Meta-analysis based on Sisks et al. (2018) - V.1

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```
# Load packages
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.0 --
```

```
## v ggplot2 3.3.5     v purrr   0.3.4
## v tibble  3.0.4     v dplyr   1.0.2
## v tidyr   1.1.2     v stringr 1.4.0
## v readr   1.4.0     v forcats 0.5.0
```

```
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
library(meta)
```

```
## Warning: package 'meta' was built under R version 4.0.5
```

```
## Loading 'meta' package (version 5.2-0).
## Type 'help(meta)' for a brief overview.
## Readers of 'Meta-Analysis with R (Use R!)' should install
## older version of 'meta' package: https://tinyurl.com/dt4y5drs
```

```
library(readxl)

# Import data
df1 <- read_excel('data/mindset.xlsx', sheet = 'Meta-analysis 1')
```

Data cleaning

```
# Glimpse data
glimpse(df1)
```

```
## Rows: 273
## Columns: 35
## $ `Document #`                          <dbl> 1, 2, 2, 2, 3, 3, 3, 3, 4, 5, 6...
## $ `Study #`                             <dbl> 1, 2, 2, 2, 3, 3, 3, 3, 4, 5, 6...
## $ `Sample #`                            <dbl> 1, 2, 3, 4, 5, 163, 164, 165, 6...
## $ `Sample Country`                      <chr> "Indonesia", "USA", "USA", "USA...
## $ `ES #`                                <dbl> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, ...
## $ Reference                             <chr> "Adatitomo (2015)", "Bagley (20...
## $ N                                     <dbl> 123, 400, 1019, 710, 250, 272, ...
## $ `Adjusted N`                          <dbl> 123.000000, 400.000000, 1019.00...
## $ `Student Description`                 <chr> "second semester university stu...
## $ `School Level`                        <chr> "post-secondary", "post-seconda...
## $ `Development Stage`                   <chr> "Adults", "Adults", "Adults", "...
## $ `Risk status`                         <chr> "low", "moderate", "moderate", ...
## $ SES                                   <chr> "not reported", "not reported",...
## $ `MS Measure`                          <chr> "Mindset about intelligence", "...
## $ `MS Measure Description`              <chr> "6 items, 3 growth and 3 fixed ...
## $ `Mindset Type`                        <chr> "Intelligence", "Personal attri...
## $ `Achievement Measure Description`     <chr> "Statistics final exam grade", ...
## $ `Academic Achievement Measure Type`   <chr> "Course exam", "Course grade", ...
## $ `Lab-based`                           <chr> "no", "no", "no", "no", "no", "...
## $ Published                             <chr> "yes", "no", "no", "no", "no", ...
## $ `ES type`                             <chr> "continuous", "continuous", "co...
## $ Calculation                           <chr> "Pearson's r", "sqrt of bivaria...
## $ Variance                              <dbl> 0.0079425749, 0.0024188215, 0.0...
## $ `Adjusted Variance`                   <dbl> 0.0079425749, 0.0024188215, 0.0...
## $ `Significant?`                        <chr> "N", "Y", "Y", "Y", "Y", "Y", "...
## $ r                                     <dbl> -0.12500000, 0.13266499, 0.1972...
## $ `Growth M`                            <dbl> NA, NA, NA, NA, NA, NA, NA, NA,...
## $ `Growth SD`                           <dbl> NA, NA, NA, NA, NA, NA, NA, NA,...
## $ `Other M`                             <dbl> NA, NA, NA, NA, NA, NA, NA, NA,...
## $ `Other SD`                            <dbl> NA, NA, NA, NA, NA, NA, NA, NA,...
## $ `Cohen's d`                           <dbl> NA, NA, NA, NA, NA, NA, NA, NA,...
## $ rpb                                   <dbl> NA, NA, NA, NA, NA, NA, NA, NA,...
## $ rb                                    <dbl> NA, NA, NA, NA, NA, NA, NA, NA,...
## $ `Calculated r`                        <dbl> NA, NA, NA, NA, NA, NA, NA, NA,...
## $ Notes                                 <chr> "the authors of the study also ...
```

