

# Meta-Analysis Workshop

## *Part 1: Introduction and Overview*

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# Overall Aim & Scope of the Workshop

- Conceptual introduction and overview into meta-analytics research methods
- Given the heterogeneous composition of participants:
  - No specific knowledge (beyond intro stats concepts) required
  - No programming skills / usage of specific programs required (e.g., R)

# Evidence unclear?

	<i>r</i>	<i>N</i>	Sig.?	95% CI	
				-	+
Study 1	0,25	30	n.s.	-0,13	0,63
Study 2	-0,18	40	n.s.	-0,50	0,14
Study 3	0,41	50	*	0,12	0,70
Study 4	0,09	60	n.s.	-0,17	0,35
Study 5	0,28	70	*	0,04	0,52
Study 6	0,32	80	*	0,10	0,54
Study 7	0,11	90	n.s.	-0,10	0,32
Study 8	0,31	100	*	0,11	0,51

**$r = .22$  (.13/.30);  $Q = 11.45$ ,  $df = 7$ ,  $p = .13$**

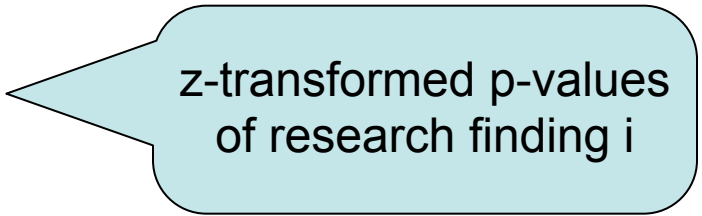
# Non-Meta-Analytic Synthesis of Evidence

- Narrative Reviews
- Vote-Counting
- Stouffer-Method (p-value aggregation)

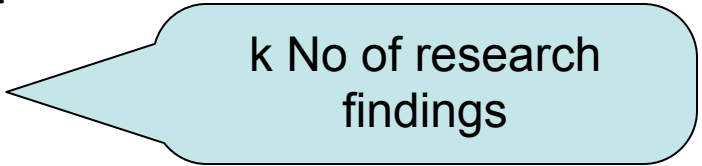


Why  
inefficient and  
biased?

$$Z_s = \frac{\sum_{i=1}^k z_{p(i)}}{\sqrt{k}}$$



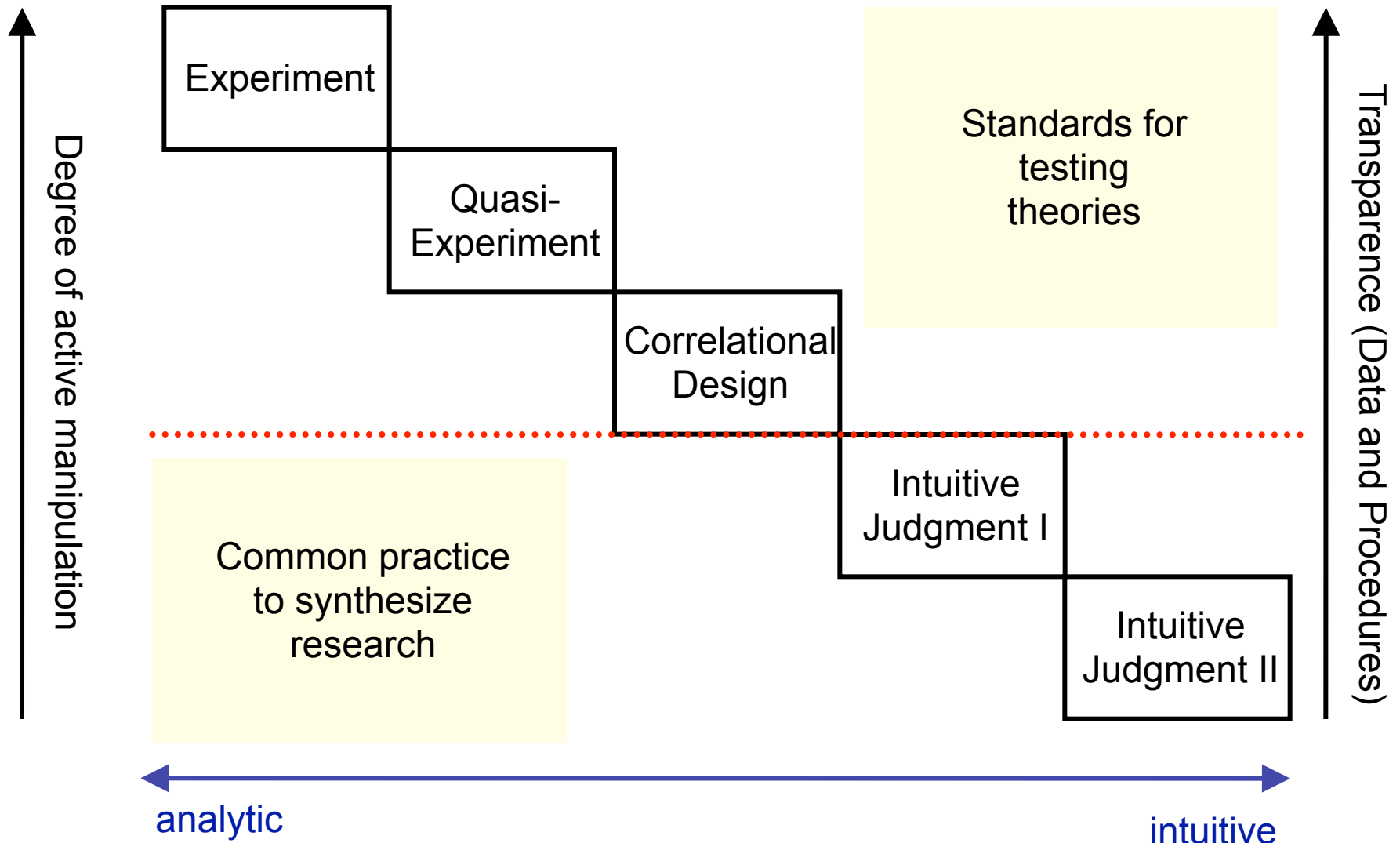
z-transformed p-values  
of research finding i



k No of research  
findings

Proposed by Stouffer et al. (1949), used by Rosenthal (1979) to compute his version of the 'fail-safe-N'.

# Theory Testing vs Research Synthesis



# Brief History

1904: Karl Pearson

1932: Ronald A. Fisher

1952 f.: Hans Eysenck

1970-er f.: 'Explosion' of (partly contradictory) empirical studies

1976 f.: Gene Glass coined the term „meta-analysis“, parallel development of meta-analytic models by:

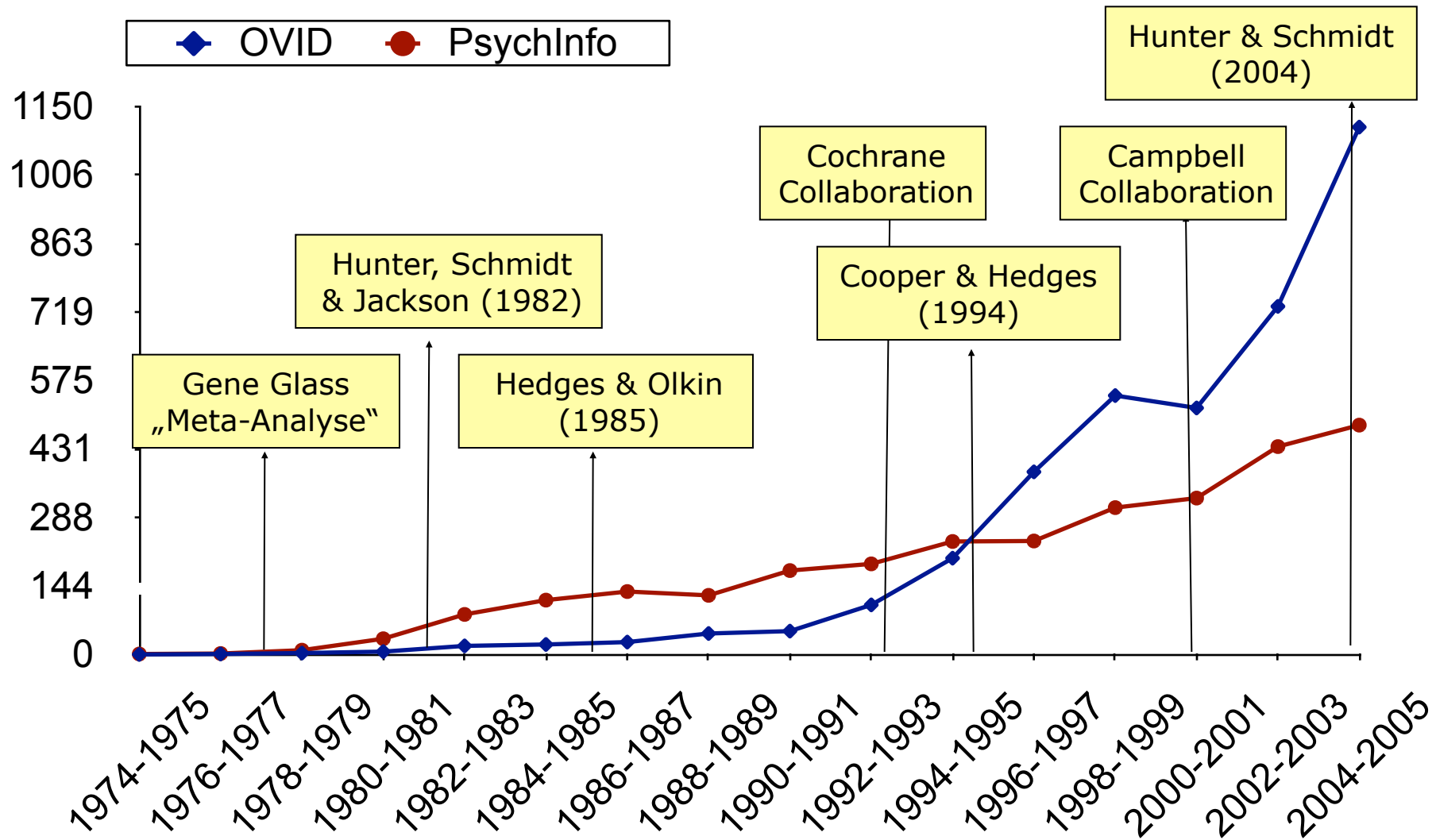
- Jack Hunter und Frank Schmidt
- Robert Rosenthal
- Thomas Chalmers
- Archibald Cochran

