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?

	r	*N*	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
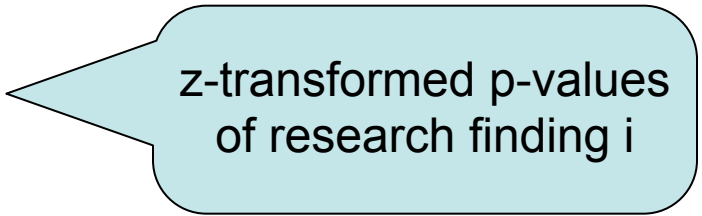
Non-Meta-Analytic Synthesis of Evidence

- Narrative Reviews

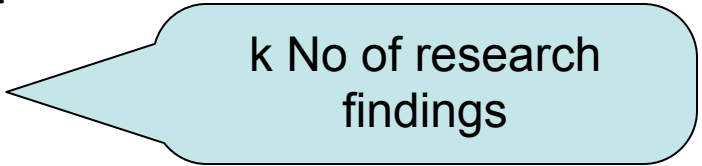- Vote-Counting

Why inefficient and biased?

- Stouffer-Method (p-value aggregation)

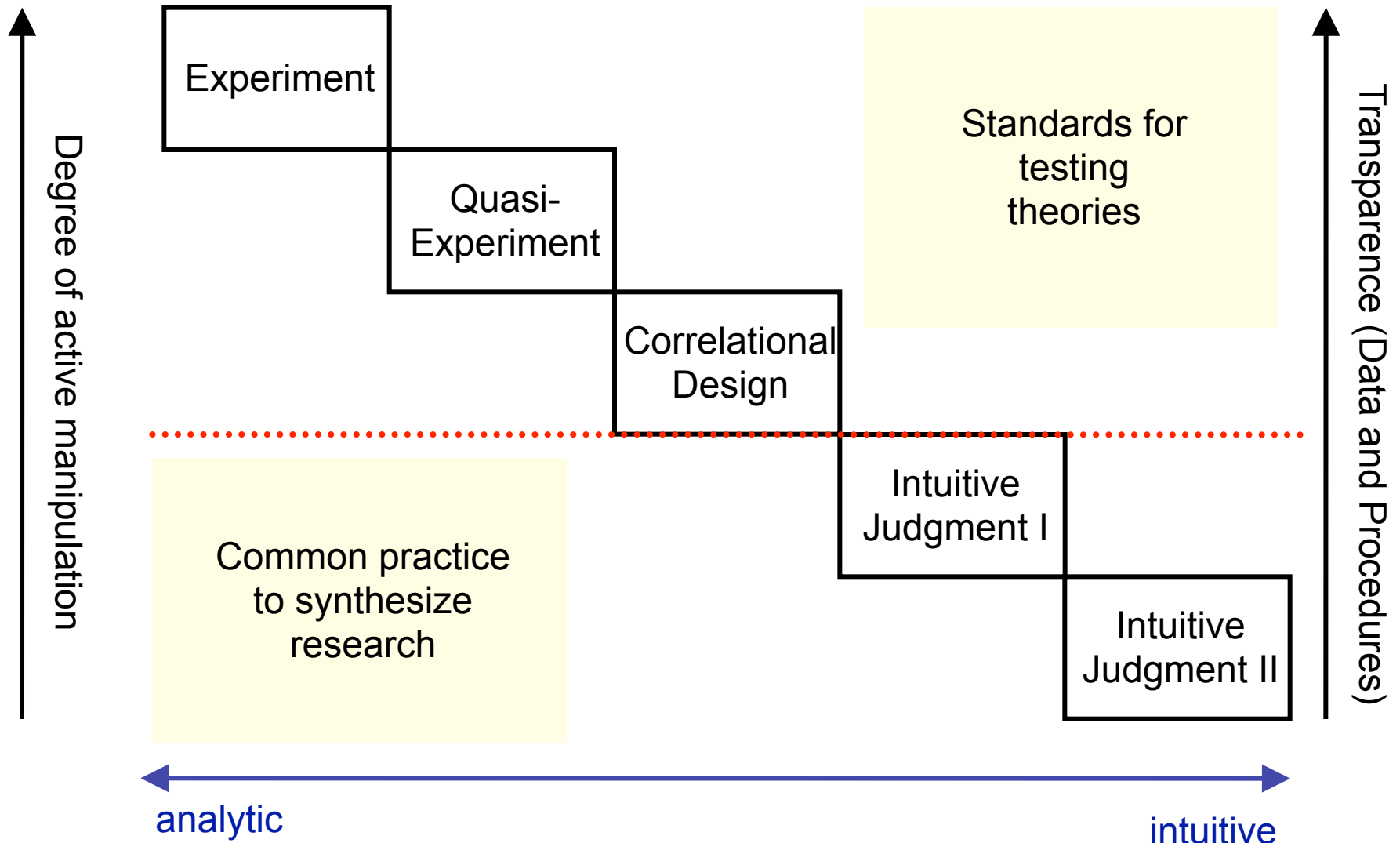$$Z_s = \frac{\sum_{i=1}^{k} z_{p(i)}}{\sqrt{k}}$$