```
# Rename columns
df2 <- rename(df1,
              document_id = 'Document #',
              study_id = 'Study #',
              sample_id = 'Sample #',
              sample_country = 'Sample Country',
              es_id = 'ES #',
              reference = 'Reference',
              n = N,
              adjusted_n = 'Adjusted N',
              student_description = 'Student Description',
```

```
            school_level = 'School Level',
            development_stage = 'Development Stage',
            risk_status = 'Risk status',
            ses = SES,
            ms_measure = 'MS Measure',
            ms_measure_description = 'MS Measure Description',
            mindset_type = 'Mindset Type',
            achievement_measure_description = 'Achievement Measure Description',
            academic_achievement_measure_type = 'Academic Achievement Measure Type',
            lab_based = 'Lab-based',
            published = 'Published',
            es_type = 'ES type',
            calculation = 'Calculation',
            variance = 'Variance',
            adjusted_variance = 'Adjusted Variance',
            is_significant = 'Significant?',
            growth_m = 'Growth M',
            growth_sd = 'Growth SD',
            other_m = 'Other M',
            other_sd = 'Other SD',
            cohen_d = "Cohen's d",
            calculated_r = 'Calculated r',
            notes = Notes)


# Check that variable types is correct
glimpse(df2)
```

```
## Rows: 273
## Columns: 35
## $ document_id                       <dbl> 1, 2, 2, 2, 3, 3, 3, 3, 4, 5, 6, ...
## $ study_id                          <dbl> 1, 2, 2, 2, 3, 3, 3, 3, 4, 5, 6, ...
## $ sample_id                         <dbl> 1, 2, 3, 4, 5, 163, 164, 165, 6, ...
## $ sample_country                    <chr> "Indonesia", "USA", "USA", "USA",...
## $ es_id                             <dbl> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11...
## $ reference                         <chr> "Adatitomo (2015)", "Bagley (2016...
## $ n                                 <dbl> 123, 400, 1019, 710, 250, 272, 27...
## $ adjusted_n                        <dbl> 123.000000, 400.000000, 1019.0000...
## $ student_description               <chr> "second semester university stude...
## $ school_level                      <chr> "post-secondary", "post-secondary...
## $ development_stage                 <chr> "Adults", "Adults", "Adults", "Ad...
## $ risk_status                       <chr> "low", "moderate", "moderate", "m...
## $ ses                               <chr> "not reported", "not reported", "...
## $ ms_measure                        <chr> "Mindset about intelligence", "Dw...
## $ ms_measure_description            <chr> "6 items, 3 growth and 3 fixed fr...
## $ mindset_type                      <chr> "Intelligence", "Personal attribu...
## $ achievement_measure_description   <chr> "Statistics final exam grade", "D...
## $ academic_achievement_measure_type <chr> "Course exam", "Course grade", "C...
## $ lab_based                         <chr> "no", "no", "no", "no", "no", "no...
## $ published                         <chr> "yes", "no", "no", "no", "no", "n...
## $ es_type                           <chr> "continuous", "continuous", "cont...
## $ calculation                       <chr> "Pearson's r", "sqrt of bivariate...
## $ variance                          <dbl> 0.0079425749, 0.0024188215, 0.000...
## $ adjusted_variance                 <dbl> 0.0079425749, 0.0024188215, 0.000...
```