1980 ff.: Institutionalisation and first textbooks

1993: Cochrane Collaboration established

2000: Campbell Collaboration established

# No of Published Meta-Analyses by Year



# Impact of Meta-Analyses

Nissen, S. E., & Wolski, K. (2007). Effect of Rosiglitazone on the risk of myocardial infarction and death from cardiovascular causes. *New England Journal of Medicine*, 356, 2457-2471.

## *The* NEW ENGLAND JOURNAL *of* MEDICINE

ESTABLISHED IN 1812

JUNE 14, 2007

VOL. 356 NO. 24

### Effect of Rosiglitazone on the Risk of Myocardial Infarction and Death from Cardiovascular Causes

Steven E. Nissen, M.D., and Kathy Wolski, M.P.H.



# Impact of Meta-Analyses

- 1.43 times higher risk of myocardial infarction in treated groups ( $p = .03$ )
- 1.64 times higher risk of death from cardiovascular causes ( $p = .06$ )
- article published online on May 21, 2007

# Impact of Meta-Analyses

**GlaxoSmithKline plc (ADR)** (Public, NYSE:GSK) - [Add to Portfolio](#) - [Discuss GSK](#)

**52.35**

-0.40 (-0.76%)

Delayed: 02:01PM ET

Open: 52.53

High: 52.66

Low: 52.33

Vol: 803,900.00

Mkt Cap: 149.46B

52Wk High: 59.98

52Wk Low: 50.58

Avg Vol: 3.40M

P/E: 13.98

F P/E: 11.66

Beta: 0.19

EPS: 3.74

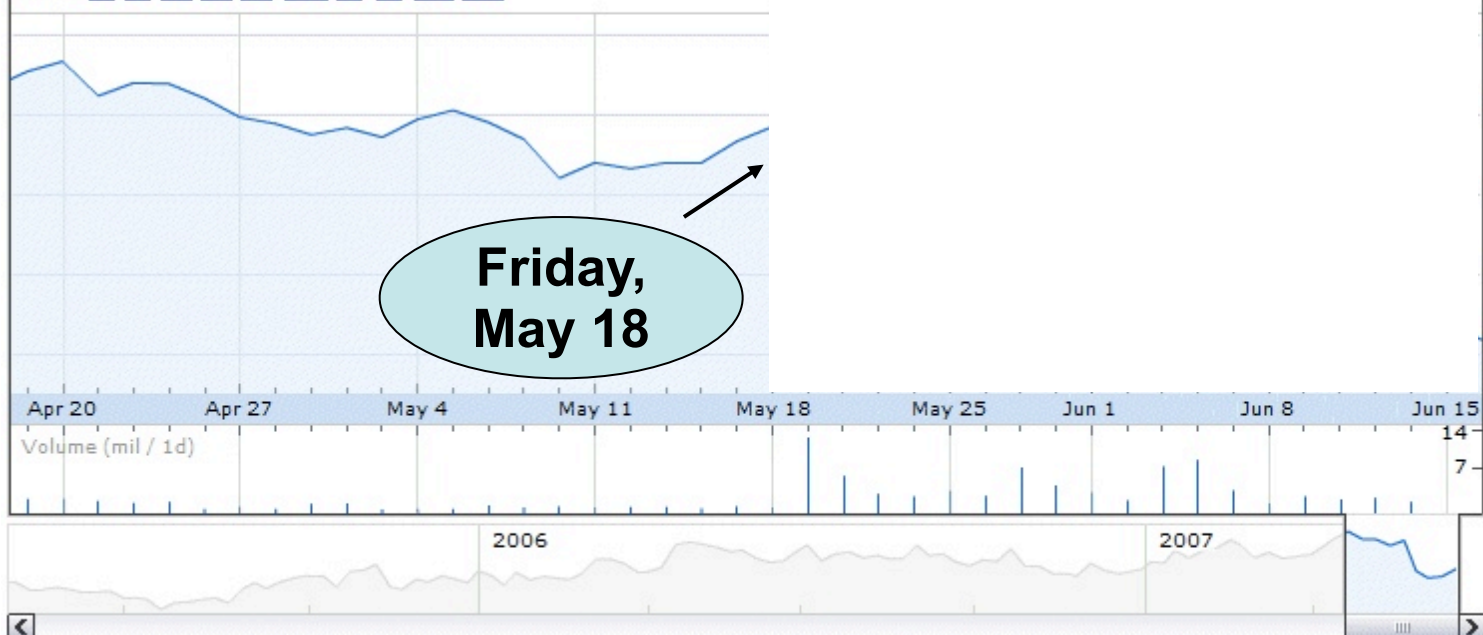
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Tip: You can drag the chart.

NYSE data delayed by 20 min. - [Disclaimer](#)

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Apr 19 - Jun 18, 2007: -6.32 (-10.77%)



Tip: You can drag the chart.

NYSE data delayed by 20 min. - [Disclaimer](#)

# Agenda

- **Core Concepts and Prerequisites**
- Meta-Analysis: Conceptual Basics
- HO-Approach Illustrated
- HS-Approach Illustrated
- Recent Trends (Selection)
- Associations
- Recommended Textbooks
- Web-Resources

# Core Concepts and Prerequisites I

- Effect size ( $ES$ )?
- Sampling distribution?
- Sampling error vs standard error?
- Computation of standard errors for different effect size estimates?
- Standard error of the effect size estimate:  $SE(i)$   
= standard deviation of the ES sampling distribution
- **Important** to separate from a meta-analytic concept introduced later:  $SE(ES)$   
= standard error of the *MEAN effect size estimate*  
= standard error of the mean effect size estimate distribution

# Core Concepts and Prerequisites II

Fundamentals of inferential statistics and hypothesis testing:

$H_0$  kept, if  $|\text{Test Statistic}| \leq (\text{critical value})$   
 $H_0$  rejected, if  $|\text{Test Statistic}| > (\text{critical value})$

$$\text{Test Statistic} = (\text{Size of Effect}) * (\text{Size of Study})$$

Synthesized by MA

Effect  
sizes  
(ES): *Types?*

Used for weighting  
indiv. ES: *Why?*

Supplement: Cooper\_Hedges\_1994\_Table16\_1.pdf

# Core Concepts and Prerequisites III

- **Systematic biases** > reduce/attenuate validity aspects of a research design, such as (according to Cook & Campbell, 1979; see also Shadish, Cook & Campbell, 2002) :
  - internal validity
  - external validity
    - time
    - subjects/persons
    - situations/settings
  - construct validity
  - statistical conclusion validity
- **Unsystematic biases** > measurement error(s) in iVs and/or dVs > affect reliability > underestimation of 'true' effect(s)