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

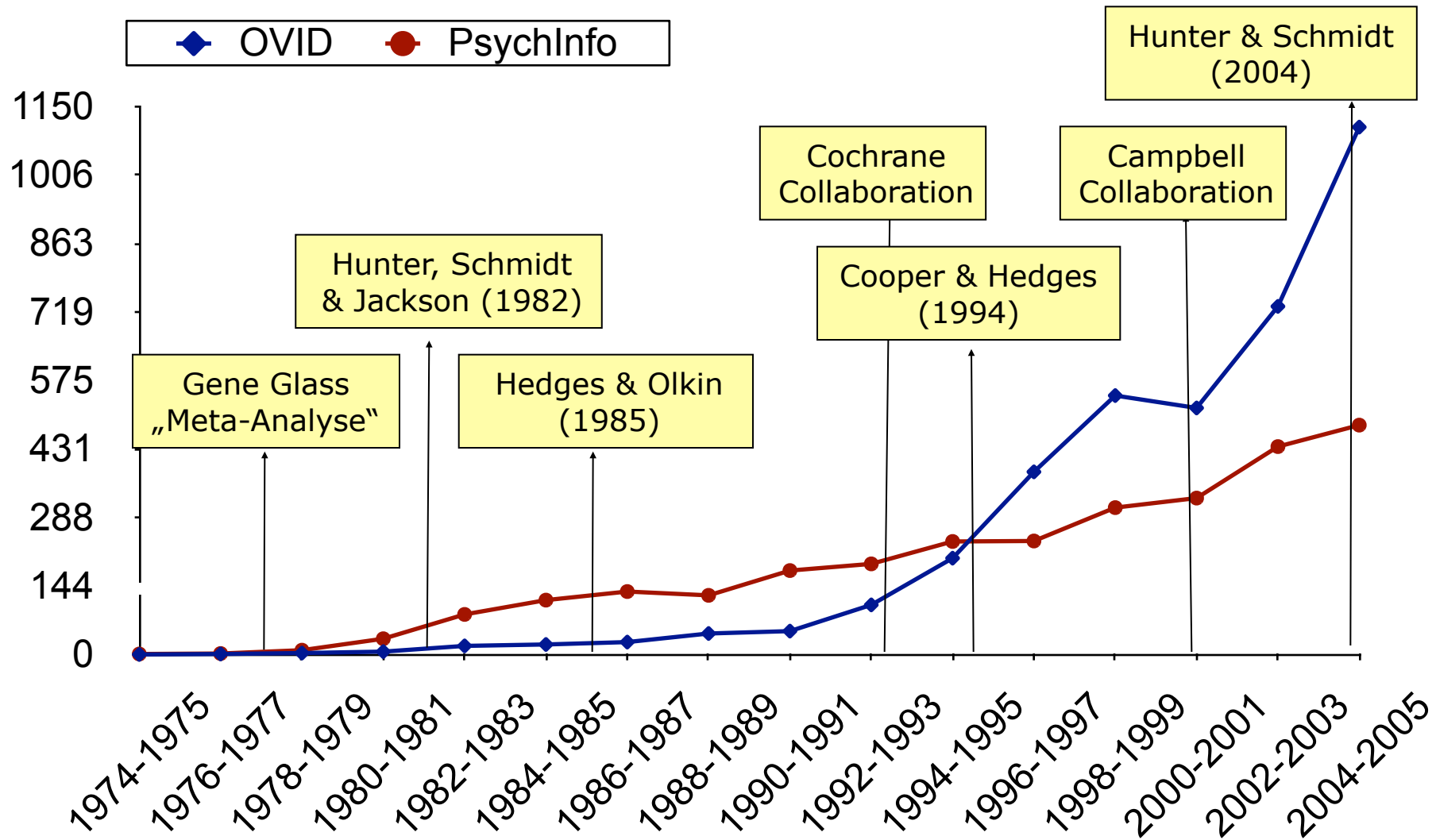1976 f.: Gene Glass coined the term „meta-analysis", parallel development of meta-analytic models by:

- 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

Impact of Meta-Analyses

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 |Test Statistic| <= (critical value)
H_0 rejected, if |Test Statistic| > (critical value)

Test Statistic = (Size of Effect) * (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.

Generic Procedure

´Study universe´

´True´ rho$_{U2}$

´True´ rho$_{U1}$

Meta-analytic integration

´mean r´

Primary studies

Rep.

r_2

r

Effect sizes (documented)