```
## $ is_significant                    <chr> "N", "Y", "Y", "Y", "Y", "Y", "Y"...
## $ r                                 <dbl> -0.12500000, 0.13266499, 0.197230...
## $ growth_m                          <dbl> NA, NA, NA, NA, NA, NA, NA, NA, N...
## $ growth_sd                         <dbl> NA, NA, NA, NA, NA, NA, NA, NA, N...
## $ other_m                           <dbl> NA, NA, NA, NA, NA, NA, NA, NA, N...
## $ other_sd                          <dbl> NA, NA, NA, NA, NA, NA, NA, NA, N...
## $ cohen_d                           <dbl> NA, NA, NA, NA, NA, NA, NA, NA, N...
## $ rpb                               <dbl> NA, NA, NA, NA, NA, NA, NA, NA, N...
## $ rb                                <dbl> NA, NA, NA, NA, NA, NA, NA, NA, N...
## $ calculated_r                      <dbl> NA, NA, NA, NA, NA, NA, NA, NA, N...
## $ notes                             <chr> "the authors of the study also me...
```

```r
# Change school_level from character to factor
df2$school_level <- as.factor(df2$school_level)
levels(df2$school_level)
```

```
##  [1] "elementary, middle and high"
##  [2] "graduate"
##  [3] "middle"
##  [4] "middle and secondary"
##  [5] "middle and secondary (mostly secondary)"
##  [6] "post-secondary"
##  [7] "primary"
##  [8] "primary and middle"
##  [9] "secondary"
## [10] "vocational courses"
```

```r
# Change development_stage from character to factor
df2$development_stage <- as.factor(df2$development_stage)
levels(df2$development_stage)
```

```
## [1] "Adolescents" "Adults"      "Children"    "Wide range"  "Wide Range"
```

```r
# Convert all "Wide Range" level to "Wide range"
# Does not work! TOBEDONE
for (i in length(df2$development_stage)) {
  if (df2$development_stage[i] == 'Wide Range') {
    df2$development_stage[i] <- 'Wide range'}
}

# Change risk_status from character to factor
# TOBEDONE: What is the meaning of '.'? Change to NA?
df2$risk_status <- as.factor(df2$risk_status)
levels(df2$risk_status)
```

```
## [1] "."        "high"     "low"      "moderate"
```

```r
# Change ses from character to factor
df2$ses <- as.factor(df2$ses)
levels(df2$ses)
```

```
## [1] "low SES"      "not low"      "not reported"
```

```r
# Change mindset_type from character to factor
df2$mindset_type <- as.factor(df2$mindset_type)
levels(df2$mindset_type)
```

```
##  [1] "Ability"
```

```
##  [2] "Ability and Intelligence"
##  [3] "Ability and Performance"
##  [4] "Ability to learn"
##  [5] "Art Ability"
##  [6] "Biology Ability"
##  [7] "English Ability"
##  [8] "Intelligence"
##  [9] "Intelligence and Reading Ability"
## [10] "Intelligence and Talent"
## [11] "Intelligence, Math Ability, and Effort"
## [12] "Math ability"
## [13] "Math Ability"
## [14] "Math intelligence"
## [15] "Math Intelligence"
## [16] "Performance and Intelligence"
## [17] "Personal attributes"
## [18] "Personality"
## [19] "Physics Intelligence"
## [20] "Reading Ability"
## [21] "School Ability"
## [22] "Science ability"
## [23] "Science Ability"
## [24] "Talent for School"
## [25] "Verbal Intelligence"
```

```
# Change academic_achievement_measure_type from character to factor
df2$academic_achievement_measure_type <- as.factor(df2$academic_achievement_measure_type)
levels(df2$academic_achievement_measure_type)
```

```
## [1] "Course exam"       "Course grade"      "GPA"
## [4] "Standardized test"
```

```
# Change lab_based from character to factor
df2$lab_based <- as.factor(df2$lab_based)
levels(df2$lab_based)
```

```
## [1] "no"  "yes"
```

```
# Change published from character to factor
df2$published <- as.factor(df2$published)
levels(df2$published)
```

```
## [1] "no"  "yes"
```

```
# Change es_type from character to factor
df2$es_type <- as.factor(df2$es_type)
levels(df2$es_type)
```

```
## [1] "categorical" "continuous"
```

```
# Change is_significant from character to factor
df2$is_significant <- as.factor(df2$is_significant)
levels(df2$is_significant)
```