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# Meta-analysis : Basics

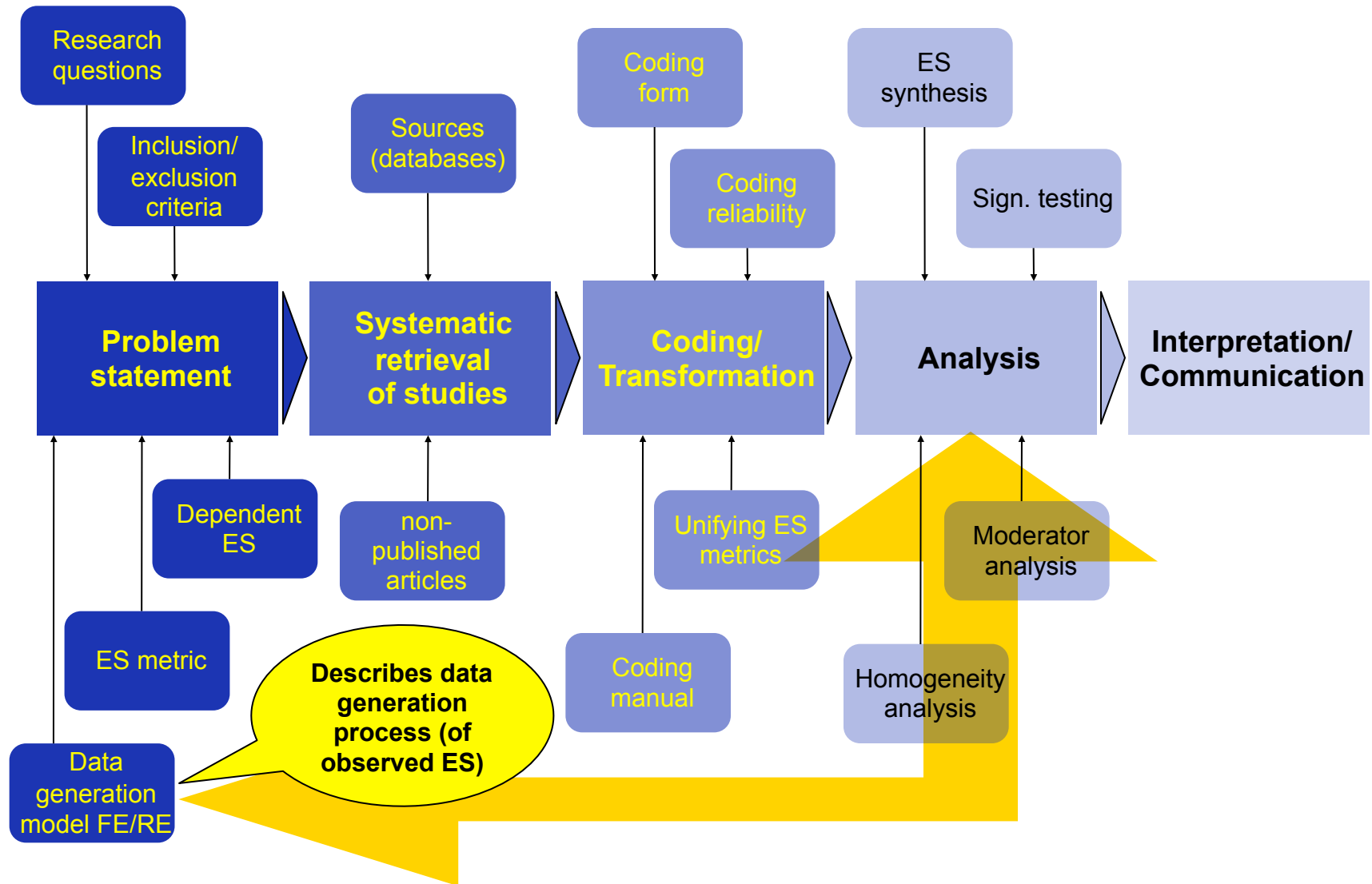
- Generic term, encompassing a comprehensive set of specific research synthesis/analysis techniques and approaches.
- **Overall process** of systematically retrieving, synthesizing, and analyzing the results of thematically related studies.
- Effect sizes are being synthesized and analysed, such as:
  - measures of association ("*r family*")
  - mean differences ("*d family*")
  - ratios and ratio differences
  - Effect sizes for dichotomous measures, such as relative risks, odds ratio and derivatives.

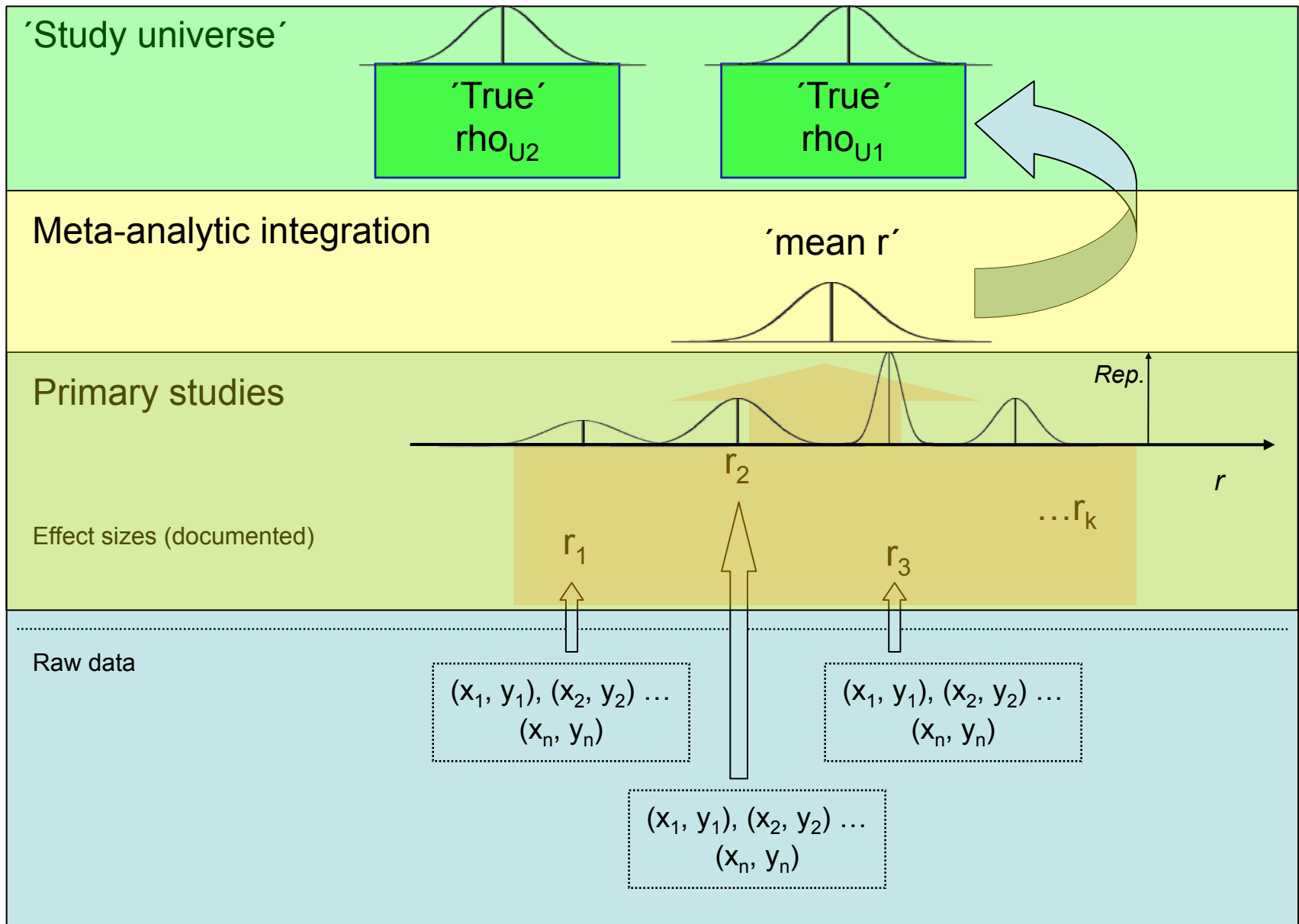
# Meta-Analysis : Objectives

Estimation of a 'true' effect, characterized by a higher precision and validity compared to primary studies.

Evidence-based ...

- ... description of a thematic area (also to identify *gaps in research*),
- ... theory testing,
- ... theory development/refinement,
- ... conclusions on the benefit / harm of an intervention.





