# rmcorrShiny: A web application for repeated measures correlation

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## Summary

The most common techniques for calculating the correlation between two variables (e.g., Pearson correlation coefficient) assume that each pair of data points arises from independent observation. Take, for example, a study that calculates the correlation between a person's age and the volume of a region of the brain. In this example, each individual contributes a data point consisting of a brain volume and an age. However, it is not uncommon for studies to use repeated measures designs, such as a study that collected the brain region volume and age at two different time points (Raz et al., 2005). Each participant in this study contributed two (repeated) data points of paired measures. Repeated measures of the same individual are no longer independent observations and should not be analyzed as such. Erroneously modeling repeated measures data as independent observations is surprisingly prevalent in published research, even though such results will generally be misleading (Aarts, Verhage, Veenvliet, Dolan, & Van Der Sluis, 2014; Bakdash, Marusich, Kenworthy, Twedt, & Zaroukian, 2020; Lazic, 2010). A common way to resolve this problem is to use aggregated data: first taking an average of the repeated measures data of each person so that every individual again contributes a single paired data point, and then calculating the correlation from these averages (between-participants).

Instead of aggregation, an alternative solution is to calculate the repeated measures correlation (Bakdash & Marusich, 2017; Bland & Altman, 1995a, 1995b), which assesses the common intra-individual (within-participants) association for paired repeated measures data. The repeated measures correlation technique is conceptually similar to a null multilevel model, with a common (fixed effect) slope but varying (random effect) intercept for each individual. Calculating the repeated measures correlation has multiple potential benefits. It is simpler and more straightforward to implement than a multilevel model, with the potential for much greater statistical power than aggregation. In addition, repeated measures correlation can provide insights into patterns within individuals that may be obscured by aggregation (Bakdash & Marusich, 2017).

## Statement of need

We previously developed the `rmcorr` package (Bakdash & Marusich, 2020) in R (R Core Team, 2020) to make the repeated measures correlation technique widely available for researchers; it has since also been adapted as a function in the `Pingouin` statistics package (Vallat, 2018) for Python. However, the use of both of these packages requires some facility with programming languages, which may limit accessibility.

Here we introduce `rmcorrShiny`, a `Shiny` (Chang et al., 2021) app, which provides an intuitive graphical interface for computing and plotting the repeated measures correlation
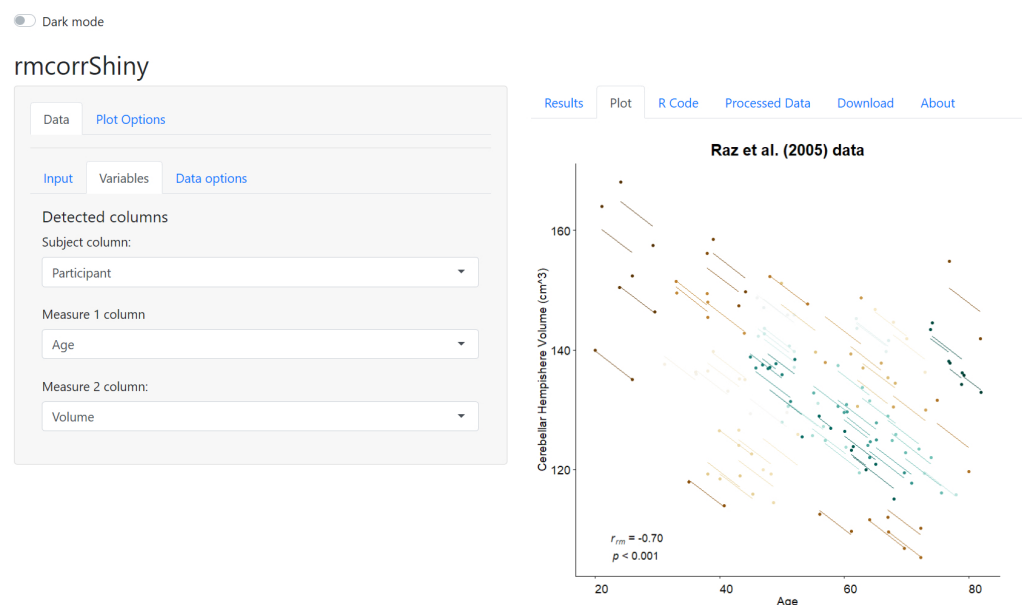
**Figure 1:** Screenshot of the `rmcorrShiny` app, showing the Data–Variables tabs (left side) and the Plot tab (right side), using sample data from Raz et al. (2005). Plot: The x-axis is age and the y-axis is volume of the cerebellar hemisphere. Each participant, plotted in a different color, contributes two points representing assessments of age and brain volume at two time periods. The corresponding lines depict the repeated measures correlation model. The negative slope indicates an age-related decrease in the volume of this brain area. See Bakdash and Marusich (2017) for more information about interpreting repeated measures correlation.

(see Figure 1). The primary features of `rmcorrShiny` include:

- The ability to import data in a variety of different file formats or to use one of four included sample datasets.
- Options for bootstrapping the confidence interval (CI) for the `rmcorr` effect size.
- The display of raw data and the output from `rmcorr` as well as formatted output for reporting scientific results.
- Multiple options to generate and customize `rmcorr` plots (making use of the `ggplot2` package (Wickham, 2016; Wickham et al., 2020) with palettes from the `RColorBrewer` (Neuwirth, 2014) and `pals` (Wright, 2019) packages).
- Customized `R` code generated using the data and options chosen by the user that can be directly pasted and executed in `R` to produce the same output as in `rmcorrShiny`, or as a starting point for additional customization in `R`.
- The ability to download plots (in multiple file formats) or a .zip file of all output.

Note that many features in `rmcorrShiny`, including the panel interface, were based on modifications of code from the `Raincloud-shiny` app (Forn-Cuní, 2021).

`rmcorrShiny` can be used in a web browser **here**, or the package can be installed from Github and run locally in `R`, using the following commands:

```
devtools::install_github("lmarusich/rmcorrShiny")
library(rmcorrShiny)
rmcorrShiny::rmcorrShiny_run()
```

## Acknowledgements

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