Scoring the implicit: The implicitMeasures package

Statement of need

Within the past decades, there has been a growing interest in the possibility of assessing people's attitudes, preferences, self-esteem, opinions and other social-psychological constructs without directly asking them. This was made possible by the advent of what are called implicit measures. Implicit measures are generally based on the speed and accuracy with which respondents are performing different categorization tasks in contrasting conditions. The assumption underlying their functioning is that respondents' performance will be faster and more accurate in the condition that is consistent with their actual attitudes, opinions, and preferences. The construct of interest is inferred from the difference in the response times in each condition.

Among implicit measures, the Implicit Association Test (IAT; Greenwald, McGhee, and Schwartz 1998) and the Single Category IAT (SC-IAT; Karpinski and Steinman 2006) are the mostly common used ones (Epifania, Robusto, and Anselmi 2020). Both tests result in a differential score (the so-called *D-score*) expressing respondents' bias in categorizing different stimuli in two contrasting conditions. While the scoring of the SC-IAT is based only on one algorithm (Karpinski and Steinman 2006), six different algorithms are available for computing the IAT *D-score* (Greenwald, Nosek, and Banaji 2003). The core procedure for the computation of the IAT *D-score* is the same for all the algorithms, which differentiate themselves according for the treatment of extreme fast responses and the replacement of error responses.

Despite that many R packages exist for computing IAT *D-score* algorithms, no packages exist for scoring the SC-IAT. Additionally, majority of existing R packages created for the computation of IAT *D-score* algorithms do not provide all the available algorithms. The packages allowing for the computation of multiple *D-score* algorithms either do not offer the chance to compare their results, or do not disambiguate the specific algorithm they are computing, raising reproducibility issue (Ellithorpe, Ewoldsen, and Velez 2015).

Recently, a Shiny Web Application (Chang et al. 2020) has been developed for computing the IAT *D-score*, called *DscoreApp* (Epifania, Anselmi, and Robusto 2019). This app provides an intuitive and easy to use user interface. By giving a detailed explanation of the *D-score* algorithms that can be computed, *DscoreApp* addresses the majority of the above mentioned replicability issues. Moreover, the graphical representation of the results can give an immediate glimpse of the general performance of the respondents. However, *DscoreApp* presents some shortcomings as well. Firstly, since it is a shiny app, it is associated with the most outstanding issue of shiny apps in general, namely, the replicability of the code Specifically, by putting the code into the shiny interface, it is impossible to call it from the command line, and this point is crucial for replication and automation. However, Epifania, Anselmi, and Robusto (2019) used a GitHub repository to let public access the code used for the computation. Despite the graphical representations of the results provided by *DscoreApp* are really useful for getting a first idea of the IAT results and they are all downloadable in a .pdf format, they cannot be further customized by the users. Moreover, *DscoreApp* computes the *D-score* only for the IAT.

`implicitMeasures` package is an `R` package aimed at overcoming both the shortcomings of the existing `R` packages for the computation of the IAT *D-score* and those of the shiny app *DscoreApp*. `implicitMeasures` provides an easy and open source way to clean and score both the IAT and the SC-IAT, to easily compare different IAT *D-score* algorithms, and to provide clear and customizable plots. Plot functions are all based on `ggplot2` (Wickham 2016).

Overview of `implicitMeasures` package

The released version of `implicitMeasures` can be installed from CRAN:

```
install.packages("implicitMeasures")
```

while the development version can be installed from GitHub:

```
# install.packages("devtools") # if you don't have devtools installed uncomment this line
devtools::install_github("OttaviaE/implicitMeasures")
```

`implicitMeasures` contains the following functions:

- `clean_iat()`: Prepare and clean IAT data
- `clean_sciat()`: Prepare and clean SC-IAT data
- `computeD()`: Compute IAT *D-score*
- `Dsciat()`: Compute SC-IAT *D-score*
- `descript_d()`: Print descriptive table of *D-score*s (also in LaTex)
- `d_distr()`: Plot IAT or SC-IAT scores (distribution)
- `d_plot()`: Plot either IAT or SC-IAT scores (points)
- `IATrel()`: Compute IAT reliability
- `multi_dsciat()`: Plot scores resulting from two SC-IATs
- `multi_dscore()`: Compute and plot multple IAT *D-score*s
- `raw_data()`: Example data set

Detailed explanations of the use of each function are provided in the package manual. The `raw_data` object is a data set included in the package. All the examples in the package documentation and vignettes are based on this data set. The data set contains data from one IAT for the assessment of the preference for Dark or Milk Choaolate (Chocolate IAT), a SC-IAT for the implicit assessment of the positive/negative evaluation of Dark Chocolate (Dark SC-IAT), and a SC-IAT for the implicit assessment of the positive/negative evaluation of Milk chocolate (Milk SC-IAT) (see: Epifania, Anselmi, and Robusto 2020 for further details).

`implicitMeasures` contains three vignettes, namely "implicitMeasures", "IAT-example", and "SC-IAT-example". Vignette "implicitMeasures" contains information regarding both the IAT and the SC-IAT, the computation of their respective scoring algorithms, as well as an explanation of the dataset (i.e., `raw_data`) included in the package. Vignettes "IAT-example" and "SC-IAT-example" provide examples of how to use the package functions for computing the IAT and SC-IAT *D-score*, respectively, for plotting their results, and for obtaining descriptive tables of the results. In the IAT case, an illustration of how to use the function for computing multiple *D-score* algorithms concurrently, as well as for plotting their results, is provided. In the SC-IAT case, also an example of how to use the package for plotting multiple SC-IATs scores in one graph is provided.

References

Chang, Winston, Joe Cheng, JJ Allaire, Yihui Xie, and Jonathan McPherson. 2020. *Shiny: Web Application Framework for R*. https://CRAN.R-project.org/package=shiny.

Ellithorpe, Morgan E, David R Ewoldsen, and John A Velez. 2015. "Preparation and Analyses of Implicit Attitude Measures: Challenges, Pitfalls, and Recommendations." *Communication Methods and Measures* 9 (4): 233–52. https://doi.org/10.1080/19312458.2015.1096330.

Epifania, O. M., Pasquale Anselmi, and Egidio Robusto. 2020. "A fairer comparison between the Implicit Association Test and the Single Category – Implicit Association Test." *Testing, Psychometrics, and Methodology in Applied Psychology* 27 (2): 1–14.

Epifania, O. M., P Anselmi, and E Robusto. 2019. "DscoreApp: An User-Friendly Web Application for Computing the Implicit Association Test d-Score." *Journal of Open Source Software* 4 (42): 1764. https://doi.org/10.21105/joss.01764.

Epifania, O. M., Egidio Robusto, and Pasquale Anselmi. 2020. "Implicit social cognition through years: The Implicit Association Test at age 21," February. https://doi.org/10.31124/advance.11914416.v1.

Greenwald, Anthony G, Debbie E McGhee, and Jordan L K Schwartz. 1998. "Measuring Individual Differences in Implicit Cognition: The Implicit Association Test." *Journal of Personality and Soclal Psychology* 74 (6): 1464–80. https://doi.org/10.1037/0022-3514.74.6.1464.

Greenwald, Anthony G, Brian A Nosek, and Mahzarin R Banaji. 2003. "Understanding and Using the Implicit Association Test: I. An Improved Scoring Algorithm." *Journal of Personality and Social Psychology* 85 (2): 197–216. https://doi.org/10.1037/0022-3514.85.2.197.

Karpinski, Andrew, and Ross B. Steinman. 2006. "The Single Category Implicit Association Test as a measure of implicit social cognition." *Journal of Personality and Social Psychology* 91 (1): 16–32. https://doi.org/10.1037/0022-3514.91.1.16.

Wickham, Hadley. 2016. *Ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag New York. https://ggplot2.tidyverse.org.