

Multiple outcomes in Meta-Analysis:  
a comparison between robust variance estimation,  
multilevel meta-analysis, and averaging effect sizes

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## Internal Report

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November 1, 2019

## Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
<b>2</b>	<b>Theoretical Aspects</b>	<b>2</b>
<b>3</b>	<b>Session Information</b>	<b>2</b>
	<b>Bibliography</b>	<b>3</b>

List of Figures

List of Tables

# 1 Introduction

In this report we consider the common problem encountered in Meta-Analysis when studies report more than one single effect-size. Common approaches to Meta-Analysis assume independence between effect sizes, so each study should contribute with only one effect size. However, this assumption is violated when studies report more than one effect because multiple effects within a study are not independent. Studies may have measured multiple outcome on the same subjects or multiple effects could have been computed considering the same control group (i.e., evaluating the effects of two different treatments using the same control group). Even when the different outcomes were evaluated on independent subjects within a study, effects can not be considered truly independent as they are related by other aspects that characterize the study such as instruments and methods used, geographic area, or research group.

In order to take into account the dependency between effect sizes, different approaches are proposed (Moeyaert et al., 2017; Pigott & Polanin, 2019):

1. averaging effect sizes
2. robust variance estimation
3. multilevel meta-analysis

In the present work we briefly describe these approaches and evaluate the possibly different results they give. We consider as a case study a meta-analysis that evaluates the effect of computer based intervention on children attitude and motivation towards mathematics. The present report is divided into different sections:

- **Section 2:** The theoretical aspects and implication of the three methods are briefly presented

## 2 Theoretical Aspects

## 3 Session Information

```
sessionInfo(package = NULL)

## R version 3.6.1 (2019-07-05)
## Platform: x86_64-apple-darwin15.6.0 (64-bit)
## Running under: macOS Mojave 10.14.6
##
## Matrix products: default
## BLAS: /Library/Frameworks/R.framework/Versions/3.6/Resources/lib/libRblas.0.dylib
## LAPACK: /Library/Frameworks/R.framework/Versions/3.6/Resources/lib/libRlapack.dylib
##
## locale:
## [1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
##
## attached base packages:
## [1] stats      graphics  grDevices  utils      datasets  methods   base
##
## other attached packages:
## [1] forcats_0.4.0  stringr_1.4.0  dplyr_0.8.3    purrr_0.3.2
## [5] readr_1.3.1    tidyr_1.0.0    tibble_2.1.3    tidyverse_1.2.1
## [9] kableExtra_1.1.0 ggplot2_3.2.1  robumeta_2.0    metafor_2.1-0
## [13] Matrix_1.2-17  knitr_1.25
##
## loaded via a namespace (and not attached):
## [1] tidyselect_0.2.5 xfun_0.10      haven_2.1.1
## [4] lattice_0.20-38  colorspace_1.4-1 vctrs_0.2.0
## [7] generics_0.0.2  htmltools_0.4.0 viridisLite_0.3.0
## [10] rlang_0.4.0      pillar_1.4.2   glue_1.3.1
## [13] withr_2.1.2      tikzDevice_0.12.3 modelr_0.1.5
## [16] readxl_1.3.1     lifecycle_0.1.0 cellranger_1.1.0
## [19] munsell_0.5.0    gtable_0.3.0   rvest_0.3.4
## [22] evaluate_0.14    broom_0.5.2    Rcpp_1.0.2
## [25] scales_1.0.0     backports_1.1.5 filehash_2.4-2
## [28] webshot_0.5.1    jsonlite_1.6    hms_0.5.1
## [31] digest_0.6.21    stringi_1.4.3   grid_3.6.1
## [34] cli_1.1.0        tools_3.6.1     magrittr_1.5
## [37] lazyeval_0.2.2   crayon_1.3.4    pkgconfig_2.0.3
## [40] zeallot_0.1.0    xml2_1.2.2      lubridate_1.7.4
## [43] assertthat_0.2.1 rmarkdown_1.16  httr_1.4.1
## [46] rstudioapi_0.10 R6_2.4.0         nlme_3.1-141
## [49] compiler_3.6.1
```

## References

- Moeyaert, M., Ugille, M., Natasha Beretvas, S., Ferron, J., Bunuan, R., & Van den Noortgate, W. (2017). Methods for dealing with multiple outcomes in meta-analysis : a comparison between averaging effect sizes, robust variance estimation and multilevel meta-analysis. *International Journal of Social Research Methodology*, 20(6), 559–572. doi:10.1080/13645579.2016.1252189
- Pigott, T. D., & Polanin, J. R. (2019). Methodological Guidance Papers: High-Quality Meta-Analysis in a Systematic Review. *Review of Educational Research*, 23. doi:10.3102/0034654319877153