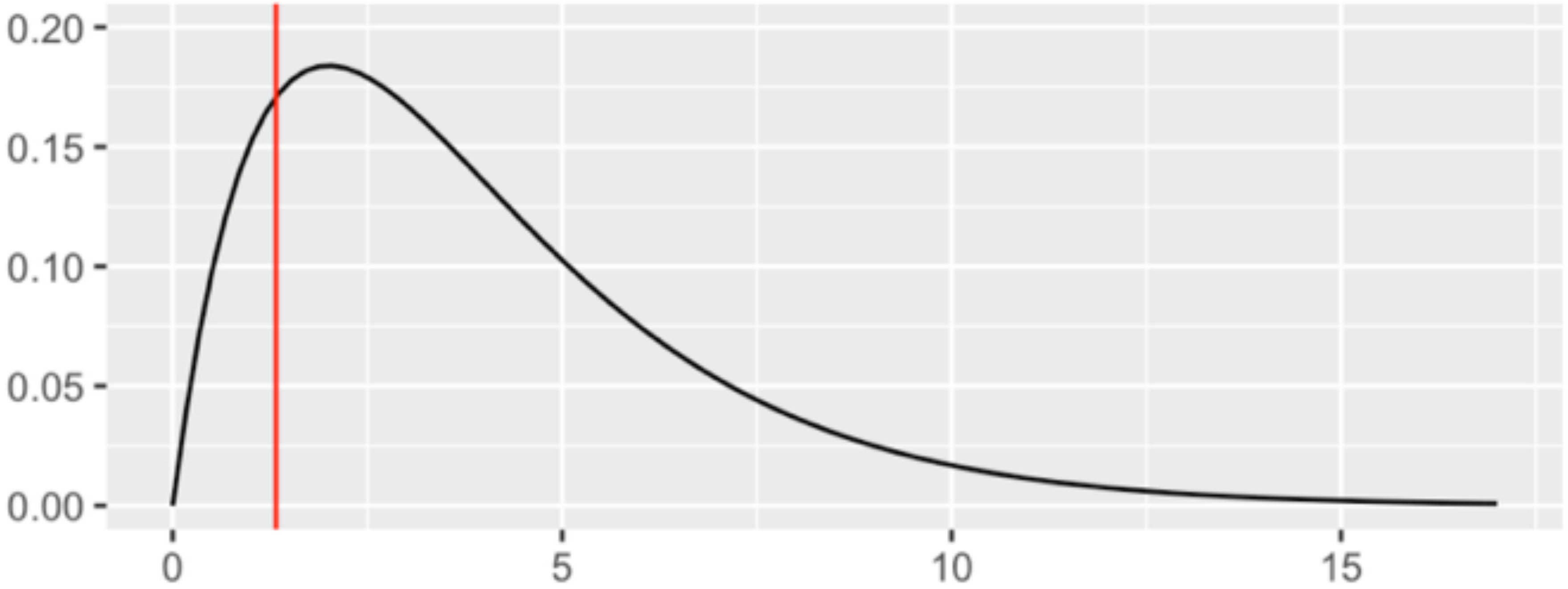


Distribution of statistic

via permutation



via approximation



infer makes statistical inference tidy and transparent.

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- dataframe in, dataframe out

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- dataframe in, dataframe out
- compose tests and intervals with pipes

infer makes statistical inference tidy and transparent.

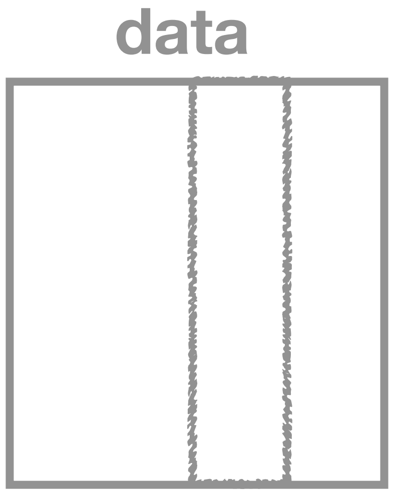
- dataframe in, dataframe out
- compose tests and intervals with pipes
- unite computational and approximation methods

infer makes statistical inference tidy and transparent.

- dataframe in, dataframe out
- compose tests and intervals with pipes
- unite computational and approximation methods
- reading an infer chain describes an inferential procedure