$\dots r_k$

r_1

r_3

Raw data

$(x_1, y_1), (x_2, y_2) \dots (x_n, y_n)$

$(x_1, y_1), (x_2, y_2) \dots (x_n, y_n)$

$(x_1, y_1), (x_2, y_2) \dots (x_n, y_n)$
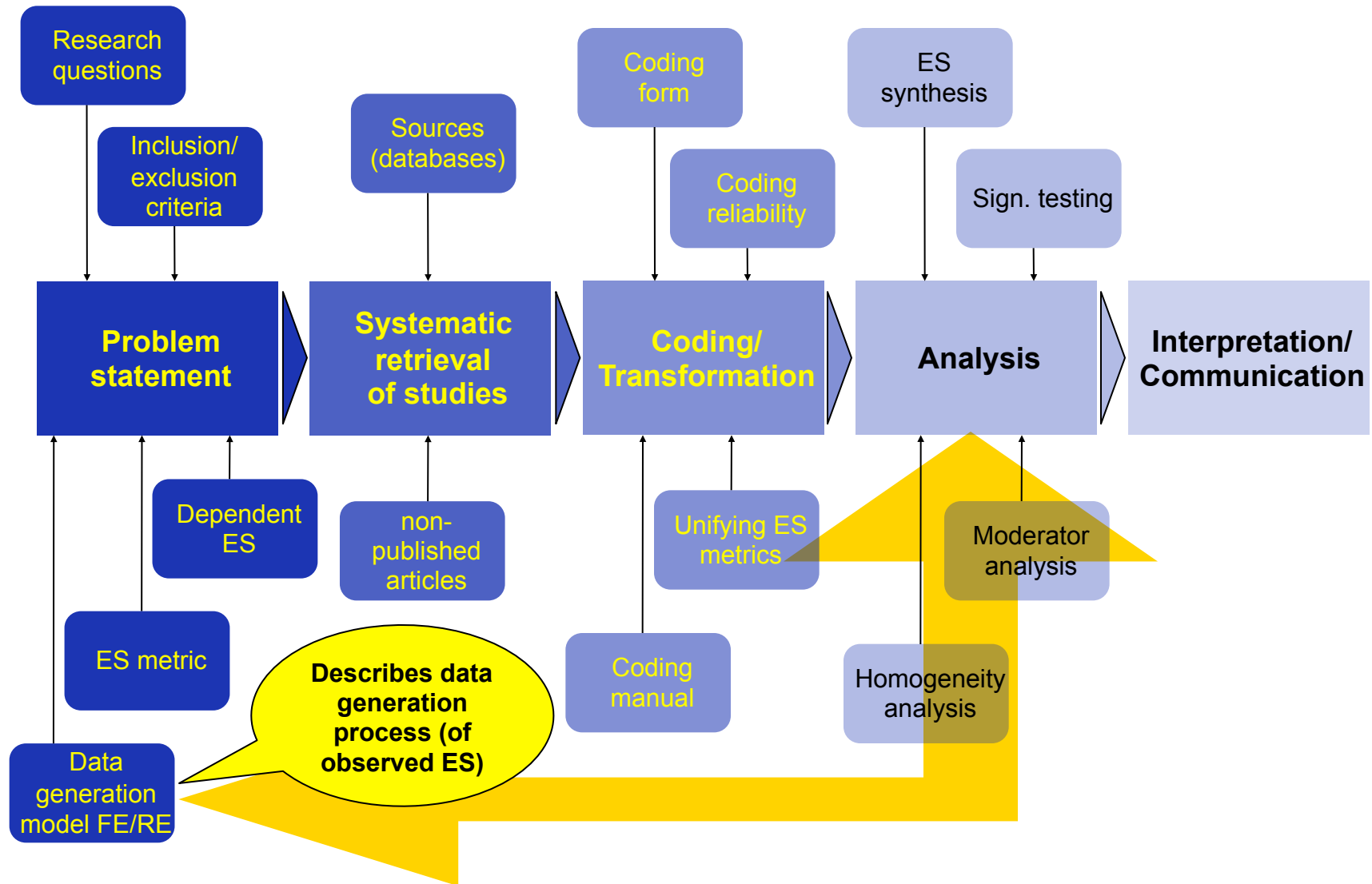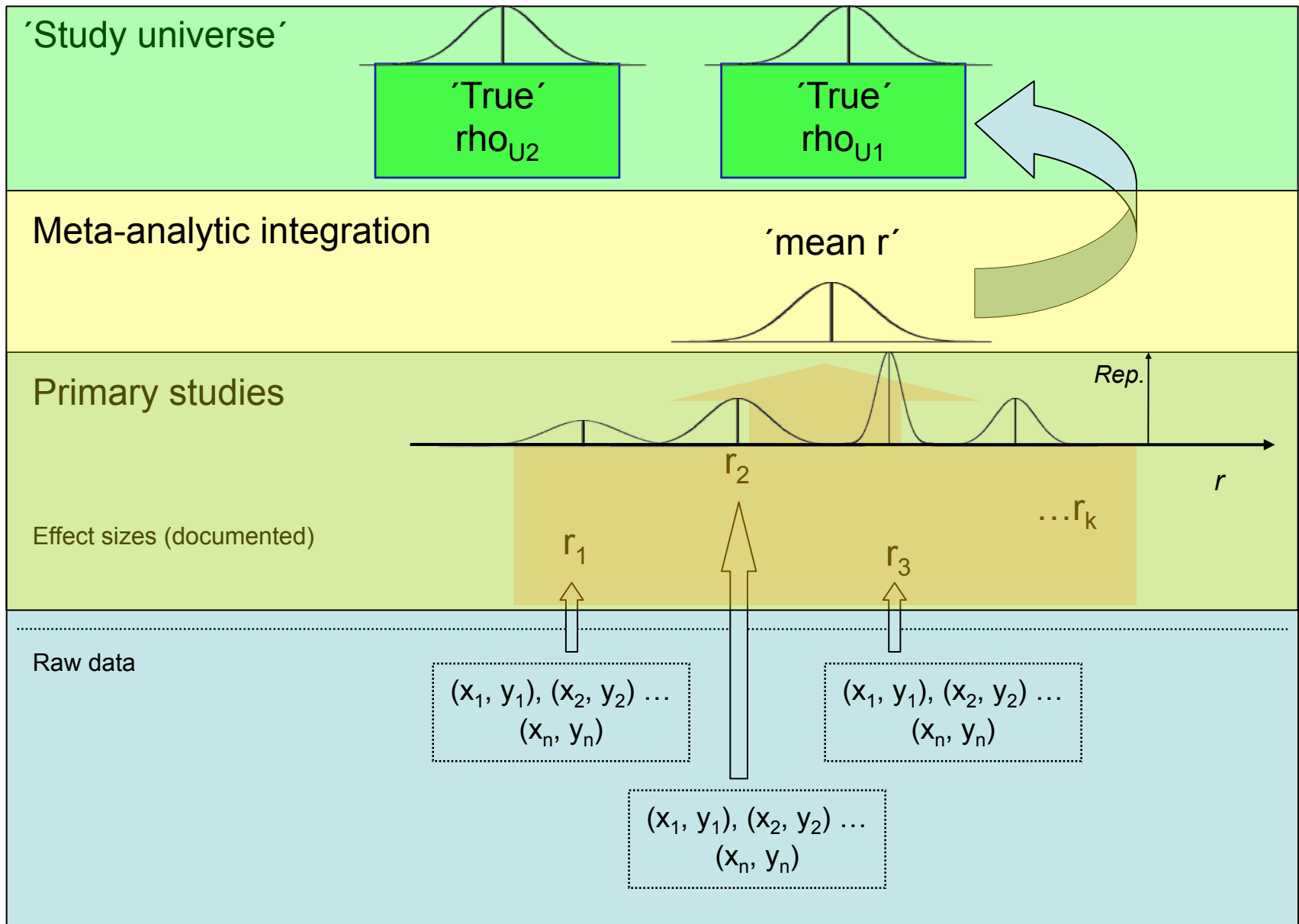
Two Common Approaches (in Psychology)

