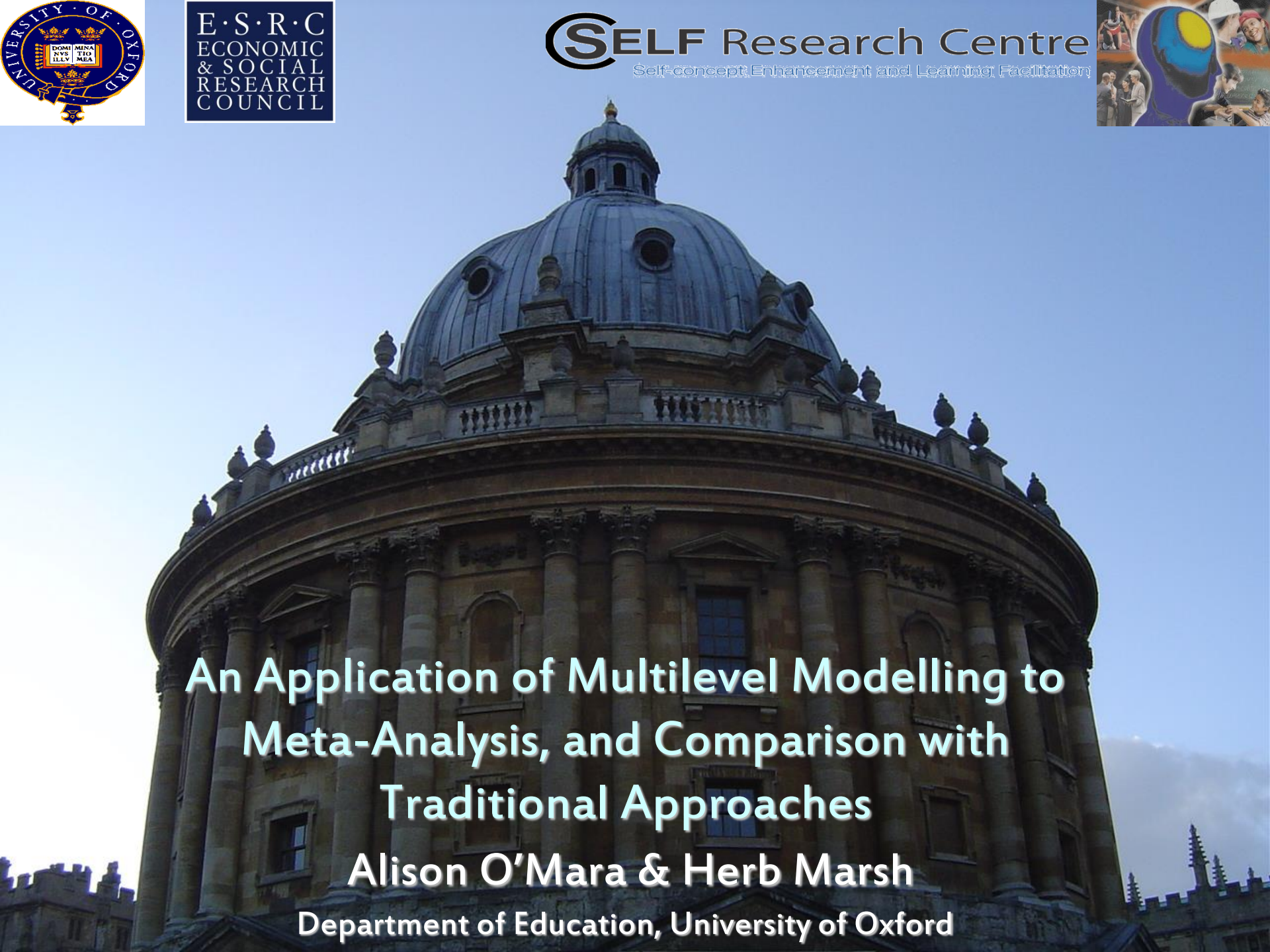

# An Application of Multilevel Modelling to Meta-Analysis, and Comparison with Traditional Approaches

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# Substantive and methodological synergy

- Enhancing self-concept of children and adolescents through interventions
- Methods of meta-analysis

# Meta-analysis

- Systematic synthesis of various studies on a particular research question
- Collect all studies relevant to a topic
- "Content analysis"
- An effect size is calculated for each outcome
- Effect sizes with similar features are grouped together and compared
- This allows identification of moderator variables

