Power Analysis in R

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Setup for today

- install the `pwr` package
- make a notebook and load it with `library(pwr)`
- download *oaks.csv* from Canvas and read it in with `read.csv()`

Overview

- A note on citing packages
- Review 6-step hypothesis testing procedure
- Power analysis in R

Citing R Packages

Citing R Packages

- R packages are made by people!
- You can (and should) cite packages just like you would cite a scientific paper
- Find the citation with `citation()`

Citing R Packages

"Power analyses were conducted with the *pwr* package in R (Champley 2018)."

```
citation("pwr")
```

```
##
## To cite package 'pwr' in publications use:
##
##   Stephane Champely (2018). pwr: Basic Functions for Power
##   Analysis. R package version 1.2-2.
##   https://CRAN.R-project.org/package=pwr
##
## A BibTeX entry for LaTeX users is
##
##   @Manual{,
##     title = {pwr: Basic Functions for Power Analysis},
##     author = {Stephane Champely},
##     year = {2018},
##     note = {R package version 1.2-2},
##     url = {https://CRAN.R-project.org/package=pwr},
##   }
```

Hypothesis testing

Hypothesis testing

Whenever you are asked to test a hypothesis in this class, you **must** use the 6-step hypothesis testing procedure (unless we say otherwise).

1. Hypothesis
2. Choose and justify the test

3–5. Do the test! (in R)

6. Summary statement

Exercise 1

The city of Cambridge collects data on all city trees including location, diameter (in cm), and species. These data are made available on data.cambridgema.gov. I downloaded the data and randomly sampled 20 oak trees growing in parks and 20 oak trees growing in cemeteries. The data are available on Canvas.

Test the hypothesis that oak trees grown in parks have a different diameter than oak trees grown in cemeteries.

Power Analysis

`pwr` package

The `pwr` package has power analyses for many different tests:

- Two proportions/binomial, `pwr.2p.test()`
- T-tests, `pwr.t.test()`
- Chi-squared test, `pwr.chisq.test()`
- One way ANOVA, `pwr.anova.test()`
- Linear models, `pwr.f2.test()`
- Correlation, `pwr.r.test()`

Power of a t-test

`pwr.t.test()` has 4 required arguments. Define 3 of the 4 of them, and it will calculate and return the 4th

- `n` - sample size
- `d` - effect size
- `sig.level` - type I error probability (default 0.05)
- `power` - power of test

Power of a t-test

Additional arguments define the type of t-test:

- `type` - one-sample, two-sample, or paired-sample t-test?
- `alternative` - same as in `t.test()`

Power of a t-test

If we want to know the **power** of a test, what information do you need to supply to `pwr.t.test()`?

```
pwr.t.test(n = ,
           d = ,
           sig.level = ,
           power = )
```

Power of a t-test

```
pwr.t.test(n = 15, d = 0.5, sig.level = 0.05) # power = ?
```

```
##
##      Two-sample t test power calculation
##
##               n = 15
##               d = 0.5
##       sig.level = 0.05
##           power = 0.262443
##     alternative = two.sided
##
## NOTE: n is number in *each* group
```

Estimating required sample size

If you want to know the **sample size** required to detect a difference at some power, what do you need to supply to `pwr.t.test()`?

```
pwr.t.test(n = ,
           d = ,
           sig.level = ,
           power = )
```

Estimating required sample size

```
pwr.t.test(d = 0.6, power = 0.8, sig.level = 0.05) # n = ?
```

```
##
##      Two-sample t test power calculation
##
##               n = 44.58577
##               d = 0.6
##       sig.level = 0.05
##           power = 0.8
##     alternative = two.sided
##
## NOTE: n is number in *each* group
```

Power to detect differences in oaks

What is the power of the t-test we did to detect a difference between park and cemetery oaks?

- `n` = ?
- `sig.level` = ?
- `d` = ?

$$d = \frac{|\ \mu_1 - \mu_2\ |}{\sigma}$$

Estimate!

Estimating parameters for `pwr.t.test`

```
oaks <- read.csv("data/oaks.csv")
oaks %>% group_by(Location) %>% summarize(mean = mean(diameter), n = n())
```

```
## # A tibble: 2 x 3
##   Location       mean     n
##   <fct>         <dbl> <int>
## 1 Cemetery Tree  19.8    20
## 2 Park Tree      12.9    20
```

```
d.est = (19.85 - 12.85)/sd(oaks$diameter)
d.est
```

```
## [1] 0.5610889
```

- Is this a large or small effect size?

Power analysis

```
pwr.t.test(n = 20, d = d.est)
```

```
##
##      Two-sample t test power calculation
##
##               n = 20
##               d = 0.5610889
##       sig.level = 0.05
##           power = 0.4089662
##     alternative = two.sided
##
## NOTE: n is number in *each* group
```

- Is this a lot of power?
- What is the probability we made a type II error?
- What could you do to increase your power?

Learn more about power!

1. If you want to detect a medium effect size (d = 0.5) with power = 0.8 and a typical alpha of 0.05, what is the minimum sample size should you should have? (two-tailed, two sample t-test)

2. How big of an effect size (d) can you detect with a power of 0.6 and a sample size of 20 in a paired t-test?

3. Which has greater power, an independent two sample t-test or a paired t-test?