# Two Common Approaches (in Psychology)

- "HO"-Meta-Analysis (Hedges/Olkin)
  - Data generation model: True effects are confounded by (up to two different types of) sampling error
  - Approx. 75% of all meta-analyses published in *Psychological Bulletin* are HO meta-analyses (fixed effects model)
- Psychometric MA (Hunter/Schmidt)
  - Data generation model : 'True' effects are attenuated by sampling error and systematic artifacts
  - Approx. 80% of all meta-analyses in IO Psychology
- No(t) (more) popular in Psychology:  
Glass meta-analysis, p-value aggregation according to Rosenthal, Bayesian approaches

# Agenda

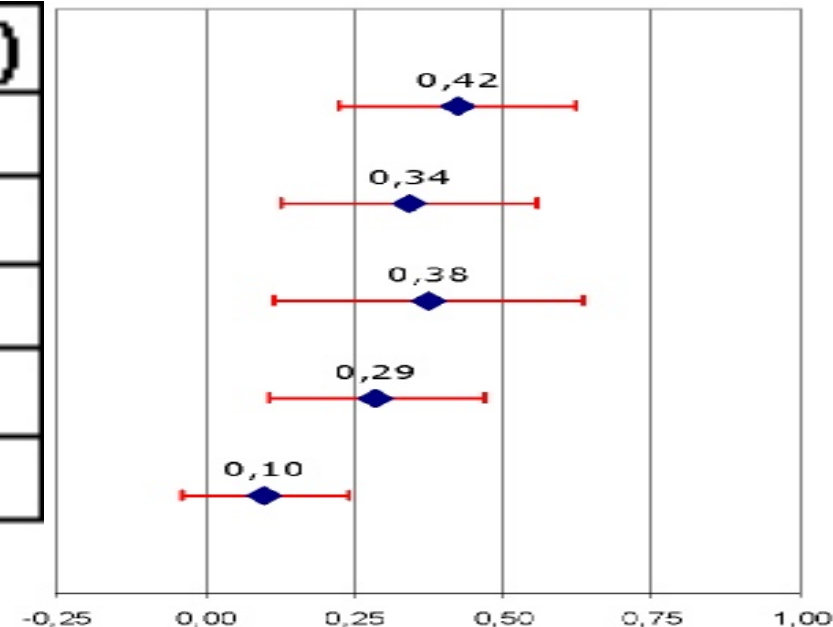
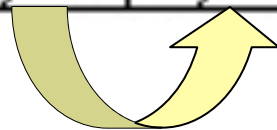
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# HO-Meta-Analysis: Synthesis & Analysis

Step 1:  
 **$Z[r]$  Transformation**

$$ES_i = Zr_i = \frac{1}{2} \ln \left[ \frac{1 + r_i}{1 - r_i} \right]$$

	N	r	Z[r]	SE(Z[r])
S 1	100	0,40	0,42	0,10
S 2	86	0,33	0,34	0,11
S 3	60	0,36	0,38	0,13
S 4	120	0,28	0,29	0,09
S 5	200	0,10	0,10	0,07



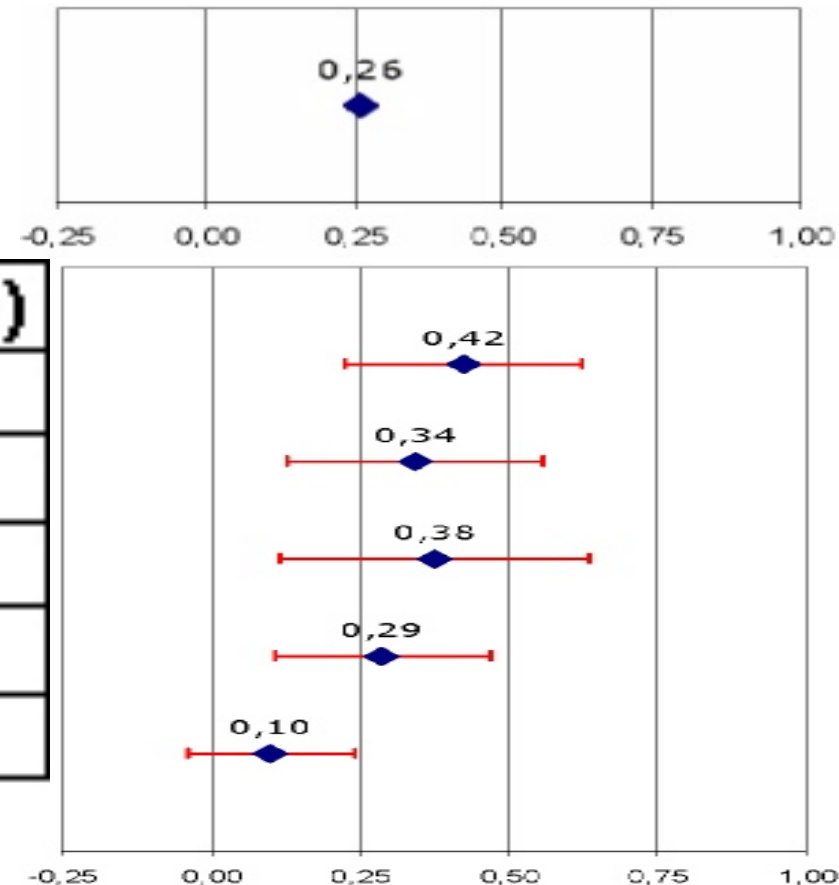
# HO-Meta-Analysis: Synthesis & Analysis

$$\overline{ES} = \frac{\sum_{i=1}^k (w_i \times ES_i)}{\sum_{i=1}^k w_i} \quad w_i = \frac{1}{SE_i^2}$$

$$SE_i = \sqrt{\frac{1}{n-3}}$$

	N	r	Z[r]	SE(Z[r])
S 1	100	0,40	0,42	0,10
S 2	86	0,33	0,34	0,11
S 3	60	0,36	0,38	0,13
S 4	120	0,28	0,29	0,09
S 5	200	0,10	0,10	0,07

## Step 2: Weighted Synthesis





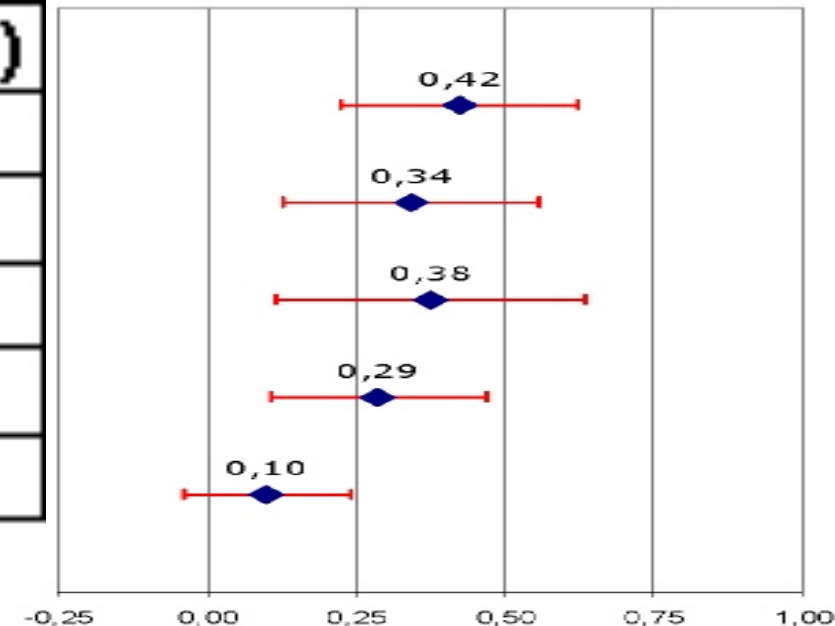
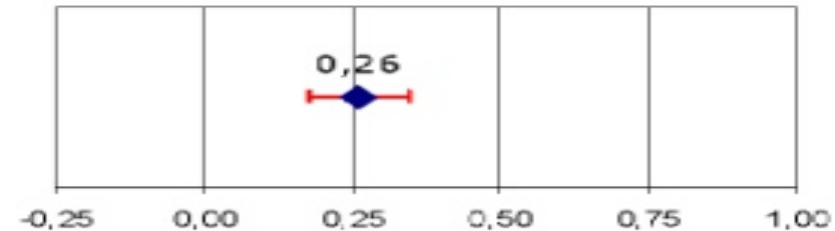
# HO-Meta-Analysis: Synthesis & Analysis

$$\overline{ES} \pm 1.96(SE_{\overline{ES}})$$

$$SE_{\overline{ES}} = \sqrt{\frac{1}{\sum_{i=1}^k w_i}}$$

	N	r	Z[r]	SE(Z[r])
S 1	100	0,40	0,42	0,10
S 2	86	0,33	0,34	0,11
S 3	60	0,36	0,38	0,13
S 4	120	0,28	0,29	0,09
S 5	200	0,10	0,10	0,07