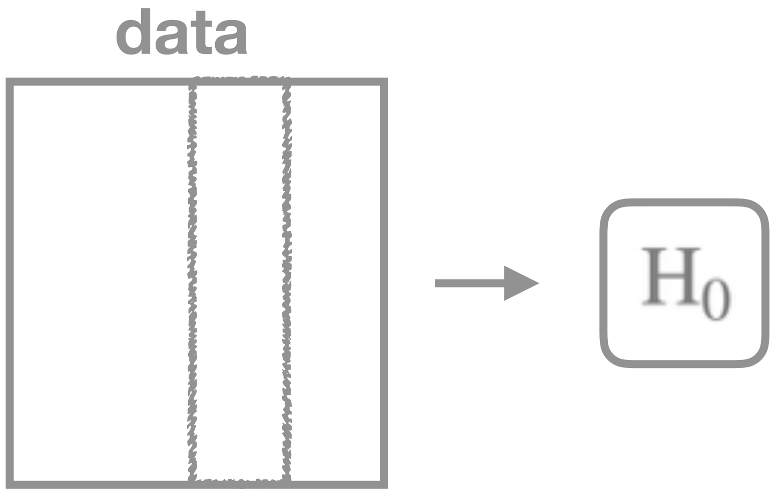
The **`infer`** verbs

The `infer` verbs



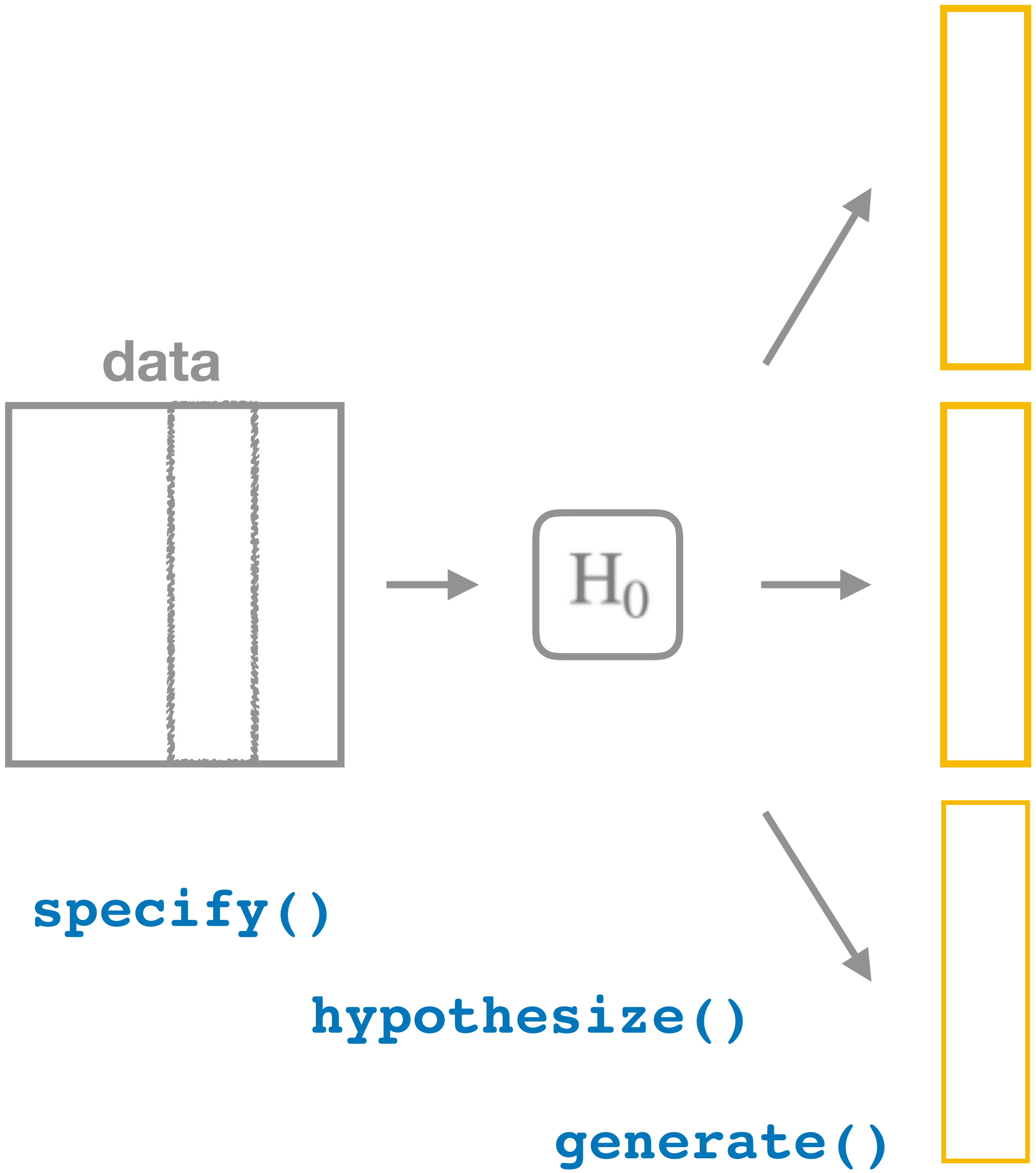
`specify()`

The `infer` verbs



```
specify()
          hypothesize()
```

The infer verbs

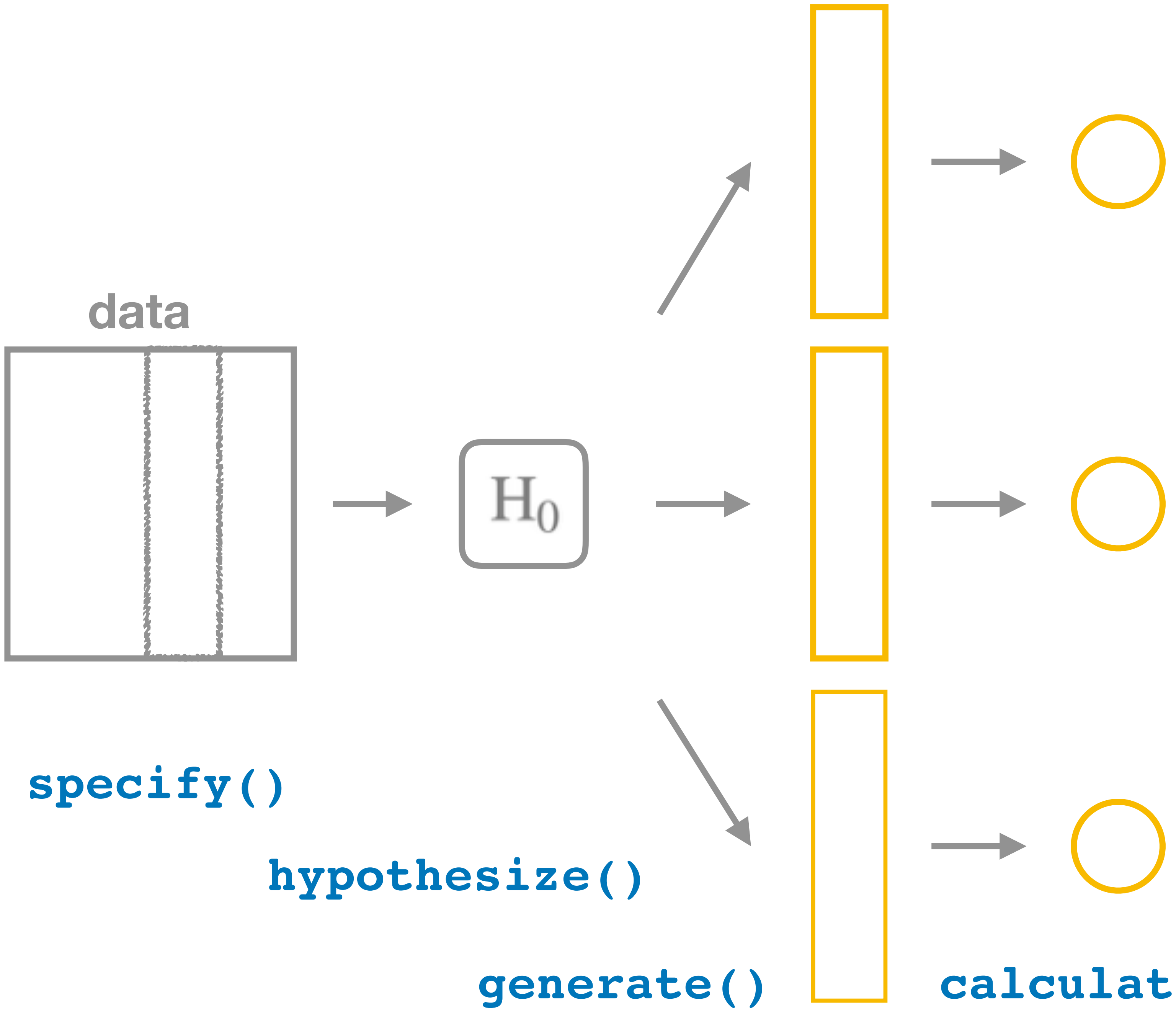


specify()

hypothesize()

generate()

The infer verbs



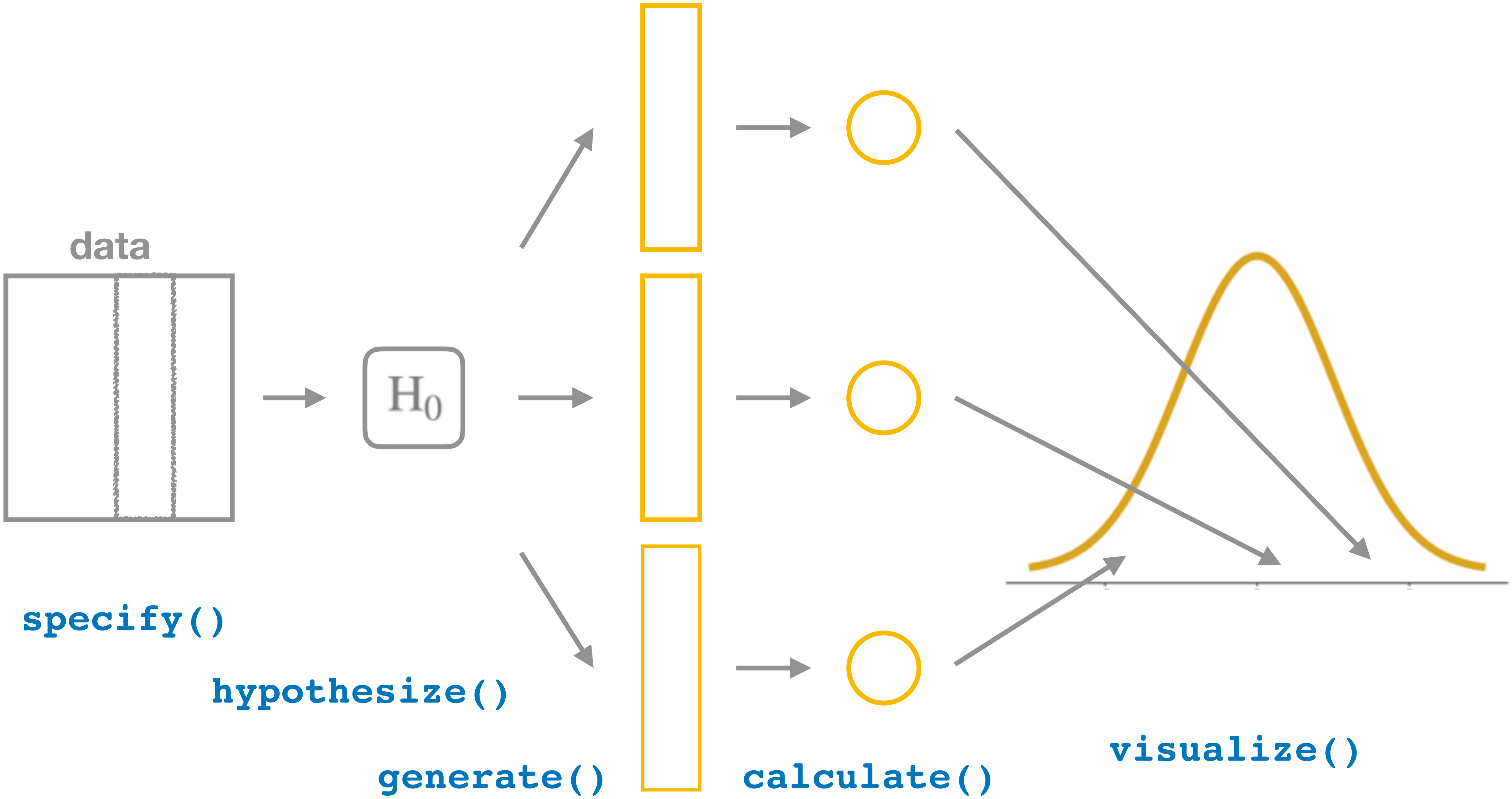
specify()

hypothesize()

generate()

calculate()