- "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

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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
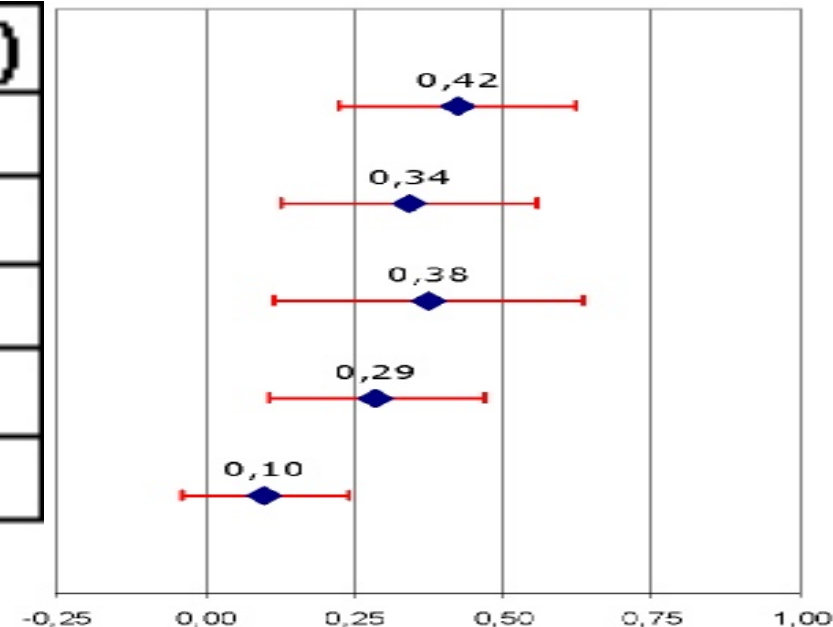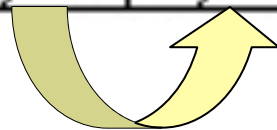
HO-Meta-Analysis: Synthesis & Analysis

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

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

Step 2: Weighted Synthesis

	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
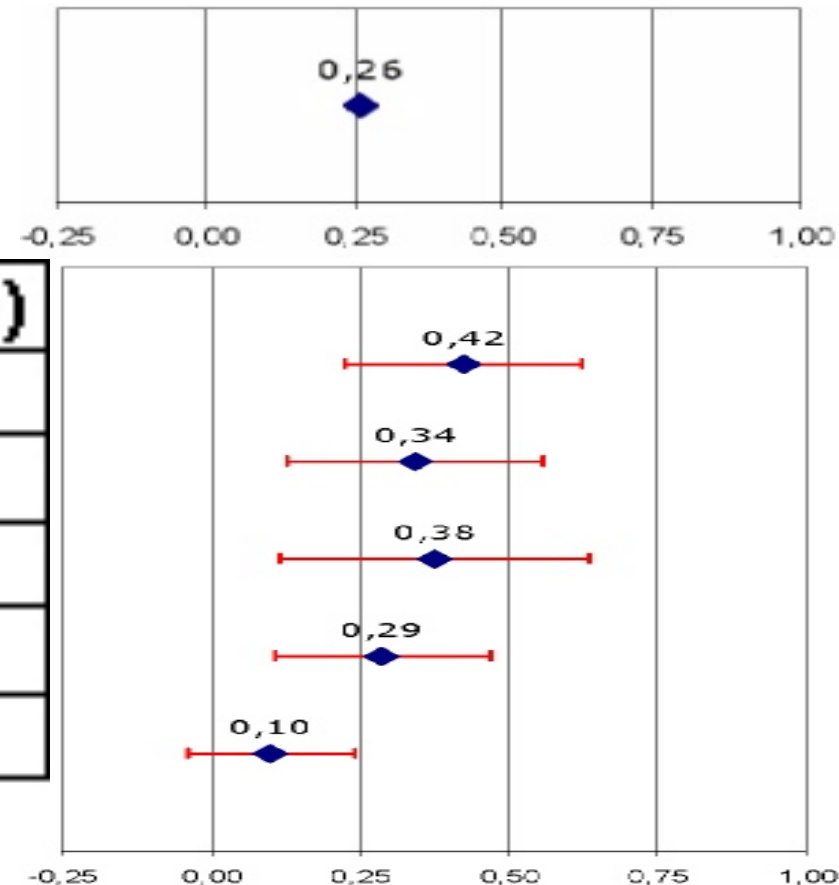
HO-Meta-Analysis: Synthesis & Analysis

