

Analysis of CSV File Reading in R

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- Background
- Experiment
- ANOVA
- Additional Analysis
- Discussion

Motivation

- Importing a dataset might sound easy, but...
- Statisticians struggle with reading in large datasets (Matthews, 2021)
- `read.csv()`, part of base R (R Core Team, 2021), is old and slow.
- There are better and more efficient data I/O algorithms in R (Gillespie & Lovelace, 2021)
 - `rio::import()` (Chan et al., 2021)
 - `readr::read_csv()` (Wickham & Hester, 2021) - part of tidyverse (Wickham et al., 2019)
 - `data.table::fread()` (Dowle & Srinivasan, 2021)

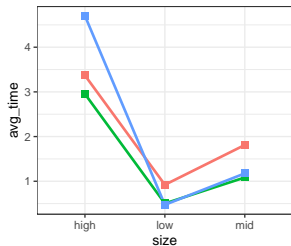
Experiment

- 3^3 factorial design (Montgomery, 2012)
 - File size: low ($\sim 0.49\text{GB}$), medium ($\sim 1.22\text{GB}$), high ($\sim 1.96\text{GB}$)
 - Computer: Lenovo, Dell, MacBook
 - Function: `rio::import()`, `readr::read_csv()`,
`data.table::fread()`
- $n = 20$ replicates
- $y_{ijkl} = \mu + \tau_i + \beta_j + \gamma_k + (\tau\beta)_{ij} + (\tau\gamma)_{ik} + (\beta\gamma)_{jk} + (\tau\beta\gamma)_{ijk} + \epsilon_{ijkl}$
 - $i, j, k = 1, 2, 3$
 - $l = 1, 2, \dots, 20$

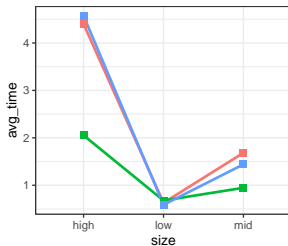
- Generate 3 files of different sizes consisting of columns of randomly-drawn samples from $N(0, 1)$, then export to CSV.
- 3^3 possible combinations of R package, file size, and computer.
- Use the 3 reading functions to load the CSV files, then `Sys.time()` to measure time elapsed.
- Obtain 20 replicates for each combination according to the order of a random sample of 1 through 3^3 .

Data Understanding

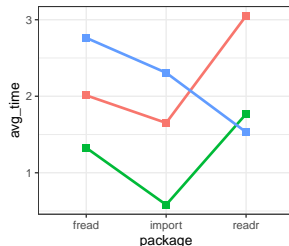
- Interaction plots



package — fread — import — readr



computer — dell — lenovo — mac



computer — dell — lenovo — mac

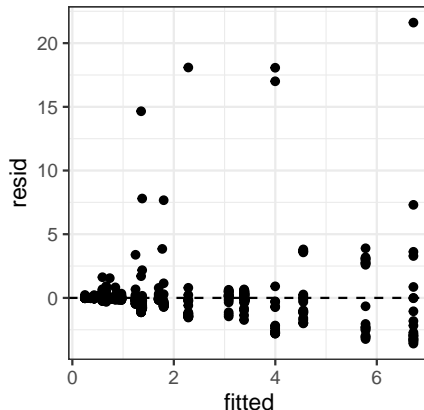
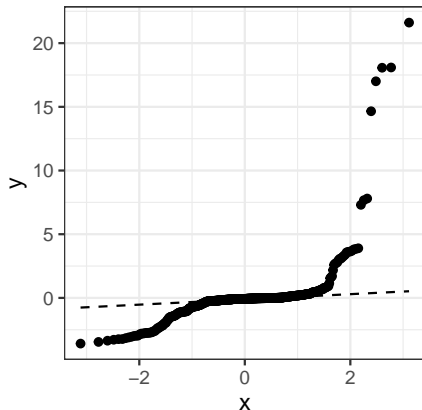
- All model terms are significant. . .