The `infer` verbs



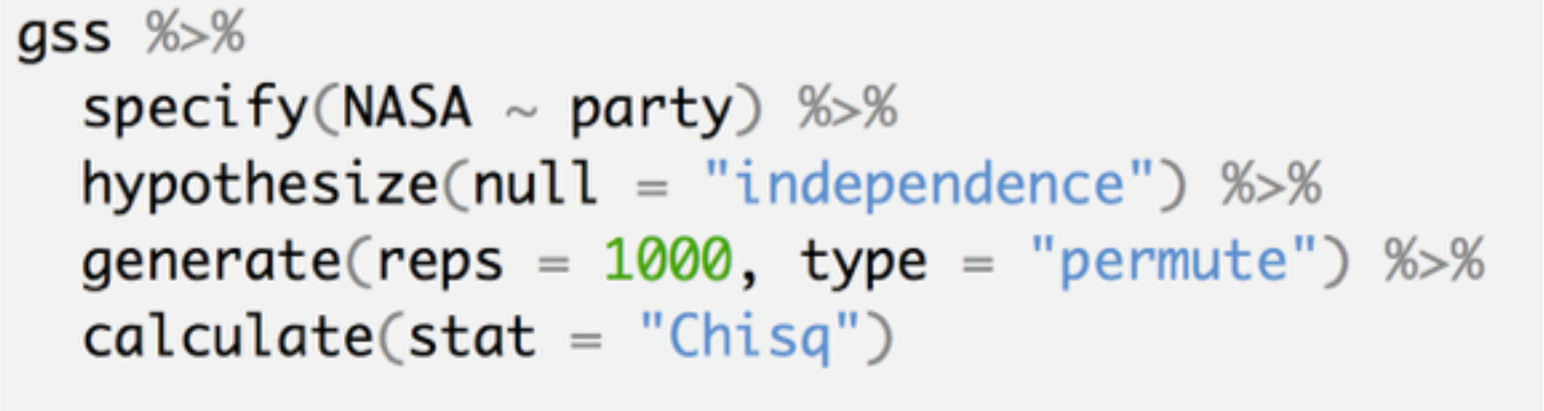
`specify()`

`hypothesize()`

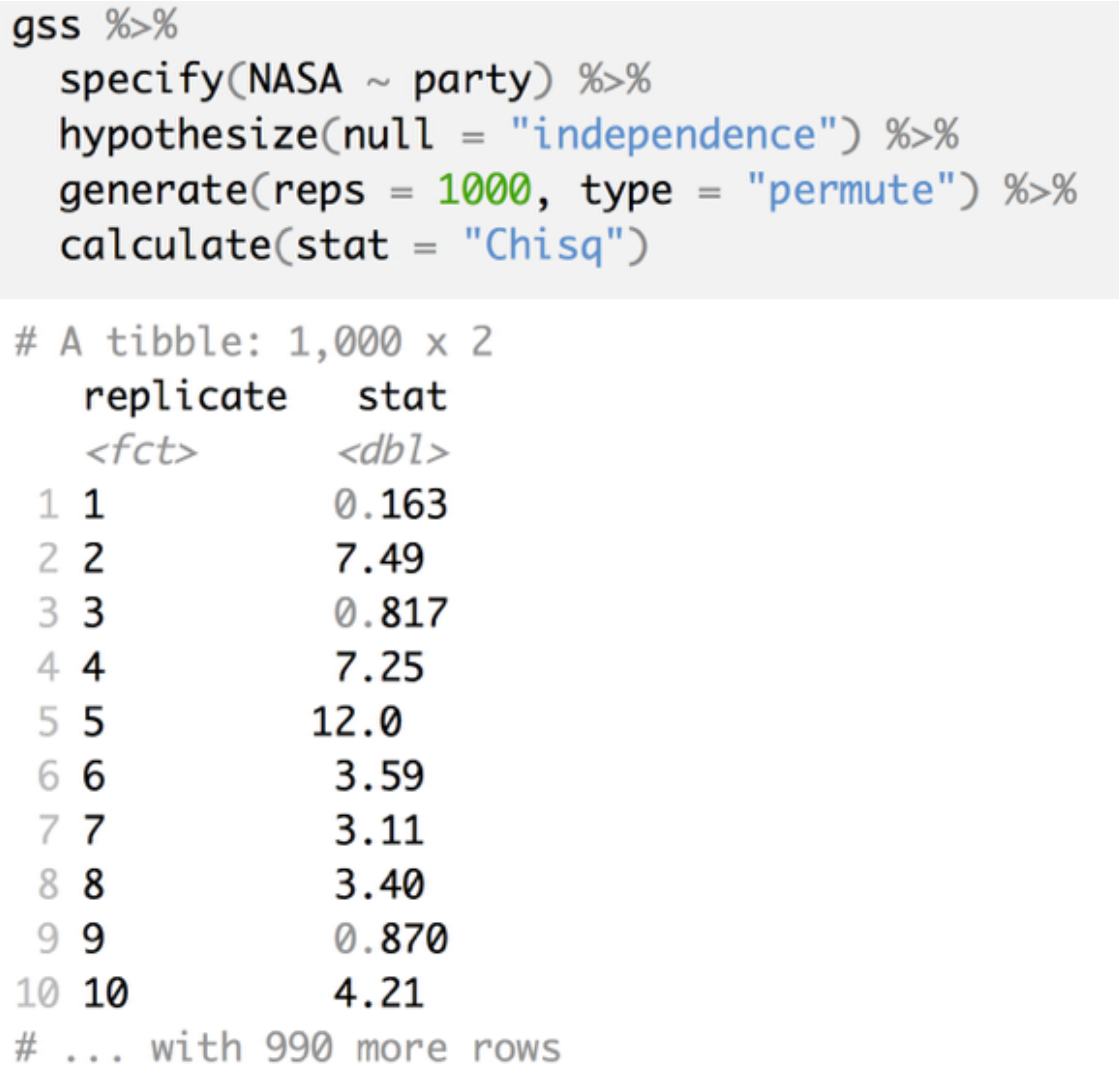
`generate()`

`calculate()`

`visualize()`



```r
gss %>%
  specify(NASA ~ party) %>%
  hypothesize(null = "independence") %>%
  generate(reps = 1000, type = "permute") %>%
  calculate(stat = "Chisq")
```



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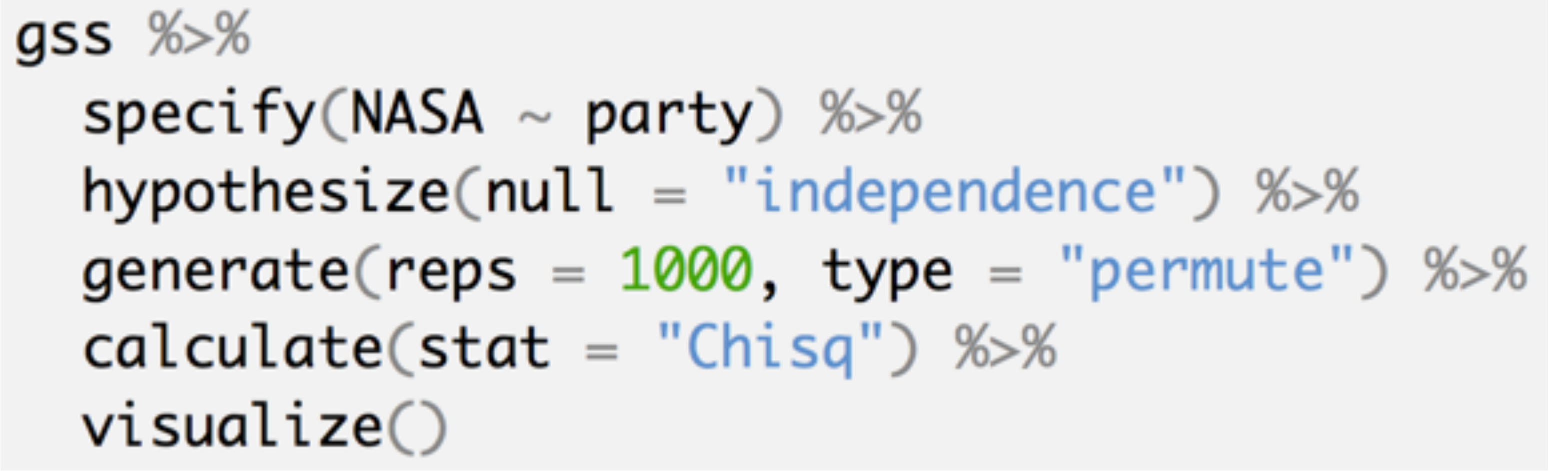
  generate(reps = 1000, type = "permute") %>%
  calculate(stat = "Chisq")
```