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

$$SE_{\overline{ES}} = \sqrt{\dfrac{1}{\sum\limits_{i=1}^{k} w_i}}$$

Step 3:
Significance Testing

	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
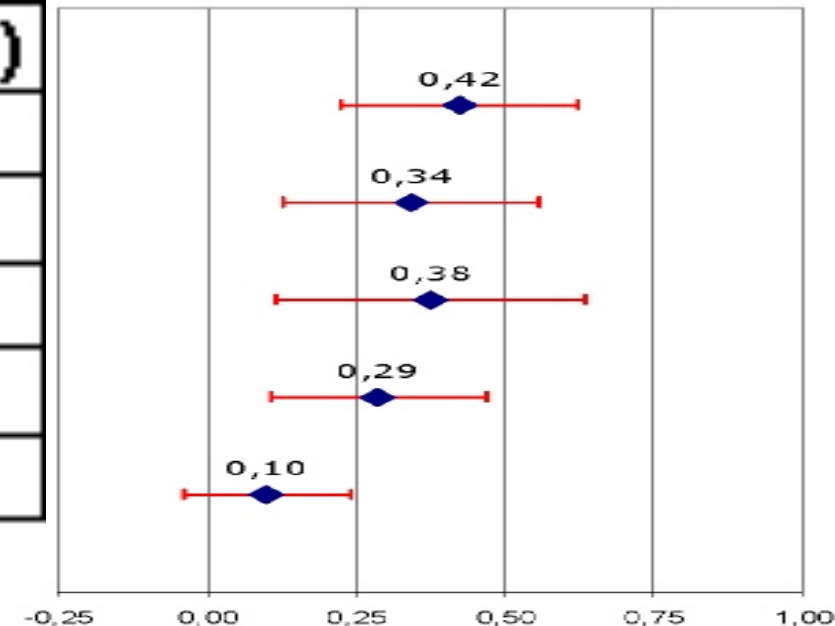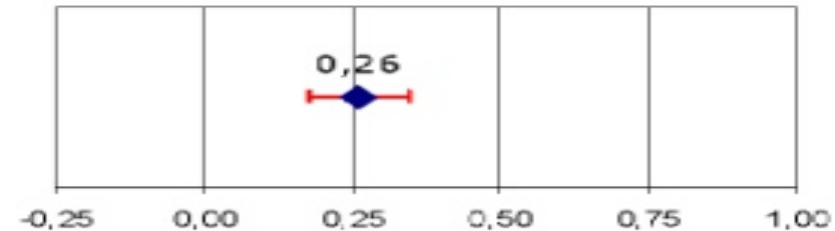
HO-Meta-Analysis: Synthesis & Analysis

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

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

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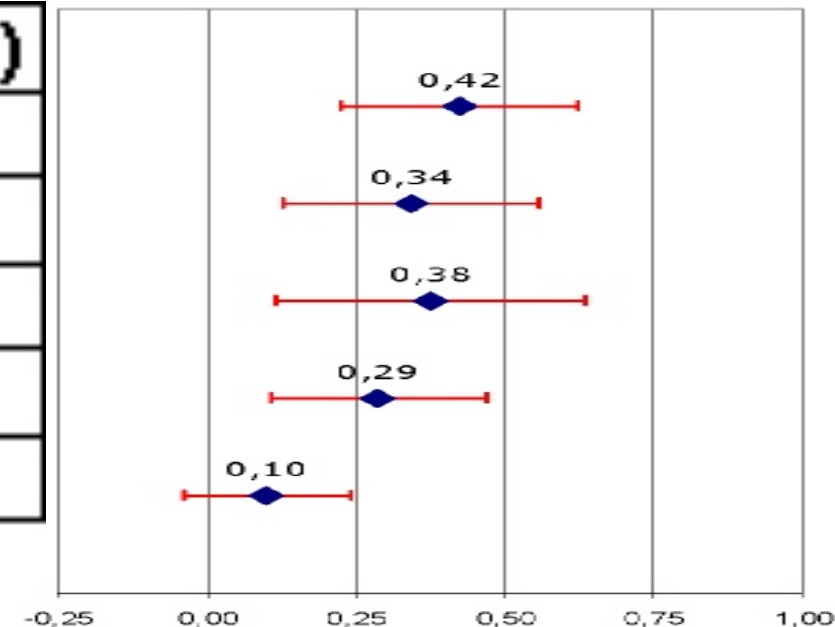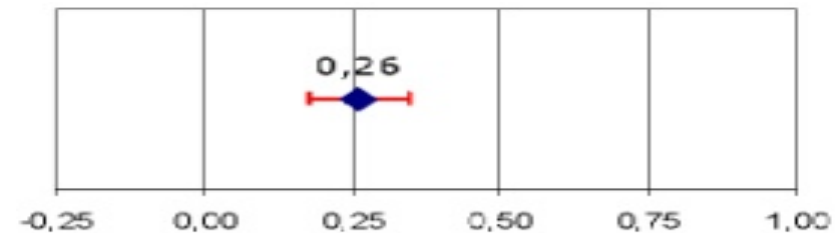
	N	r	Z[r]	SE(Z[r])
S 1	100	0,40	0,42	0,10
S 2	86	0,33	0,34	0,11
S 3	60	0,36	0,38	0,13
S 4	120	0,28	0,29	0,09
S 5	200	0,10	0,10	0,07

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Psychometric MA: Data Generation Model

Attenuation model

$$\rho_o = A * \rho$$

„True" non-attenuated correlation

$$\rho_o = r_o + e$$

$$E(e) = 0$$

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

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

Psychometric MA : Procedure

- <u>Dis</u>attenuation model:

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

- Integration model:

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

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

Psychometric MA : Synthesis

	A	r[c]	SE(r[c])
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

	N	r[o]	SE(r[o])
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
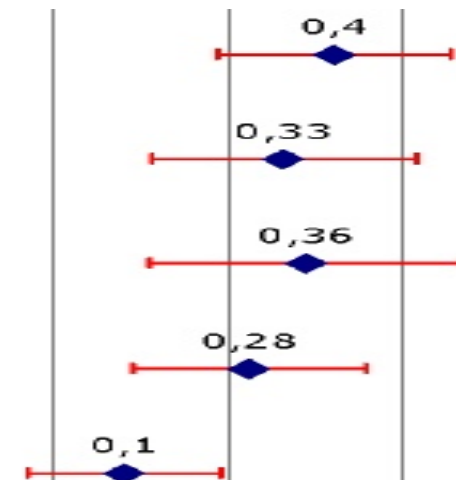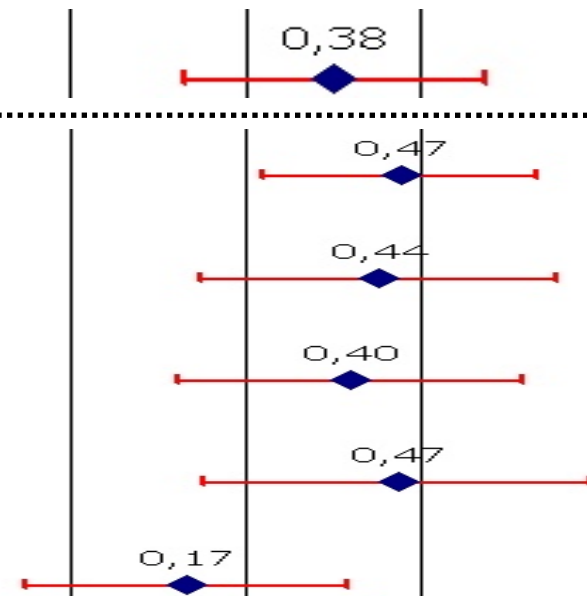
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Discussion : „Evergreens"

- 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: Cochrane Collaboration

www.cochrane.de

www.cochrane.org

Associations: Campbell Collaboration

www.campbellcollaboration.org

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Lipsey & Wilson (2001)