```
## [1] "N" "Y"
```

Meta-analysis 1

- REM
- REML to estimate tau
- No hakn correction

```
meta1 <- metacor(cor = r,
                 n = n,
                 studlab = reference,
                 data= df2,
                 fixed = FALSE,
                 random = TRUE,
                 method.tau = 'REML',
                 hakn = FALSE,
                 title = "Mindset and Academic Achievement")
meta1
```

```
## Review:     Mindset and Academic Achievement
##
## Number of studies combined: k = 273
## Number of observations: o = 419854
##
##                          COR           95%-CI     z  p-value
## Random effects model 0.1067 [0.0867; 0.1265] 10.41 < 0.0001
##
## Quantifying heterogeneity:
##  tau^2 = 0.0187 [0.0164; 0.0284]; tau = 0.1369 [0.1279; 0.1685]
##  I^2 = 97.0% [96.8%; 97.1%]; H = 5.74 [5.56; 5.92]
##
## Test of heterogeneity:
##        Q d.f. p-value
##  8958.24  272       0
##
## Details on meta-analytical method:
## - Inverse variance method
## - Restricted maximum-likelihood estimator for tau^2
## - Q-profile method for confidence interval of tau^2 and tau
## - Fisher's z transformation of correlations
```

- 273 studies were combined in the meta-analysis
- Estimated correlation is 0.1070679 with standard error 0.0102841 with 95% confidence interval [0.0869115, 0.1272244], which excludes zero.
- τ^2, the between-study variance, is 0.0187471 with 95% confidence interval [0.0163586, 0.0283962], which does not include zero. Indicates heterogeneity.

Meta-analysis 2: hakn = TRUE

Change from Meta-analysis 1 only one thing:

- Apply the hakn correction to control for the uncertainty in our estimate of the between-study heterogeneity.

```
meta2 <- metacor(cor = r,
                 n = n,
                 studlab = reference,
                 data= df2,
                 fixed = FALSE,
                 random = TRUE,
                 method.tau = 'REML',
                 hakn = TRUE,
                 title = "Mindset and Academic Achievement")
meta2
```

```
## Review:     Mindset and Academic Achievement
##
## Number of studies combined: k = 273
## Number of observations: o = 419854
##
##                          COR           95%-CI     t  p-value
## Random effects model 0.1067 [0.0858; 0.1274] 10.00 < 0.0001
##
## Quantifying heterogeneity:
##  tau^2 = 0.0187 [0.0164; 0.0284]; tau = 0.1369 [0.1279; 0.1685]
##  I^2 = 97.0% [96.8%; 97.1%]; H = 5.74 [5.56; 5.92]
##
## Test of heterogeneity:
##        Q d.f. p-value
##  8958.24  272       0
##
## Details on meta-analytical method:
## - Inverse variance method
## - Restricted maximum-likelihood estimator for tau^2
## - Q-profile method for confidence interval of tau^2 and tau
## - Hartung-Knapp adjustment for random effects model
## - Fisher's z transformation of correlations
```

Conclusion: The confidence interval is slightly larger than meta1, and the test is based on a t-distribution instead of a z-distribution. The estimate stays the same.

Applying the correction does not change any conclusion, so I will not apply it in subsequent analyses.

Meta-analysis 3: method.tau = 'DL'

```
meta3 <- metacor(cor = r,
                 n = n,
                 studlab = reference,
                 data= df2,
                 fixed = FALSE,
                 random = TRUE,
                 method.tau = 'DL',
                 hakn = FALSE,
                 title = "Mindset and Academic Achievement")
meta3
```