```
# A tibble: 1,000 x 2
   replicate   stat
   <fct>      <dbl>
 1 1          0.163
 2 2          7.49
 3 3          0.817
 4 4          7.25
 5 5         12.0
 6 6          3.59
 7 7          3.11
 8 8          3.40
 9 9          0.870
10 10         4.21
# ... with 990 more rows
```



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```

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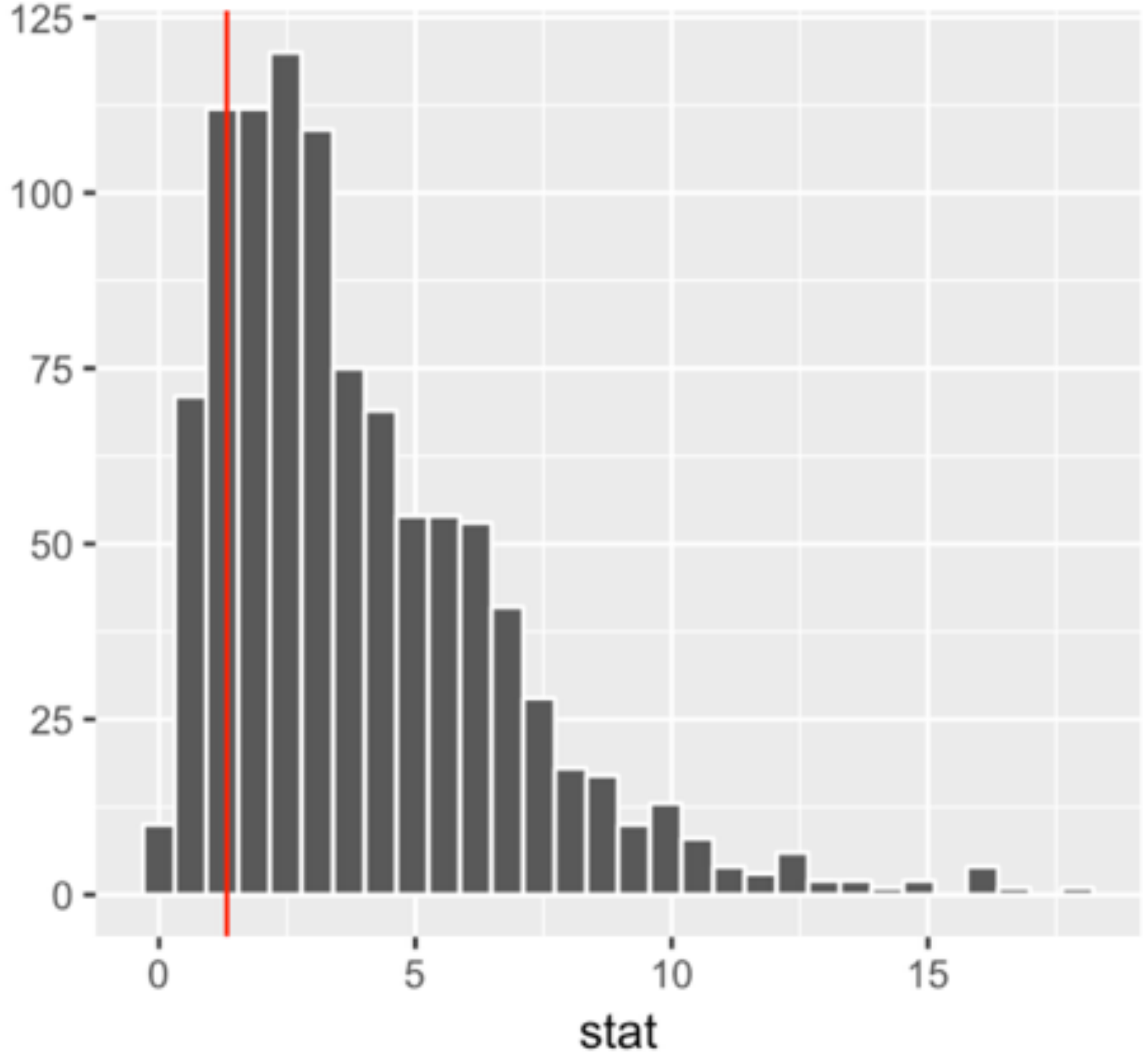

```
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  hypothesize(null = "independence") %>%
  generate(reps = 1000, type = "permute") %>%
  calculate(stat = "Chisq") %>%
  summarize(p_val = mean(stat > obs_stat))
```

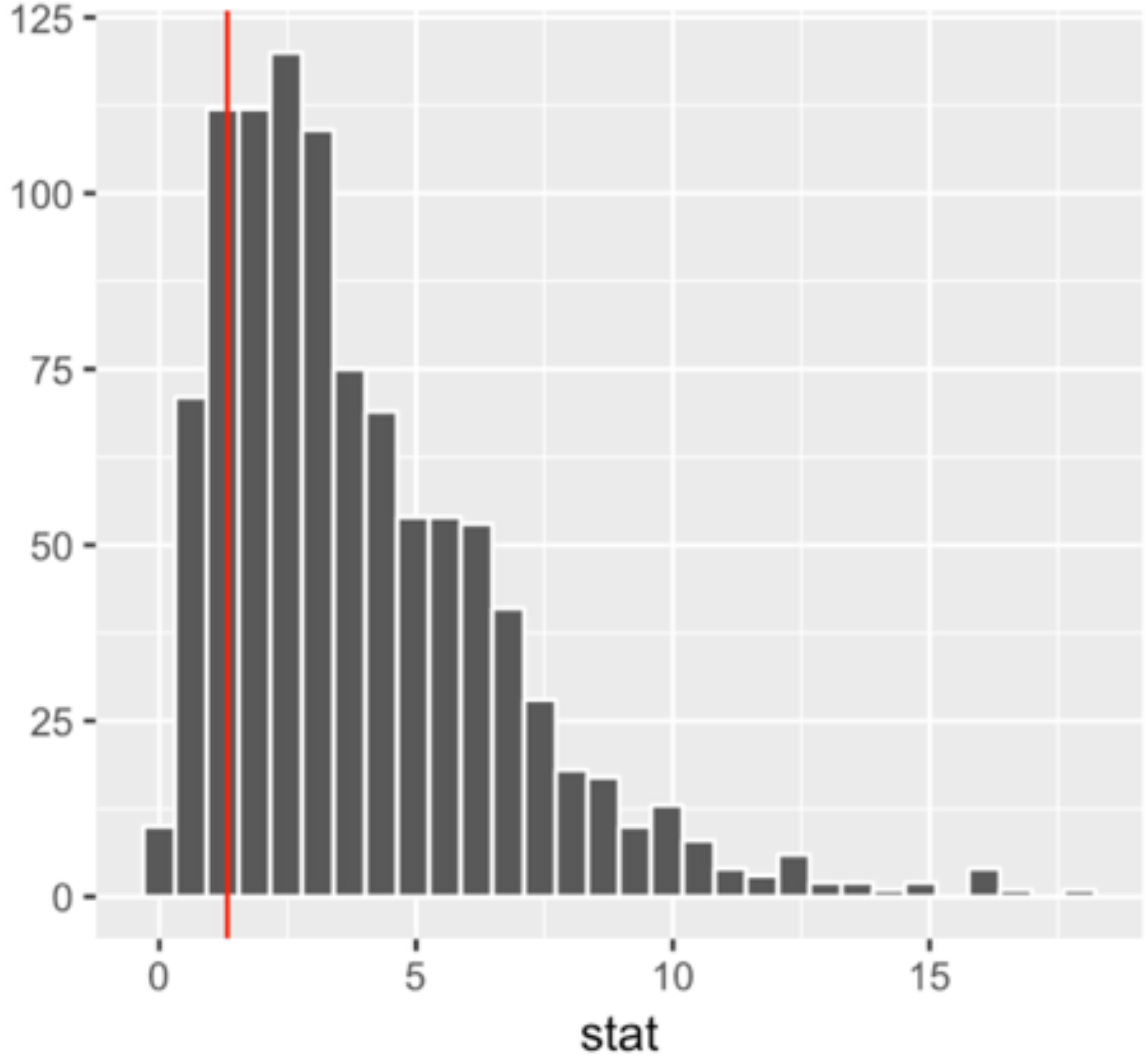