## Step 3: Significance Testing



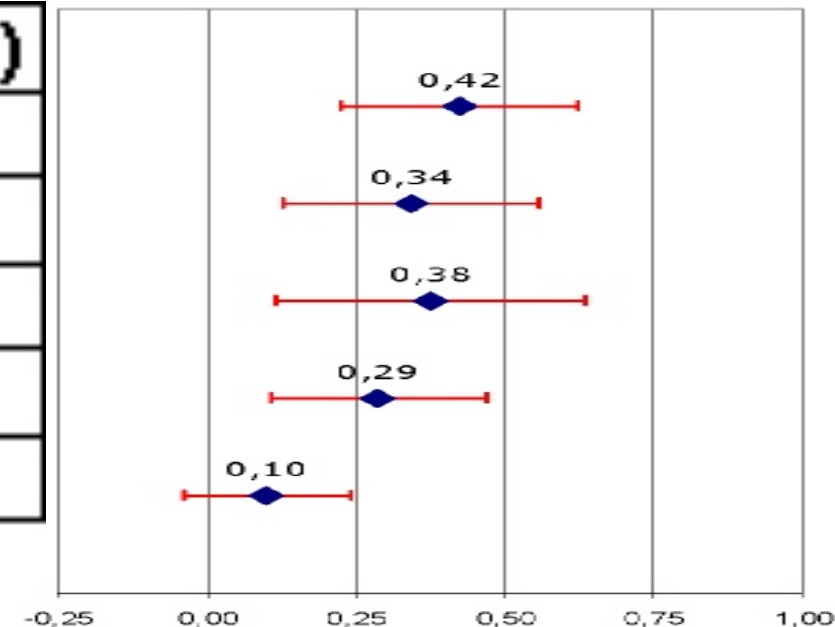
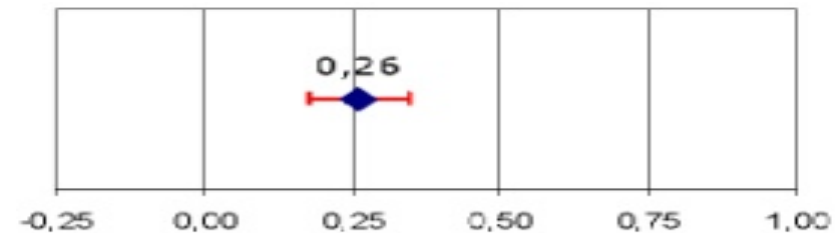
# HO-Meta-Analysis: Synthesis & Analysis

$$Q_T = \sum_{i=1}^k \frac{(ES_i - \overline{ES})^2}{SE_i^2} = \sum_{i=1}^k w_i (ES_i - \overline{ES})^2$$

$Q_T$  is approx.  $\chi^2$  distributed with  $df = k-1$

	N	r	Z[r]	SE(Z[r])
S 1	100	0,40	0,42	0,10
S 2	86	0,33	0,34	0,11
S 3	60	0,36	0,38	0,13
S 4	120	0,28	0,29	0,09
S 5	200	0,10	0,10	0,07

## Step 4: Homogeneity Analysis



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# Psychometric MA: Data Generation Model

## Attenuation model

$$\rho_o = A * \rho$$

$\rho_o = r_o + e$   
 $E(e) = 0$

$$A = \prod_{j=1}^m a_j$$

„True“  
 non-attenuated  
 correlation

The diagram illustrates the Attenuation model. At the top, the equation  $\rho_o = A * \rho$  is shown. A red dashed arrow points from the  $\rho$  term to a yellow box containing the text „True“ non-attenuated correlation. Two black arrows point downwards from the equation. The left arrow points to the equation  $\rho_o = r_o + e$  with  $E(e) = 0$  below it. The right arrow points to the equation  $A = \prod_{j=1}^m a_j$ .

Examples for  $a(j)$ :

$a(1,2)$ : Measurement errors (att. reliability),  
 $a(3,4)$ : Artificial dichotomization.

# Psychometric MA : Procedure

- Disattenuation model:

$$\rho = \frac{\rho_o}{A} = \frac{r_o}{A} + \frac{e}{A} = r_c + e_c$$

- Integration model:

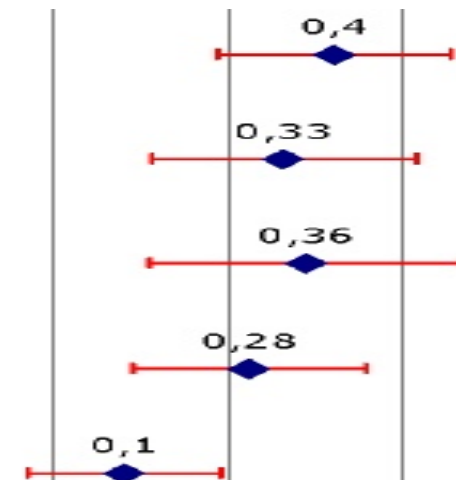
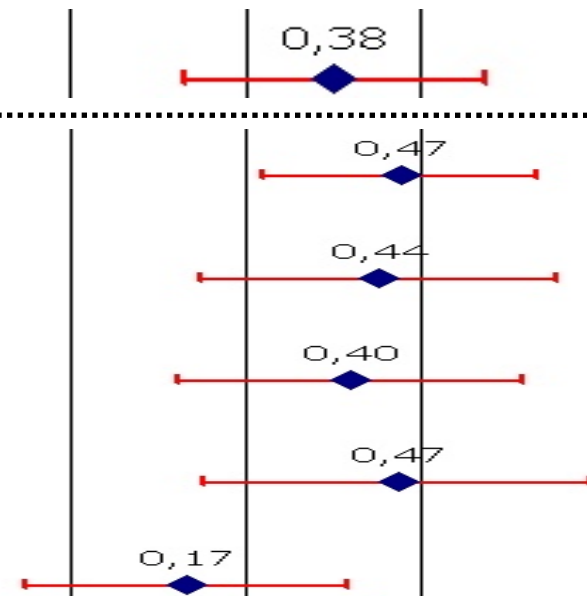
$$\overline{r_c} = \frac{\sum_{i=1}^k (w_i * r_{c(i)})}{\sum_{i=1}^k w_i} \quad \overline{SE_c^2} = \frac{\sum_{i=1}^k (w_i * SE_{c(i)}^2)}{\sum_{i=1}^k w_i} \quad w_i = N_i * A_i^2$$

- 75% rule for homogeneity 'testing' (rule of thumb)

# Psychometric MA : Synthesis

	<b>A</b>	<b>r[c]</b>	<b>SE(r[c])</b>
S 1	0,85	0,47	0,10
S 2	0,75	0,44	0,13
S 3	0,90	0,40	0,13
S 4	0,60	0,47	0,14
S 5	0,60	0,17	0,12

	<b>N</b>	<b>r[o]</b>	<b>SE(r[o])</b>
S 1	100	0,40	0,08
S 2	86	0,33	0,10
S 3	60	0,36	0,11
S 4	120	0,28	0,08
S 5	200	0,10	0,07



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# Discussion : „Evergreens“

- HO- versus psychometric approach?
- Incommensurability:
  - Multiple (general) vs single (narrow) criteria
  - Incommensurability of aggregated constructs (apple-and-oranges problem).
  - Incommensurability of corrected versus uncorrected estimates ( 'statistical fruit salad problem' )
- Selective publication?  
File-drawer problem and publication bias
- Quality of primary studies?
- Dependent effect sizes?



# Some Recent Trends

- Cumulative and meta-meta-analyses
- Multivariate meta-analyses (MA-SEM):
  - How to synthesize correlation matrices?
  - How to test homogeneity of correlation matrices?
  - Uneven No of available effect sizes?
  - Which N to use when doing SEM on synthesized matrices?
  - Correlation versus covariance as input for SEM?
- Merging SEM and Meta-Analysis

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# Associations: Campbell Collaboration

The Campbell Collaboration

http://www.campbellcollaboration.org/

## THE CAMPBELL COLLABORATION

What helps? What harms? Based on what evidence?

**Left Sidebar:**

- The Campbell Library
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- Newsletters
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- Funding opportunities
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**News Section:**

### Push for evidence-based teen pregnancy research

The Campbell review [Interventions Intended to Reduce Pregnancy-Related Outcomes Among Adolescents](#) highlighted the "relative dearth of evidence to judge the overall effectiveness of particular intervention strategies". So a recent US funding initiative is a very positive development.

[Read more...](#)

### New Editor for the Education Group

The Campbell Collaboration announces the confirmation of Sandra Wilson as Editor of the Education Coordinating Group, Associate Director and a Senior Research Associate at the [Peabody Research Institute](#) at Vanderbilt University

[Read more...](#)

### Commentary on "important" Campbell review

The US-based [National Center for Juvenile Justice](#) (NCJJ) has commented extensively on the recently published Campbell review [Formal System Processing of Juveniles: Effects on Delinquency](#).

[Read more...](#)

**Spotlight Event:**

### Joint Cochrane/Campbell Co-Colloquium: "Bringing evidence-based decision making to new heights"

18-22 October 2010  
Keystone, Colorado, USA

Improving decision-making through systematic reviews on the effects of interventions within the areas of education, crime and justice, and social welfare.