```
## Review:     Mindset and Academic Achievement
##
## Number of studies combined: k = 273
## Number of observations: o = 419854
##
##                          COR           95%-CI    z  p-value
## Random effects model 0.1074 [0.0843; 0.1304] 9.07 < 0.0001
##
## Quantifying heterogeneity:
##  tau^2 = 0.0271; tau = 0.1645; I^2 = 97.0% [96.8%; 97.1%]; H = 5.74 [5.56; 5.92]
##
## Test of heterogeneity:
##        Q d.f. p-value
##  8958.24  272       0
##
## Details on meta-analytical method:
## - Inverse variance method
## - DerSimonian-Laird estimator for tau^2
## - Fisher's z transformation of correlations
```

Meta-analysis 4: method.tau = 'PM'

```
meta4 <- metacor(cor = r,
                 n = n,
                 studlab = reference,
                 data= df2,
                 fixed = FALSE,
                 random = TRUE,
                 method.tau = 'PM',
                 hakn = FALSE,
                 title = "Mindset and Academic Achievement")
meta4
```

```
## Review:     Mindset and Academic Achievement
##
## Number of studies combined: k = 273
## Number of observations: o = 419854
##
##                          COR           95%-CI    z  p-value
## Random effects model 0.1069 [0.0858; 0.1278] 9.90 < 0.0001
##
## Quantifying heterogeneity:
##  tau^2 = 0.0214 [0.0164; 0.0284]; tau = 0.1463 [0.1279; 0.1685]
##  I^2 = 97.0% [96.8%; 97.1%]; H = 5.74 [5.56; 5.92]
##
## Test of heterogeneity:
##        Q d.f. p-value
##  8958.24  272       0
##
## Details on meta-analytical method:
## - Inverse variance method
## - Paule-Mandel estimator for tau^2
## - Q-profile method for confidence interval of tau^2 and tau
## - Fisher's z transformation of correlations
```

Meta-analysis 5: method.tau = 'EB'

```
meta5 <- metacor(cor = r,
                 n = n,
                 studlab = reference,
                 data= df2,
                 fixed = FALSE,
                 random = TRUE,
                 method.tau = 'EB',
                 hakn = FALSE,
                 title = "Mindset and Academic Achievement")
meta5
```

```
## Review:     Mindset and Academic Achievement
##
## Number of studies combined: k = 273
## Number of observations: o = 419854
##
##                          COR           95%-CI    z  p-value
## Random effects model 0.1069 [0.0858; 0.1278] 9.91 < 0.0001
##
## Quantifying heterogeneity:
##  tau^2 = 0.0214 [0.0164; 0.0284]; tau = 0.1463 [0.1279; 0.1685]
##  I^2 = 97.0% [96.8%; 97.1%]; H = 5.74 [5.56; 5.92]
##
## Test of heterogeneity:
##        Q d.f. p-value
##  8958.24  272       0
##
## Details on meta-analytical method:
## - Inverse variance method
## - Empirical Bayes estimator for tau^2
## - Q-profile method for confidence interval of tau^2 and tau
## - Fisher's z transformation of correlations
```

Meta-analysis 6: method.tau = 'SJ'

```
meta6 <- metacor(cor = r,
                 n = n,
                 studlab = reference,
                 data= df2,
                 fixed = FALSE,
                 random = TRUE,
                 method.tau = 'SJ',
                 hakn = FALSE,
                 title = "Mindset and Academic Achievement")
meta6
```

```
## Review:     Mindset and Academic Achievement
##
## Number of studies combined: k = 273
## Number of observations: o = 419854
##
##                          COR           95%-CI    z  p-value
## Random effects model 0.1077 [0.0837; 0.1316] 8.75 < 0.0001
##
## Quantifying heterogeneity:
##  tau^2 = 0.0298 [0.0164; 0.0284]; tau = 0.1726 [0.1279; 0.1685]
##  I^2 = 97.0% [96.8%; 97.1%]; H = 5.74 [5.56; 5.92]
##
## Test of heterogeneity:
##        Q d.f. p-value
##  8958.24  272       0
##
## Details on meta-analytical method:
## - Inverse variance method
## - Sidik-Jonkman estimator for tau^2
## - Q-profile method for confidence interval of tau^2 and tau
## - Fisher's z transformation of correlations
```