Term	df	SS	MS	F	p-value
size	2	908.9852	454.4926	98.1034	0.0000
computer	2	118.6155	59.3078	12.8017	0.0000
package	2	38.4974	19.2487	4.1549	0.0162
size:computer	4	136.3553	34.0888	7.3582	0.0000
size:package	4	87.9878	21.9970	4.7481	0.0009
computer:package	4	114.5762	28.6441	6.1829	0.0001
size:computer:package	8	144.3655	18.0457	3.8952	0.0002
Residuals	513	2376.6214	4.6328		

- However . . .

ANOVA

- There are issues with both **normality** and **homoscedasticity**



- Confirmed by Shapiro-Wilk and Levene tests (both with p -value ≈ 0)

- Transforming the data (log, Box-Cox) did not fix issues with model assumptions
- This leads us to consider a nonparametric approach
 - No distribution assumption about the data
 - Permutation test for a three way factorial designs
 - `asbio::perm.fact.test()` (Aho, 2021)

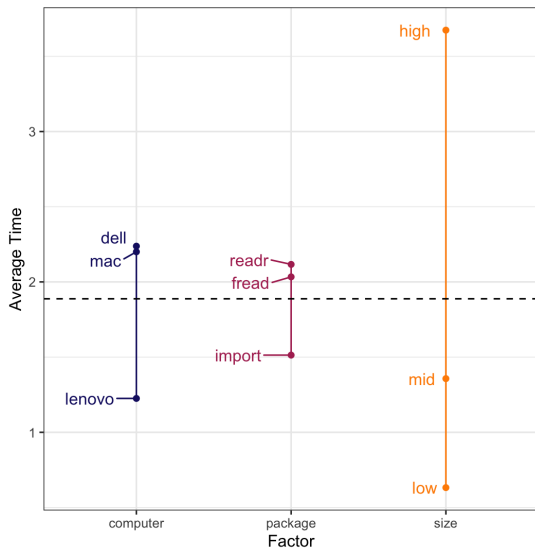
- A permutation test gives significant results

Term	Initial F	df	p-value
size	98.1034	2	0.0001
computer	12.8017	2	0.0001
package	4.1549	2	0.0123
size:computer	7.3582	4	0.0001
size:package	4.7481	4	0.0007
computer:package	6.1829	4	0.0002
size:computer:package	3.8952	8	0.0003
Residuals		513	

- Post-hoc analysis: pairwise permutation tests
- Use False Discovery Rate (Benjamini & Hochberg, 1995) as p -value adjustment method
- Which pairs differ in mean reading time?
 - Speed: all pairs
 - Computer: Lenovo-Dell, Lenovo-Mac
 - Package/Function: `data.table::fread()` - `rio::import()`,
`rio::import()` - `readr::read_csv()`