**Bottom Bar:** Contact Us | RSS Feed

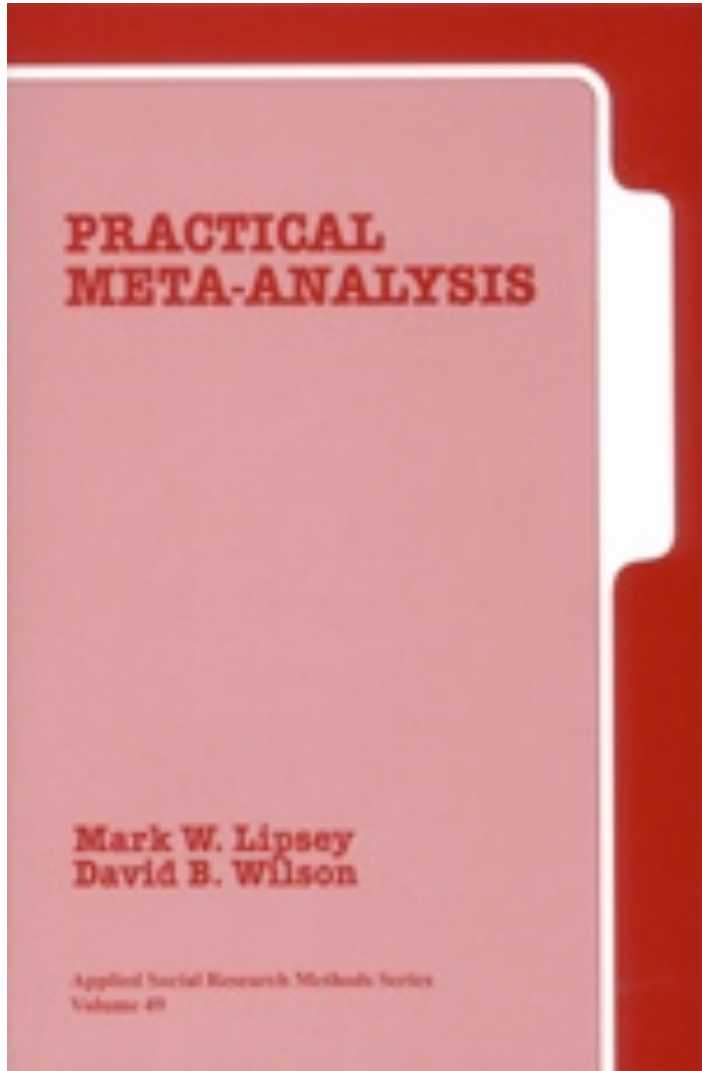
[www.campbellcollaboration.org](http://www.campbellcollaboration.org)

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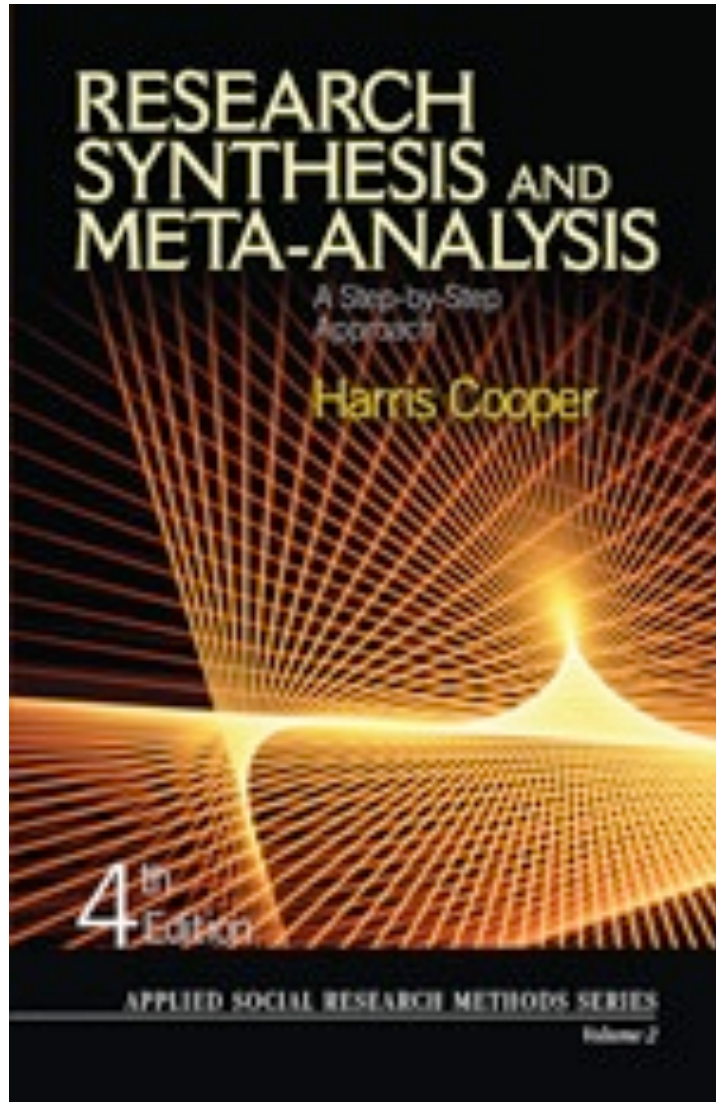
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# Lipsey & Wilson (2001)

Lipsey, M.W., & Wilson, D.B.(2001). *Practical Meta-analysis*. Thousand Oaks: Sage.



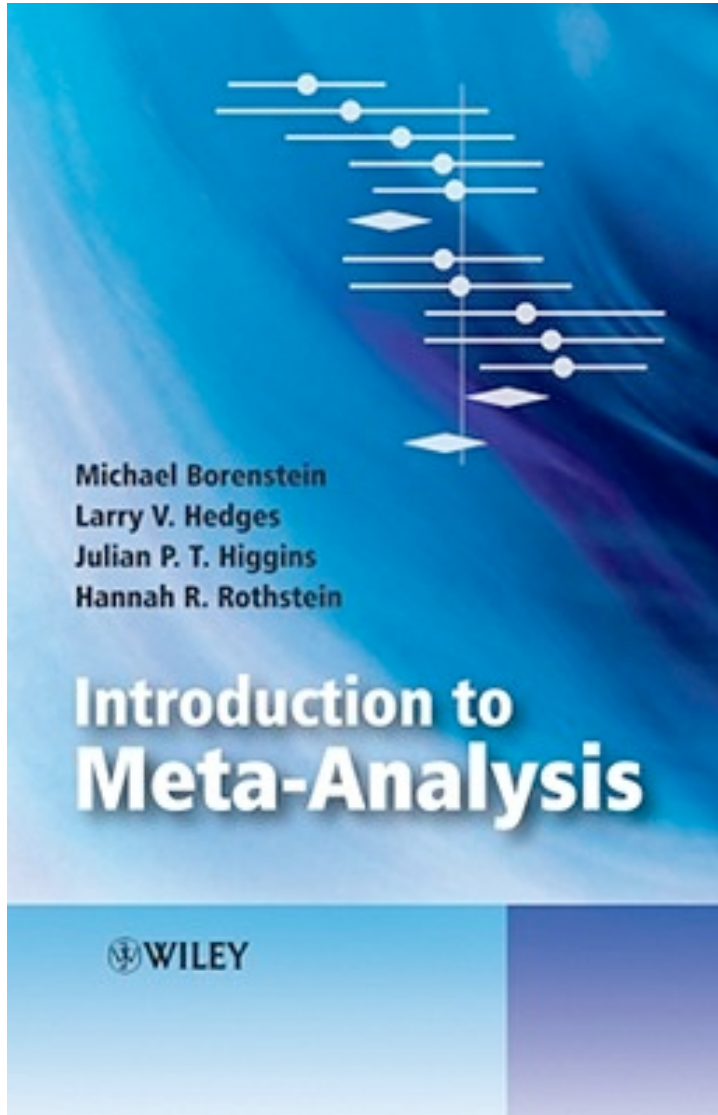
# Cooper (2010)



Cooper, H. (2010). *Research Synthesis and Meta-Analysis: A Step-by-Step Approach*. Thousand Oaks, CA: Sage.



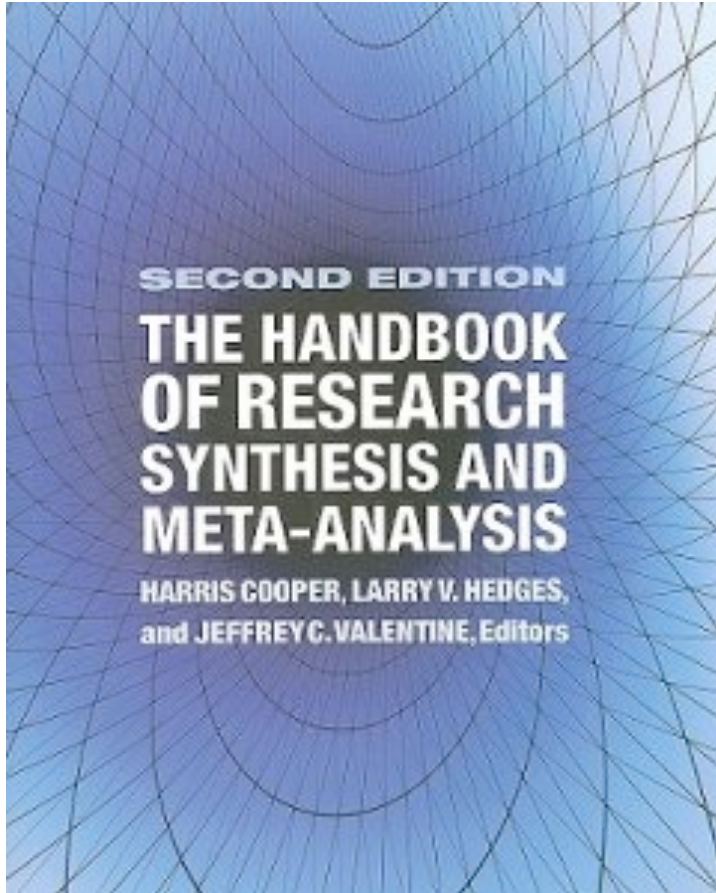
# Borenstein et al. (2009)



Borenstein, M., Hedges, L.V., Higgins, J.P.T, & Rothstein, H.R. (2009). *Introduction to Meta-Analysis*. Chichester, UK: Wiley.