```
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  calculate(stat = "Chisq") %>%
  summarize(p_val = mean(stat > obs_stat))
```
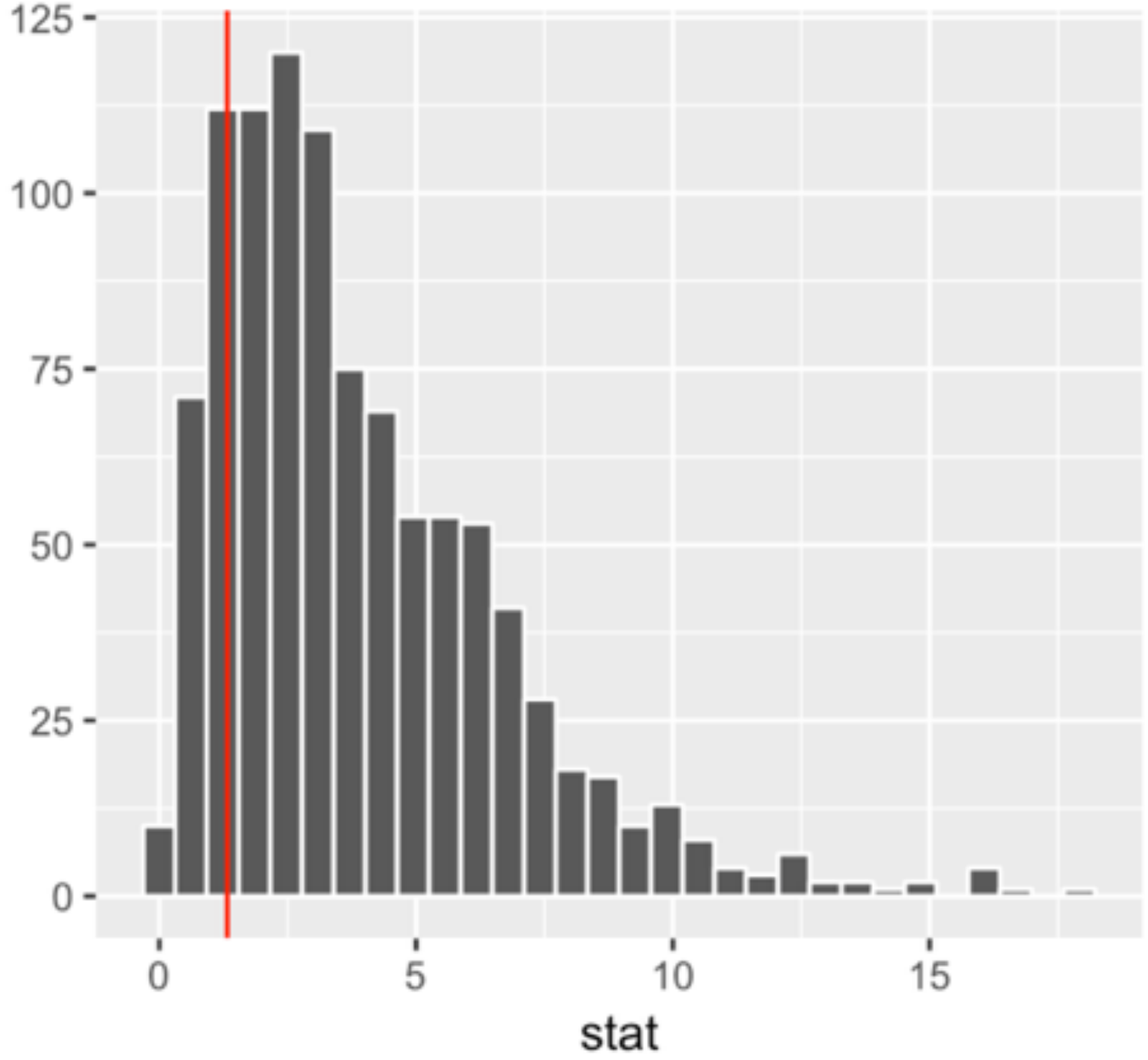
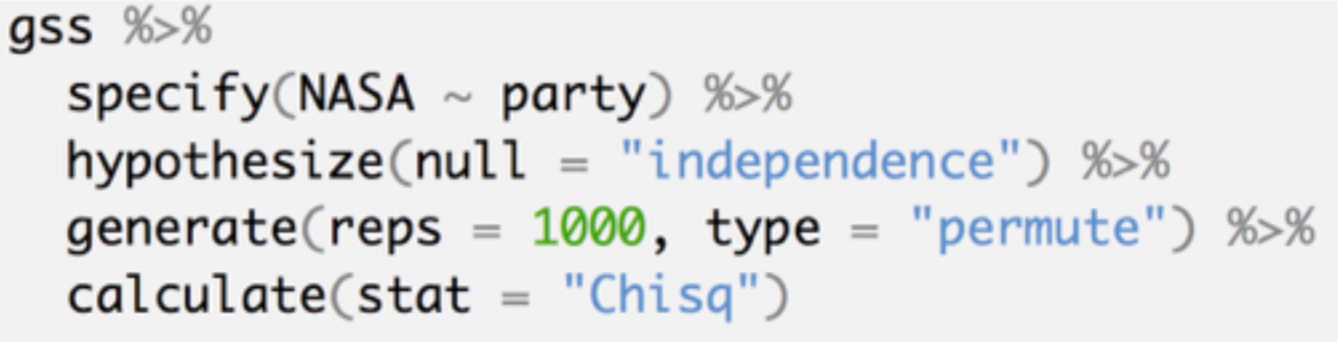

```
# A tibble: 1 x 1
  p_val
  <dbl>
1 0.864
```



Reusable parts

Reusable parts



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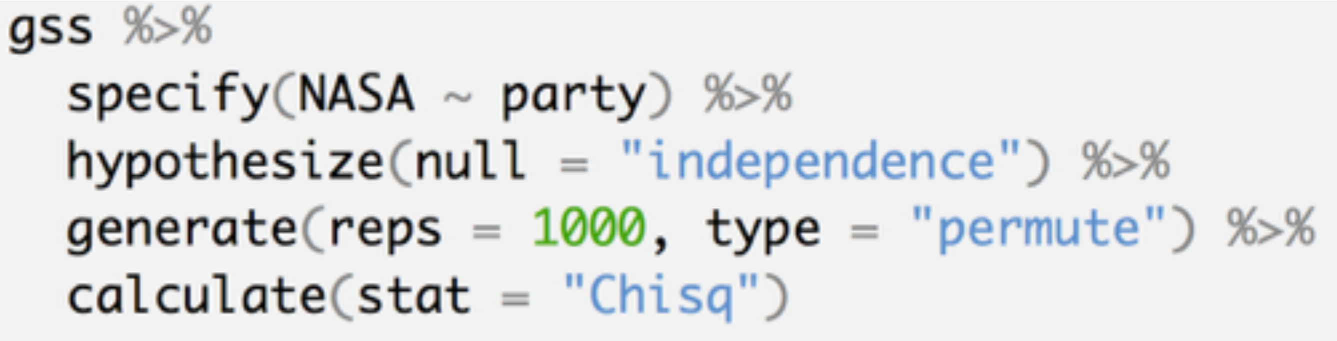
```

Permutation Chi-squared

Reusable parts



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```
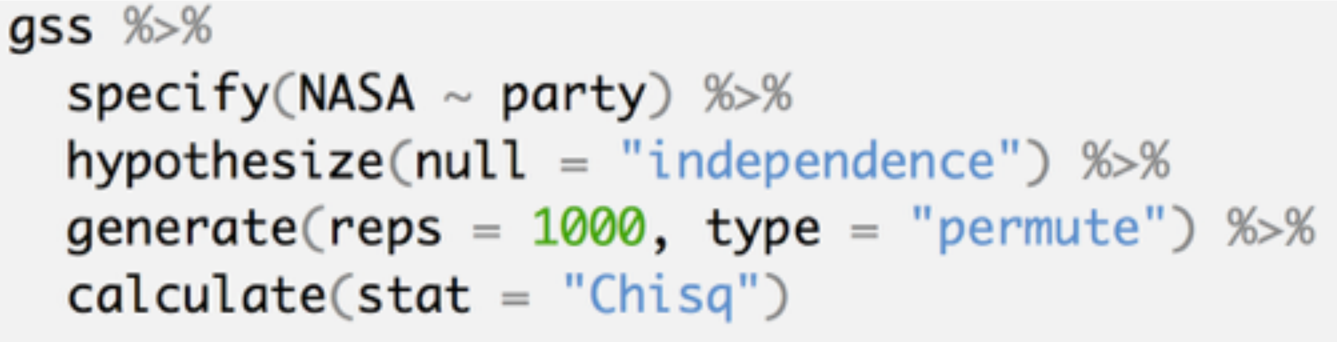