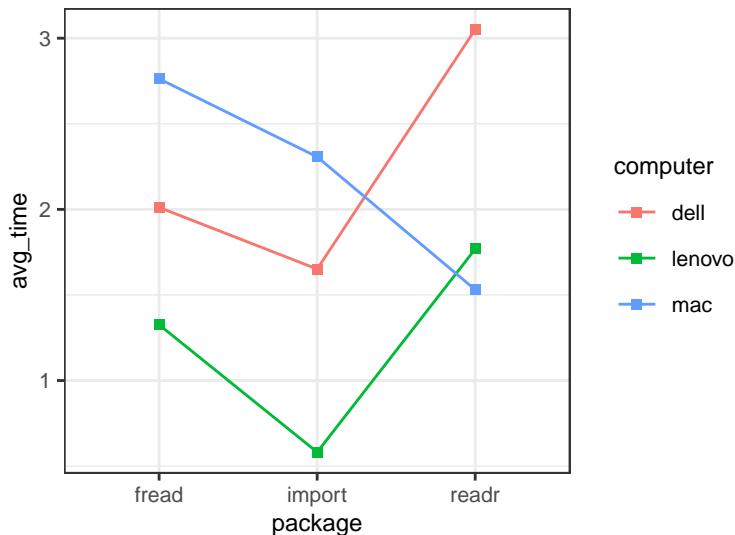
ANOVA

- Univariate effects plot of the factors



Additional Analysis

- Investigate reading method (package/function) for MacBook only

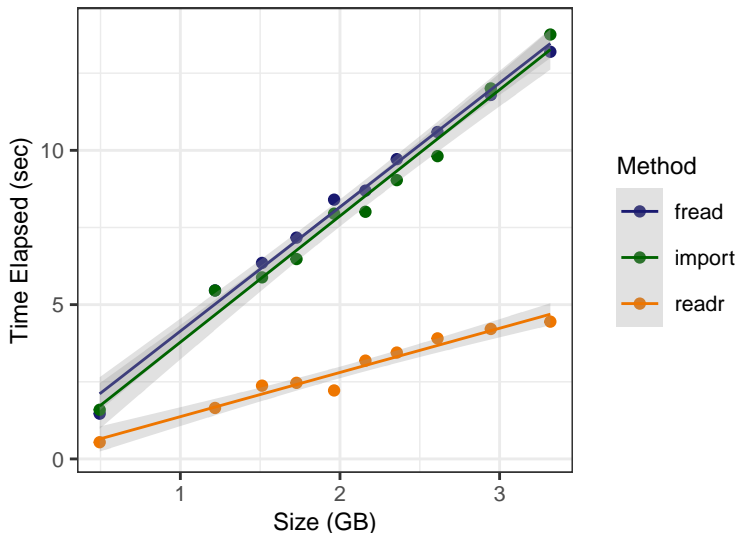


Additional Analysis

- A simulation study
- Simulate more data, in addition to the existing 3 data files
- Consider 10 file sizes (in GB)
 - **0.49, 1.22**, 1.51, 1.73, **1.96**, 2.16, 2.36, 2.61, 2.94, 3.32
- Use MacBook to read in each file using the 3 functions, and record the time elapsed

Additional Analysis

- Clearly there's a difference in algorithm reading time when using Mac



Additional Analysis

- ANCOVA: $y_{ij} = \mu + \tau_i + \beta(x_{ij} - \bar{x}_{..}) + \epsilon_{ij}$
 - Response: time elapsed (in seconds)
 - Treatment: R function (3 levels)
 - Covariate: file size (in GB)

Term	SS	df	F	p-value
(Intercept)	10.5154	1	8.4657	0.0073
package	187.3580	2	75.4188	0.0000
size	192.4662	1	154.9502	0.0000
Residuals	32.2950	26		

Additional Analysis

- Model assumptions are met.

statistic	p.value	method
0.9732	0.6286	Shapiro-Wilk normality test

statistic	p.value	df	df.residual	method
2.3633	0.1133	2	27	Levene test

Additional Analysis

- Multiple comparisons - Tukey contrasts

contrast	estimate	se	statistic	adj p-value
import - fread	-0.2873	0.4984	-0.5764	0.8338
readr - fread	-5.4391	0.4984	-10.9127	0.0000
readr - import	-5.1518	0.4984	-10.3362	0.0000

- readr significantly differs from the other 2 methods when using Mac.

- Similar design with more replicates
- Extend to other file formats (.tsv, .json...) and other forms of data (images, audio, ...)
- Other variables to consider:
 - On battery vs charging
 - Different environments: RStudio Desktop, RStudio Cloud, Colab Notebook, Terminal/Command Line...
 - Reading files in locally vs from a DropBox/Google Drive link

- Acknowledgments
 - Lance Davis
 - Mike Perry
 - Greg Matthews
- Greg's YouTube video: youtu.be/E5KJkooW4RY
- GitHub: github.com/qntkhvn/read_speed
- Question?

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