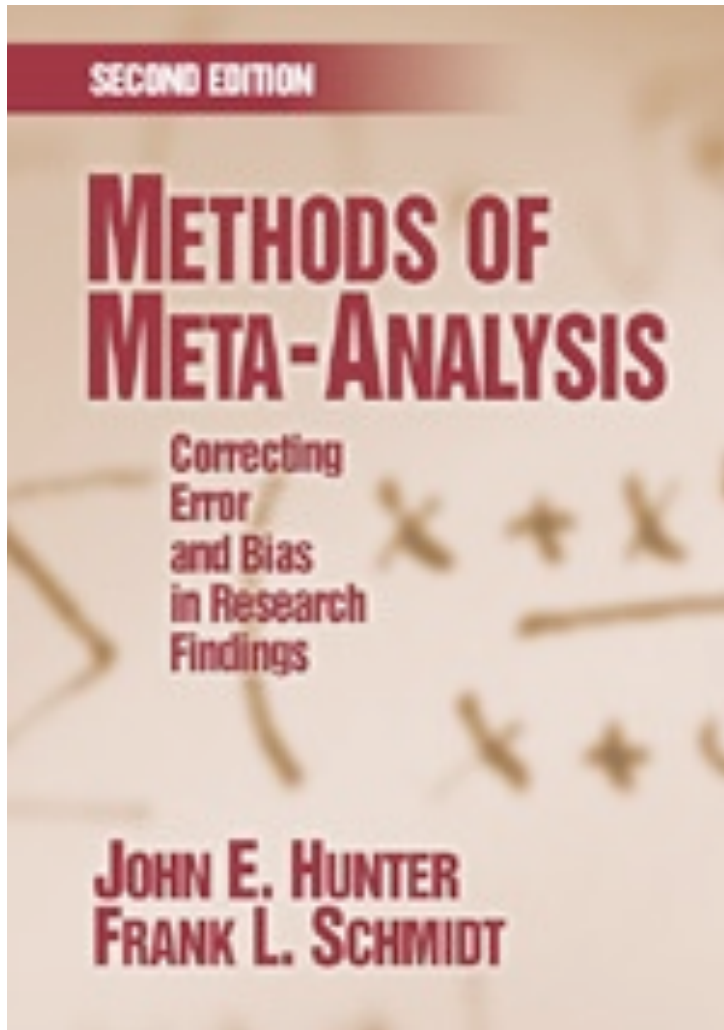


# Cooper, Hedges & Valentine (2009)



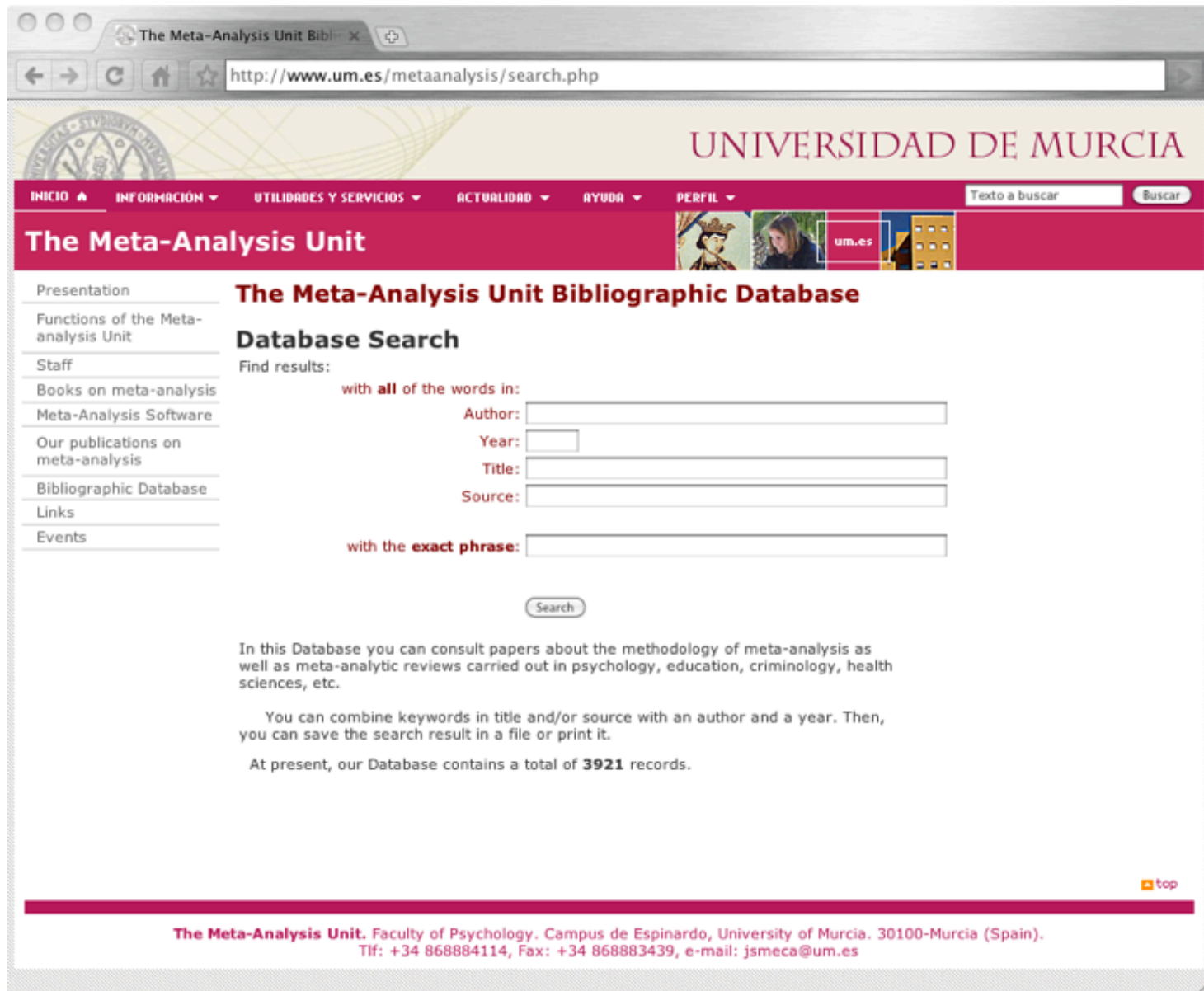
Cooper, H., Hedges, L.V., & Valentine, J.C. (Eds.) (2009). *Handbook of Research Synthesis (2nd ed.)*. New York: Russell Sage Foundation.

# Hunter & Schmidt (2004)



Hunter, J. E., & Schmidt, F. L. (2004). *Methods of meta-analysis: Correcting error and bias in research findings (2nd ed.)*. Thousand Oaks, CA: Sage.

<http://www.um.es/metaanalysis/search.php>



The screenshot shows a web browser window with the address bar displaying <http://www.um.es/metaanalysis/search.php>. The page header features the University of Murcia logo and name. A navigation menu includes links for Inicio, Información, Utilidades y Servicios, Actualidad, Ayuda, and Perfil. A search bar is located in the top right corner. The main content area is titled "The Meta-Analysis Unit Bibliographic Database" and "Database Search". It includes a sidebar with a list of links: Presentation, Functions of the Meta-analysis Unit, Staff, Books on meta-analysis, Meta-Analysis Software, Our publications on meta-analysis, Bibliographic Database, Links, and Events. The search section contains a "Find results:" label and several input fields for "Author:", "Year:", "Title:", and "Source:". There are also checkboxes for "with all of the words in:" and "with the exact phrase:". A "Search" button is located below the input fields. A paragraph of text describes the database's content, and a footer provides contact information for the Meta-Analysis Unit.

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Texto a buscar

## The Meta-Analysis Unit

Presentation

Functions of the Meta-analysis Unit

Staff

Books on meta-analysis

Meta-Analysis Software

Our publications on meta-analysis

Bibliographic Database

Links

Events

### The Meta-Analysis Unit Bibliographic Database

#### Database Search

Find results:

with **all** of the words in:

Author:

Year:

Title:

Source:

with the **exact phrase**:

In this Database you can consult papers about the methodology of meta-analysis as well as meta-analytic reviews carried out in psychology, education, criminology, health sciences, etc.