Permutation Chi-squared

Approximation Chi-squared*

Reusable parts



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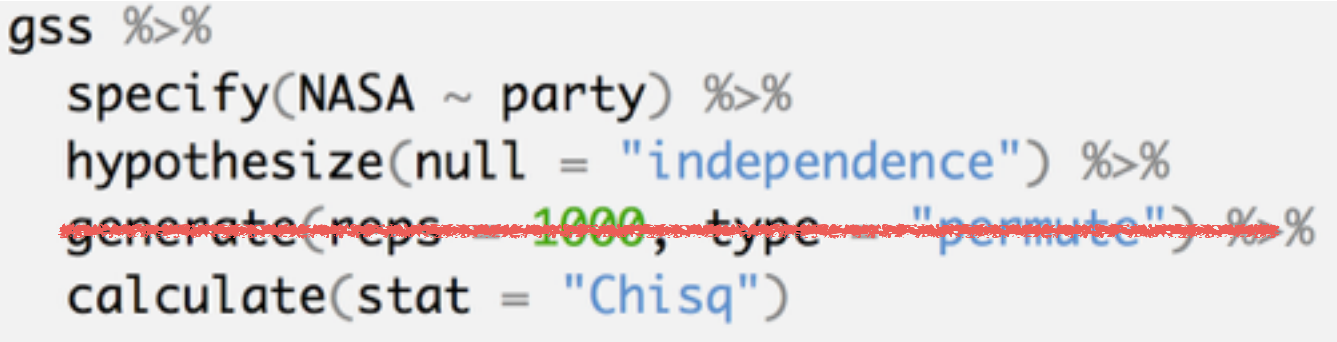
Permutation Chi-squared



```
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```
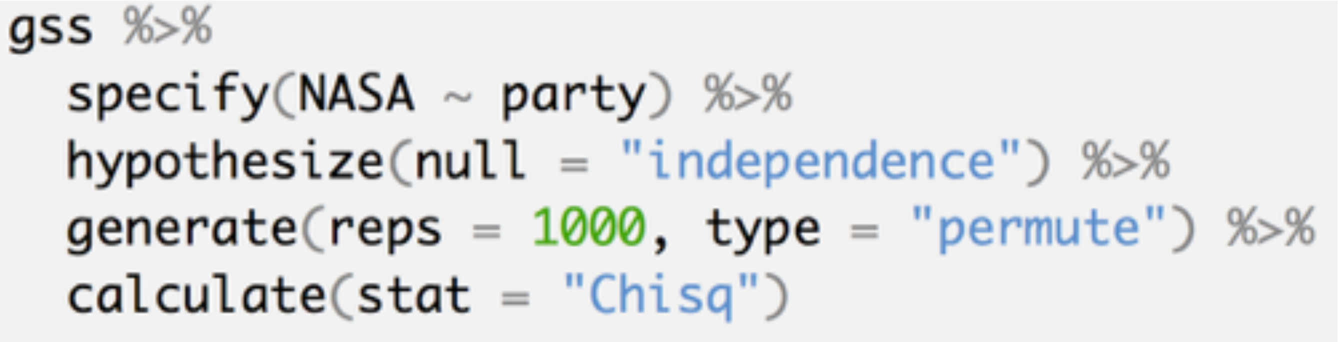

Approximation Chi-squared*

Reusable parts



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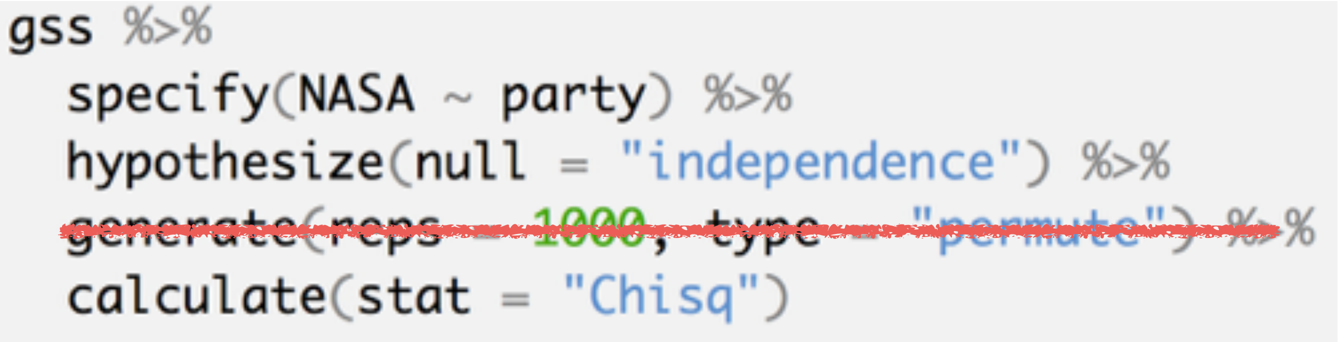
```

Permutation Chi-squared



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  ~~generate(reps = 1000, type = "permute") %>%~~
  calculate(stat = "Chisq")
```
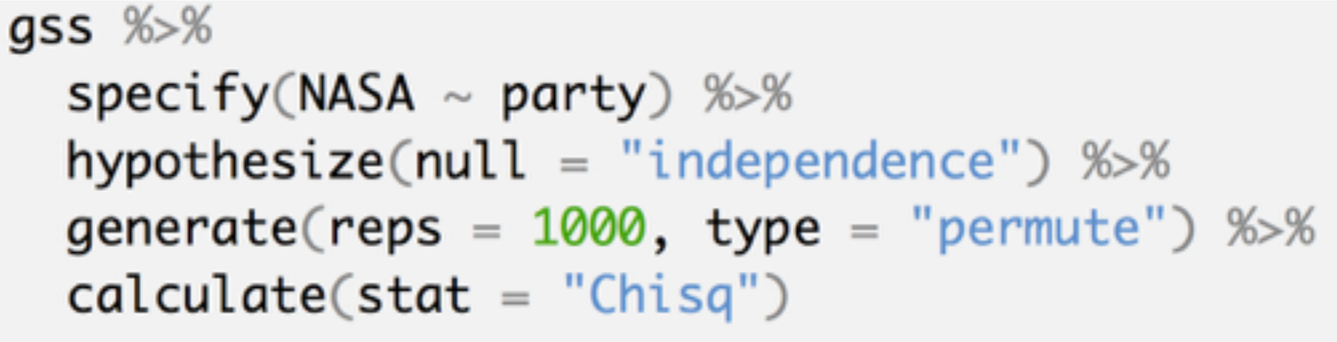

Approximation Chi-squared*

Permutation p1 - p2

Reusable parts



```
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  hypothesize(null = "independence") %>%
  generate(reps = 1000, type = "permute") %>%
  calculate(stat = "Chisq")
```
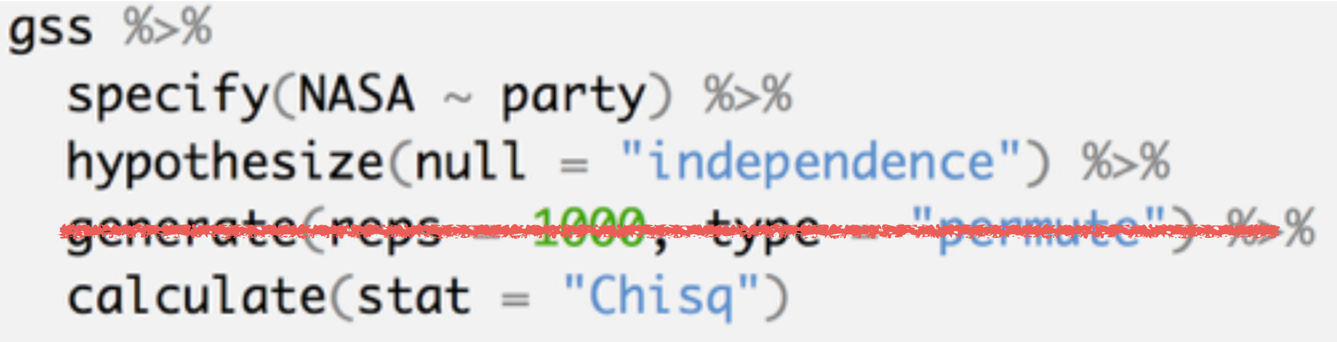

Permutation Chi-squared