PRACTICAL META-ANALYSIS

Mark W. Lipsey
David B. Wilson

Applied Social Research Methods Series
Volume 49

Lipsey, M.W., & Wilson, D.B.(2001). *Practical Meta-analysis.* Thousand Oaks: Sage.
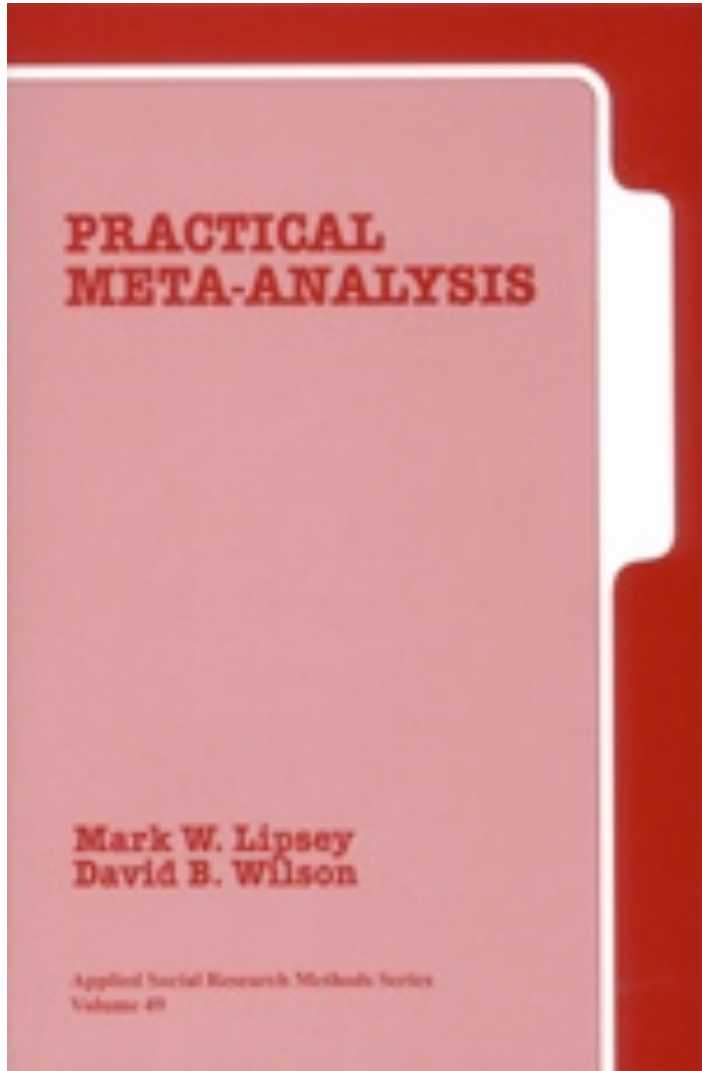
Cooper (2010)
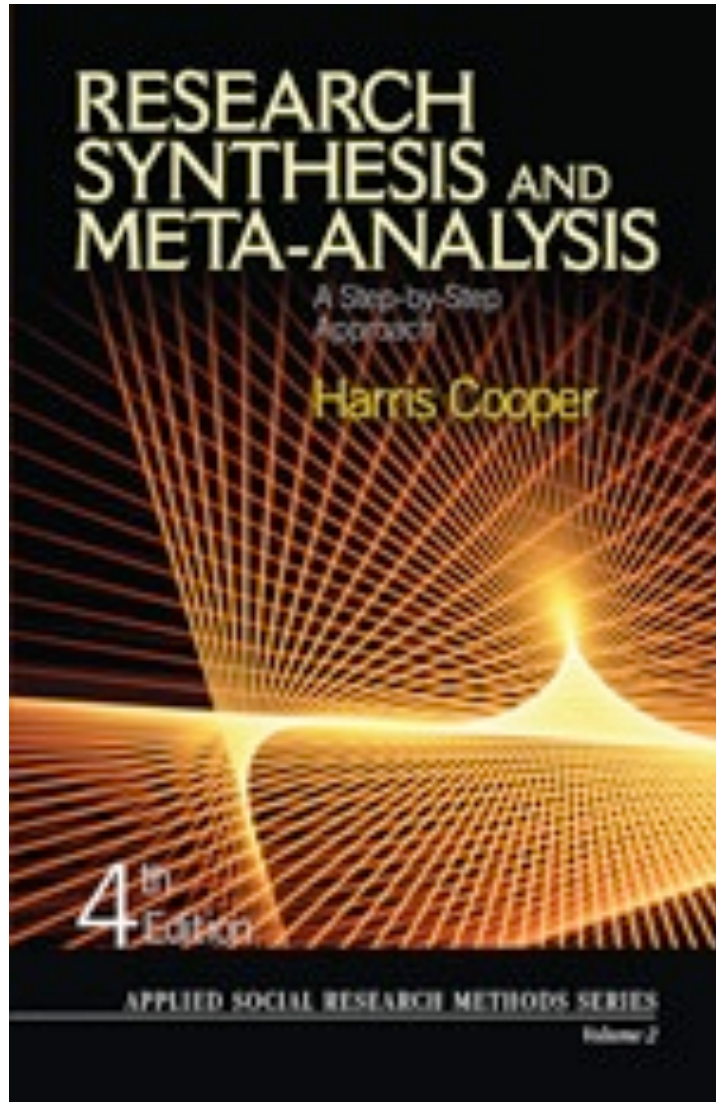
Cooper, H. (2010). *Research Synthesis and Meta-Analysis: A Step-by-Step Approach.* Thousand Oaks, CA: Sage.
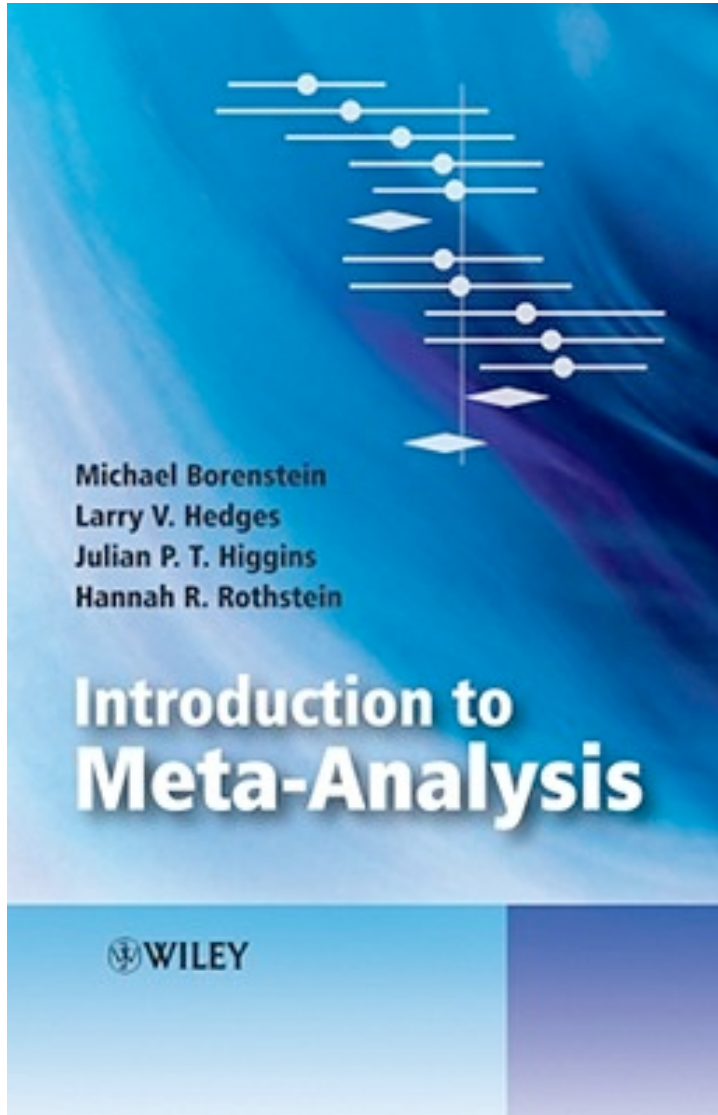
Borenstein, M., Hedges, L.V., Higgins, J.P.T, & Rothstein, H.R. (2009). *Introduction to Meta-Analysis*. Chichester, UK: Wiley.