You can combine keywords in title and/or source with an author and a year. Then, you can save the search result in a file or print it.

At present, our Database contains a total of **3921** records.

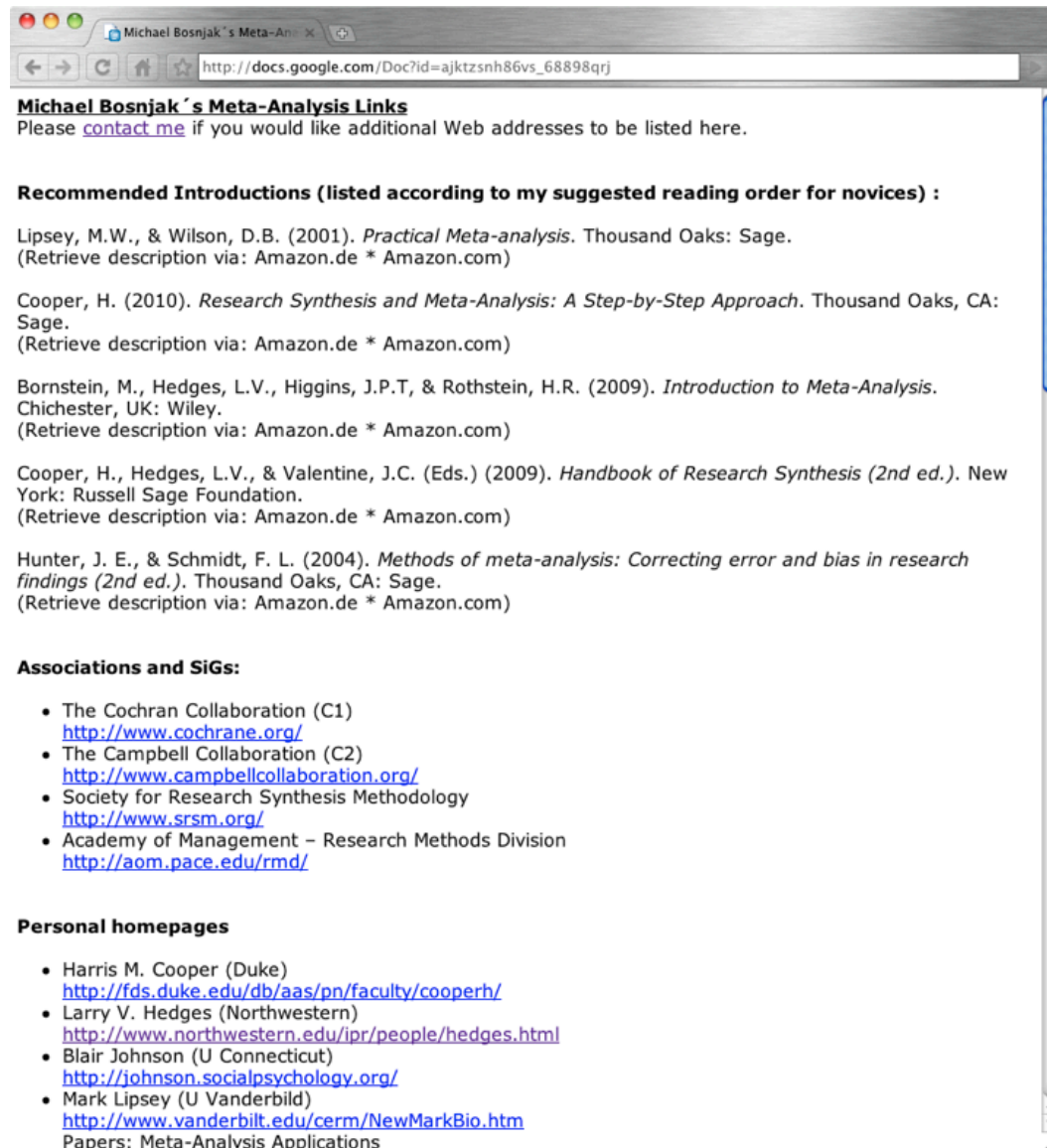
[top](#)

**The Meta-Analysis Unit.** Faculty of Psychology. Campus de Espinardo, University of Murcia. 30100-Murcia (Spain).  
Tlf: +34 868884114, Fax: +34 868883439, e-mail: [jsmeca@um.es](mailto:jsmeca@um.es)

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# [www.meta-analysis.eu](http://www.meta-analysis.eu)



A screenshot of a web browser window displaying a Google Docs page titled "Michael Bosnjak's Meta-Analysis Links". The browser's address bar shows the URL: [http://docs.google.com/Doc?id=ajktzsnh86vs\\_68898qrj](http://docs.google.com/Doc?id=ajktzsnh86vs_68898qrj). The page content includes a title, a request for contact information, a list of recommended introductions to meta-analysis, a list of associations and SiGs, and a list of personal homepages.

**Michael Bosnjak's Meta-Analysis Links**  
Please [contact me](#) if you would like additional Web addresses to be listed here.

**Recommended Introductions (listed according to my suggested reading order for novices) :**

Lipsey, M.W., & Wilson, D.B. (2001). *Practical Meta-analysis*. Thousand Oaks: Sage.  
(Retrieve description via: Amazon.de \* Amazon.com)

Cooper, H. (2010). *Research Synthesis and Meta-Analysis: A Step-by-Step Approach*. Thousand Oaks, CA: Sage.  
(Retrieve description via: Amazon.de \* Amazon.com)

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**Associations and SiGs:**

- The Cochran Collaboration (C1)  
<http://www.cochrane.org/>
- The Campbell Collaboration (C2)  
<http://www.campbellcollaboration.org/>
- Society for Research Synthesis Methodology  
<http://www.srsm.org/>
- Academy of Management – Research Methods Division  
<http://aom.pace.edu/rmd/>

**Personal homepages**

- Harris M. Cooper (Duke)  
<http://fds.duke.edu/db/aas/pn/faculty/cooperh/>
- Larry V. Hedges (Northwestern)  
<http://www.northwestern.edu/jpr/people/hedges.html>
- Blair Johnson (U Connecticut)  
<http://johnson.socialpsychology.org/>
- Mark Lipsey (U Vanderbilt)  
<http://www.vanderbilt.edu/cerm/NewMarkBio.htm>

Papers: Meta-Analysis Applications

# LMS

<http://campus.bosnjak.eu>

The screenshot shows a web browser window with the address bar displaying <http://www.psyconsult.com/campus/login/index.php>. The page title is "Prof. Dr. Bosnjak's Learning Management System". In the top right corner, it says "You are not logged in. (Login)". Below the title bar, there is a blue navigation bar with "BLMS" and a link to "Login to the site", and a language dropdown menu set to "English (en)".

The main content area is divided into two columns. The left column is titled "Returning to this web site?" and contains a login form with fields for "Username:" and "Password:", a "Login" button, a link for "Some courses may allow guest access:" with a "Login as a guest" button, and a link for "Forgotten your username or password?" with a "Yes, help me log in" button. The right column is titled "Is this your first time here?" and contains a welcome message, a list of 7 steps for creating a new account, and a "Create new account" button.

At the bottom of the page, it says "You are not logged in. (Login)" and a "Home" button.

**Prof. Dr. Bosnjak's Learning Management System** You are not logged in. (Login)

**BLMS** ▶ Login to the site English (en)

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Returning to this web site?	Is this your first time here?
<p>Login here using your username and password: (Cookies must be enabled in your browser) ?</p> <p>Username: <input type="text"/></p> <p>Password: <input type="password"/></p> <p><input type="button" value="Login"/></p> <hr/> <p>Some courses may allow guest access:</p> <p><input type="button" value="Login as a guest"/></p> <hr/> <p>Forgotten your username or password?</p> <p><input type="button" value="Yes, help me log in"/></p>	<p>Hi! For full access to courses you'll need to take a minute to create a new account for yourself on this web site. Each of the individual courses may also have a one-time "enrolment key", which you won't need until later. Here are the steps:</p> <ol style="list-style-type: none"><li>1. Fill out the <a href="#">New Account</a> form with your details.</li><li>2. An email will be immediately sent to your email address.</li><li>3. Read your email, and click on the web link it contains.</li><li>4. Your account will be confirmed and you will be logged in.</li><li>5. Now, select the course you want to participate in.</li><li>6. If you are prompted for an "enrolment key" - use the one that your teacher has given you. This will "enrol" you in the course.</li><li>7. You can now access the full course. From now on you will only need to enter your personal username and password (in the form on this page) to log in and access any course you have enrolled in.</li></ol> <p><input type="button" value="Create new account"/></p>

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You are not logged in. (Login)