```
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  ~~generate(reps = 1000, type = "permute") %>%~~
  calculate(stat = "Chisq")
```
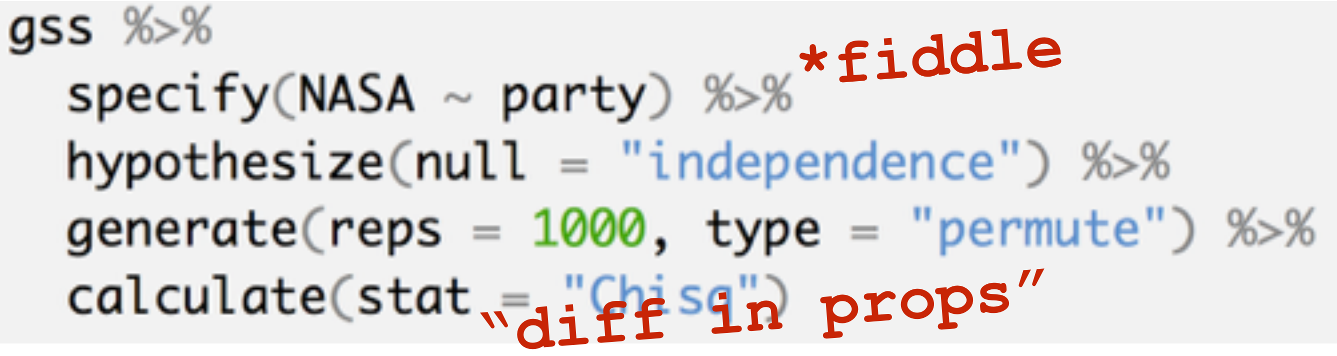
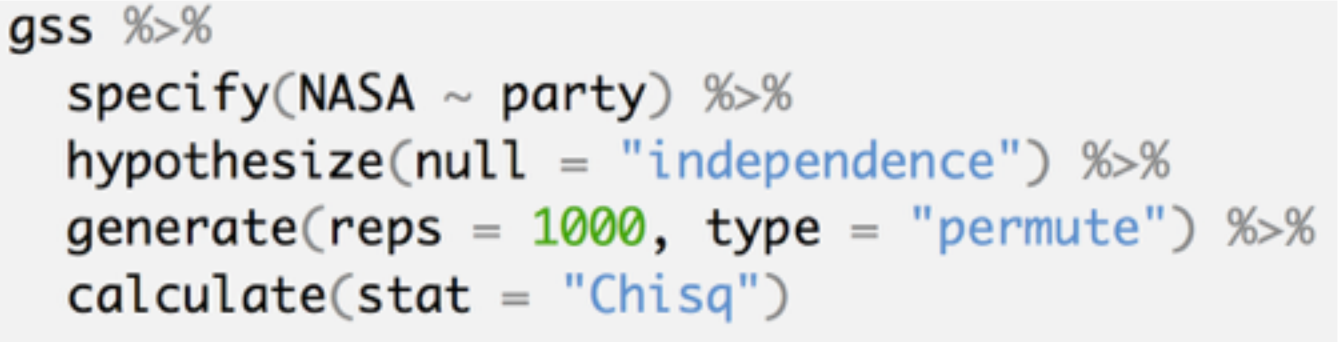

Approximation Chi-squared*



```
gss %>%
  specify(NASA ~ party) %>% *fiddle
  hypothesize(null = "independence") %>%
  generate(reps = 1000, type = "permute") %>%
  calculate(stat = "Chisq")
                 “diff in props”
```

Permutation p1 - p2

Reusable parts



```
gss %>%
  specify(NASA ~ party) %>%
  hypothesize(null = "independence") %>%
  generate(reps = 1000, type = "permute") %>%
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```
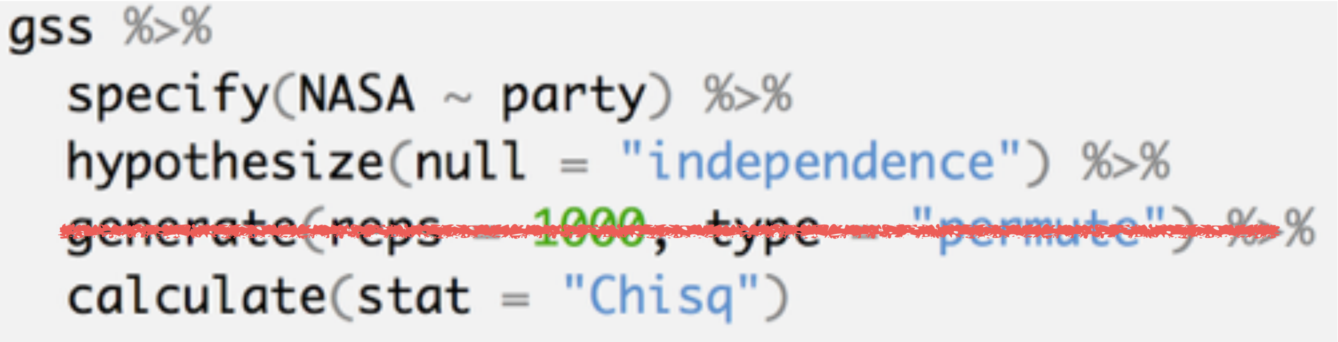

Permutation Chi-squared



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gss %>%
  specify(NASA ~ party) %>%
  hypothesize(null = "independence") %>%
  ~~generate(reps = 1000, type = "permute") %>%~~
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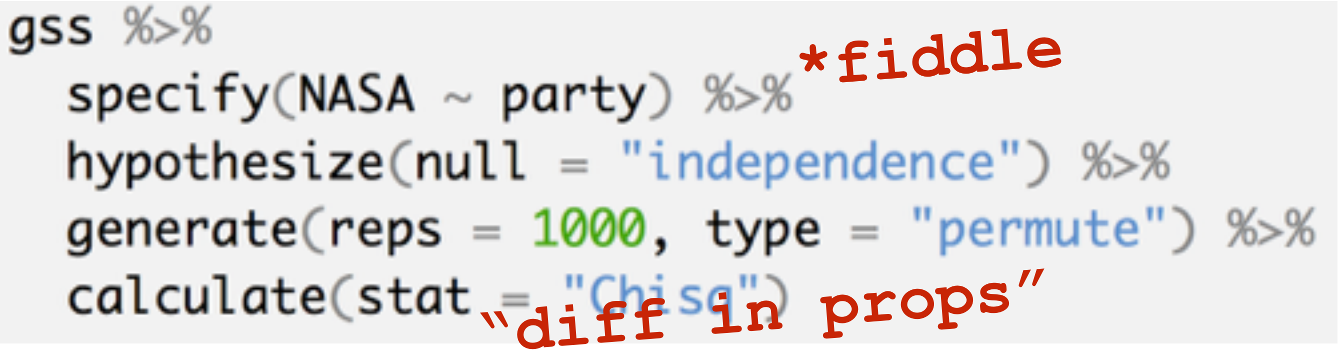
```

Approximation Chi-squared*



```
gss %>%
  specify(NASA ~ party) %>%
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  generate(reps = 1000, type = "permute") %>%
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```

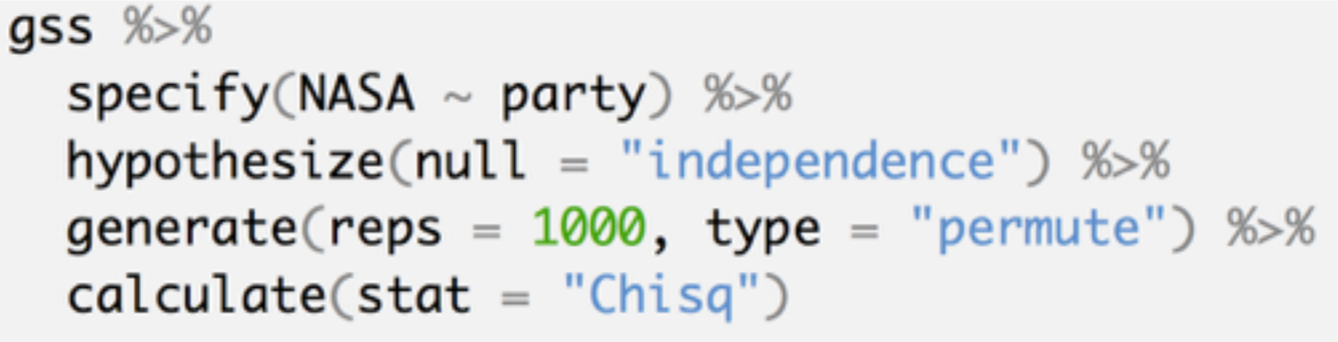
*fiddle

“diff in props”