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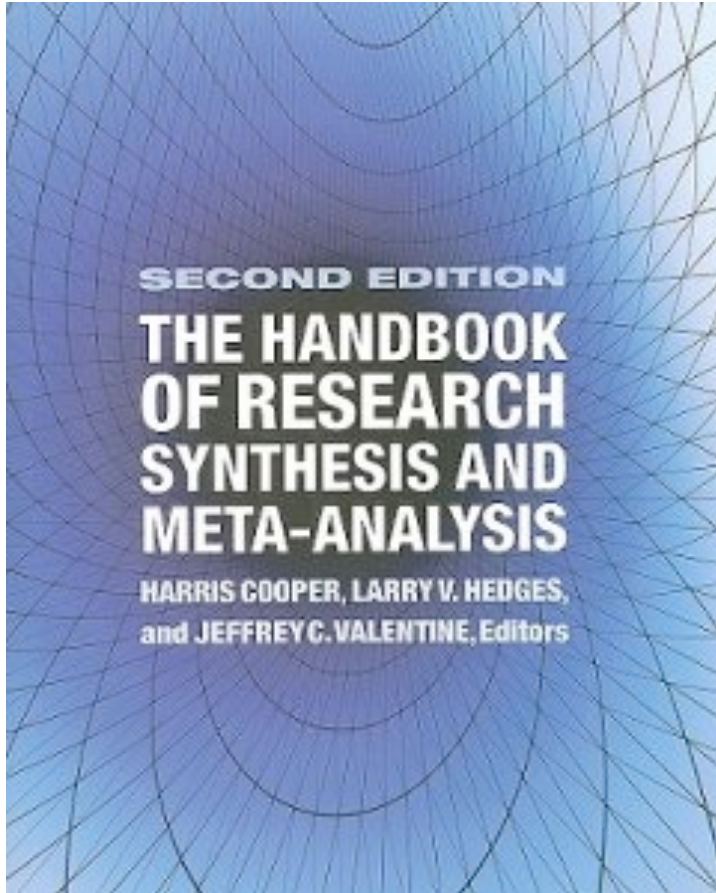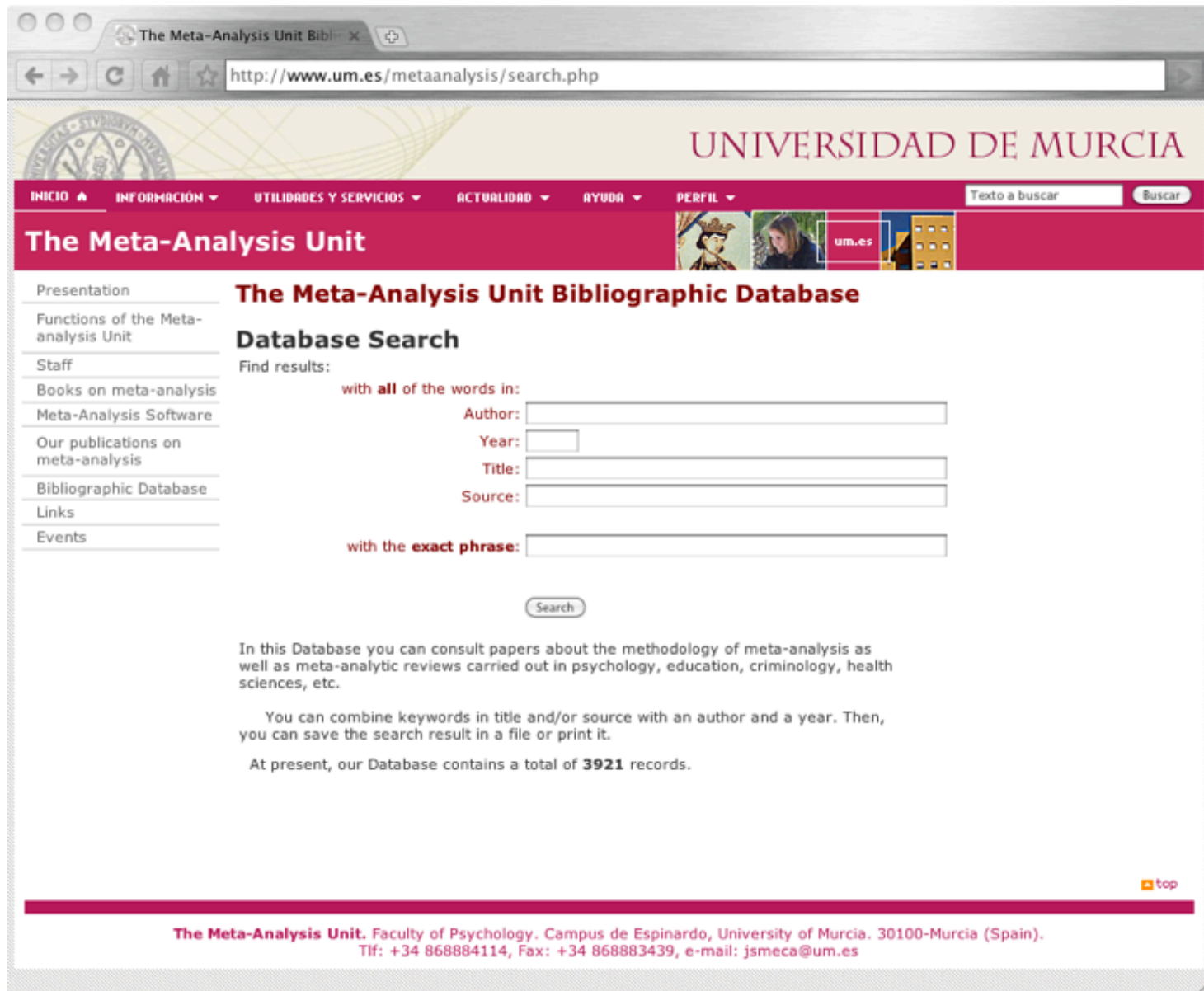
Cooper, H., Hedges, L.V., & Valentine, J.C. (Eds.) (2009). *Handbook of Research Synthesis (2nd ed.)*. New York: Russell Sage Foundation.

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

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www.meta-analysis.eu

Michael Bosnjak´s Meta-An... ×

http://docs.google.com/Doc?id=ajktzsnh86vs_68898qrj

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)

Bornstein, M., Hedges, L.V., Higgins, J.P.T, & Rothstein, H.R. (2009). *Introduction to Meta-Analysis*. Chichester, UK: Wiley.
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Cooper, H., Hedges, L.V., & Valentine, J.C. (Eds.) (2009). *Handbook of Research Synthesis (2nd ed.)*. New York: Russell Sage Foundation.
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Hunter, J. E., & Schmidt, F. L. (2004). *Methods of meta-analysis: Correcting error and bias in research findings (2nd ed.)*. Thousand Oaks, CA: Sage.
(Retrieve description via: Amazon.de * Amazon.com)

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/ipr/people/hedges.html
- Blair Johnson (U Connecticut)
  http://johnson.socialpsychology.org/
- Mark Lipsey (U Vanderbild)
  http://www.vanderbilt.edu/cerm/NewMarkBio.htm
  Papers: Meta-Analysis Applications

LMS

http://campus.bosnjak.eu