Permutation p1 - p2

Confidence interval for p1 - p2

Reusable parts



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```
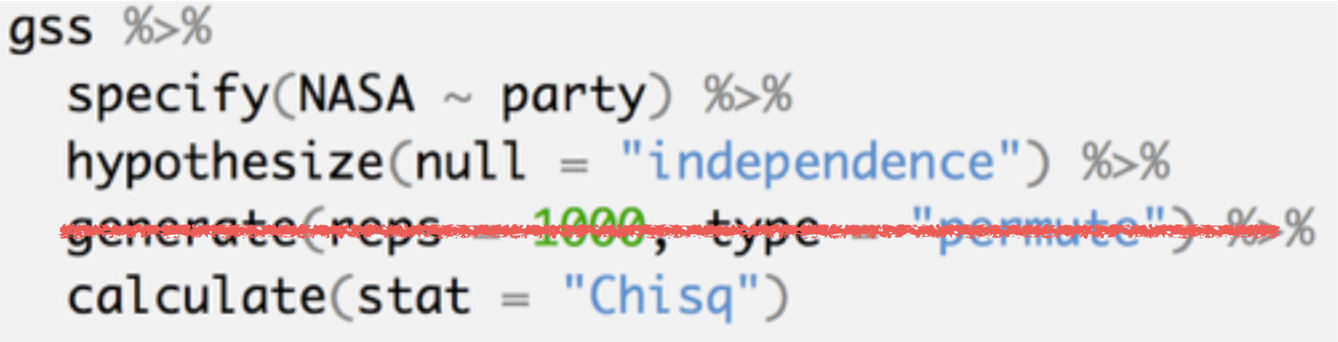

Permutation Chi-squared



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gss %>%
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  ~~generate(reps = 1000, type = "permute") %>%~~
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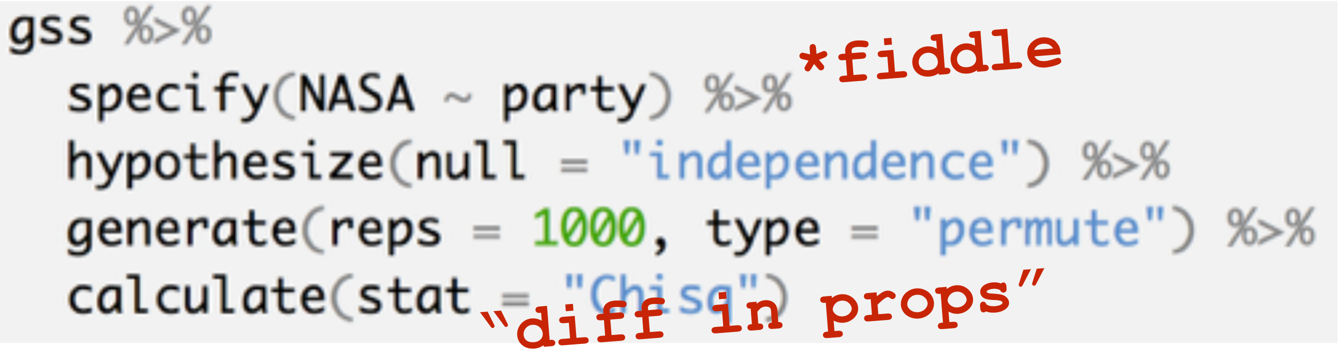
Approximation Chi-squared*

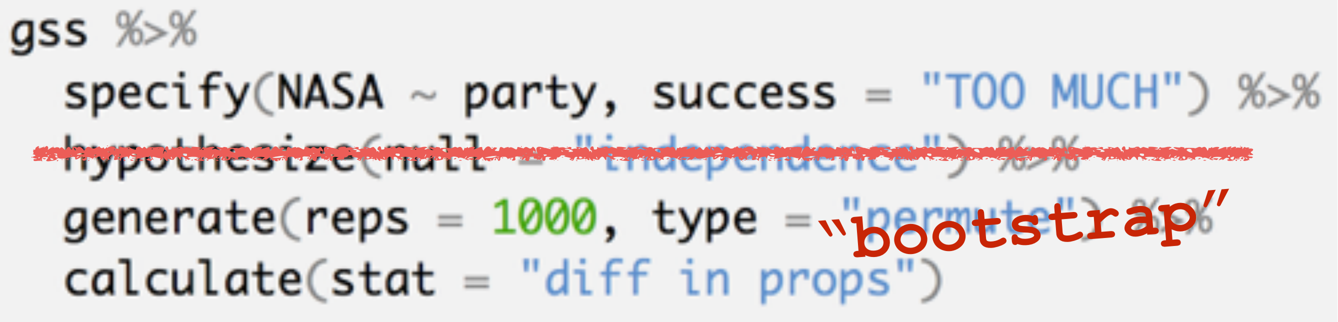


```
gss %>%
  specify(NASA ~ party) %>%
  hypothesize(null = "independence") %>%
  generate(reps = 1000, type = "permute") %>%
  calculate(stat = "Chisq")
```

*fiddle

"diff in props"

Permutation p1 - p2



```
gss %>%
  specify(NASA ~ party, success = "TOO MUCH") %>%
  ~~hypothesize(null = "independence") %>%~~
  generate(reps = 1000, type = "permute") %>%
  calculate(stat = "diff in props")
```

"bootstrap"

Confidence interval for p1 - p2

What’s to come

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- Generalize input to `calculate()`

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    - For example, `calculate(trimmed_mean)`

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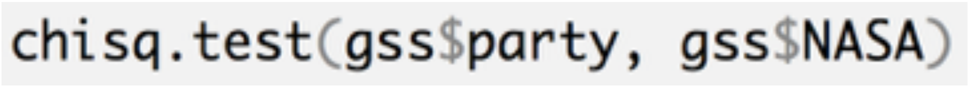
- Add list-columns to `generate()`

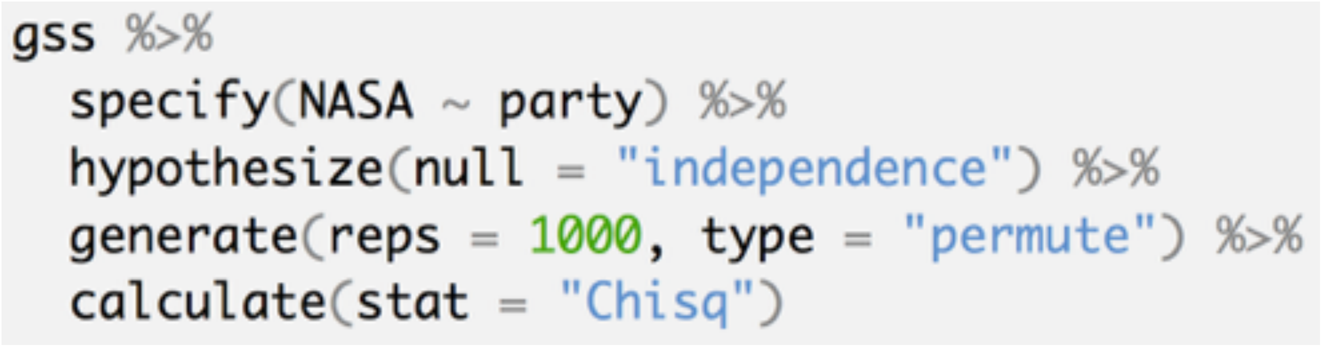
What’s to come

- Generalize input to `calculate()`
    - For example, `calculate(trimmed_mean)`
    - Support for more advanced regression models
- Spruce up `visualize()`
- Add list-columns to `generate()`
- Wrapper functions: `t_test, chisq_test,` etc.

infer makes ~~p-values~~ statistical inference ~~easier to compute.~~ tidy and transparent.



```
chisq.test(gss$party, gss$NASA)
```



```
gss %>%
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  hypothesize(null = "independence") %>%
  generate(reps = 1000, type = "permute") %>%
  calculate(stat = "Chisq")
```

- Thanks to Chester Ismay, Ben Baumer, Mine Cetinkaya-Rundel, Jo Hardin, and the other contributors.
- website: infer.netlify.com
- slides: http://bit.ly/2DYoBOz