# Model assumptions in meta-analysis

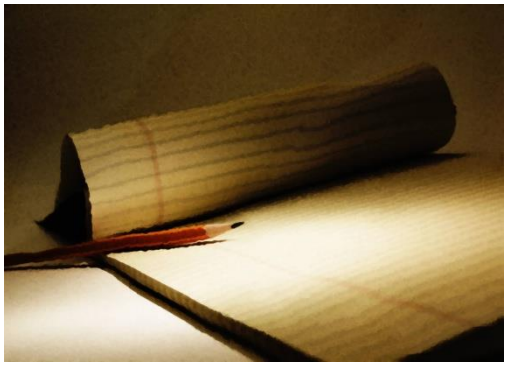
- Fixed effects
  - All of the variability between effect sizes is due to sampling error alone (Hedges & Vevea, 1998)
  - Effect sizes are independent
- Random effects
  - Variability between effect sizes is due to sampling error *plus* variability in the population of effects
  - This model assumes that studies are heterogeneous to an extent (Erez et al., 1996), because each study has different contexts, researchers, and even methods.
  - Effect sizes are independent

# Multilevel modelling meta-analysis

- Multilevel
  - Meta-analytic data is inherently hierarchical (i.e., effect sizes nested within studies)
  - Variability between effect sizes is due to sampling error *plus* variability in the population of effects
  - Effect sizes are not necessarily independent
- Allows for multiple effect sizes per study (Goldstein, 1995; Hox, 2002; Bryk & Raudenbush, 1992)
- Provides more precise and less biased estimates of between-study variance than traditional techniques (Van den Noortgate & Onghena, 2003)

# Self-concept interventions

- Unclear whether self-concept interventions are effective
- Problems in literature:
  - Methodological considerations
  - Conceptual inconsistencies
    - Focus of this presentation



# Theoretical perspectives

- UNIDIMENSIONAL
- Self evaluations are consistent across different contexts
- Self-concept is the sum or total perception of the self
- Instruments measure global evaluations ("I am a good person"), or sum together evaluations of different aspects to yield 'total' self-concept score

- MULTIDIMENSIONAL
- Domains of self-concept are distinct from each other
- E.g., math self-concept, physical appearance self-concept, social self-concept
- Instruments measure specific domains ("I am good at math")

# The problem…

- Evaluating self-concept interventions from unidimensional perspective loses information
- Meta-analyses of self-concept interventions using traditional meta-analytic methods (Haney & Durlak, 1998; Hattie, 1992) perpetuate this problem because of assumption of independence

# Sampling

- Selection criteria
  - Measure of self-concept/ self-esteem at posttest
  - Mean age of 18 or younger
  - Control group
  - Published
- Total yield of 145 articles from the years 1958 to 2000
- 200 interventions
- 460 effect sizes

Mean group 1

Mean group 2

*s*1 and *n*1 are the SD and number of participants in group 1, respectively

# Effect size calculation

Standardised Mean Difference (Hedges & Olkin, 1985)

$$\overline{ES} = \frac{\overline{X}_{G1} - \overline{X}_{G2}}{s_{pooled}}$$ , where $$s_{pooled} = \sqrt{\frac{s_1^2(n_1 - 1) + s_2^2(n_2 - 1)}{n_1 + n_2 - 2}}$$

Hedges correction for small sample size bias

$$d_i = \overline{ES}\left[1 - \frac{3}{4N - 9}\right]$$

# Weighting

- In fixed and random effects, the effect sizes are weighted by the inverse of the variance to give more weight to effects based on large sample sizes
- Variance is calculated as

$$v_i = \frac{(n1 + n2)}{(n1 \,.\, n2)} + \frac{d_i^2}{2\,(n1 + n2)}$$

# Fixed effects meta-analysis

- The analog to the ANOVA homogeneity analysis is appropriate for categorical variables
  - Also referred to as *Q*-test
  - Follows a chi-square distribution
  - Looks for systematic differences between groups of responses within a variable
- Can also conduct regression analyses (not discussed here)

# Random effects meta-analysis

- Follows the same procedures as fixed effects models (i.e., homogeneity analyses and regression), except that it adds a random variance component to the variance
- The variance component is typically calculated as

$$v_\theta = \frac{Q - (k - 1)}{\Sigma w_i - (\Sigma w_i^2 \ / \ \Sigma \ w_i)}$$

- The new weighting is by the formula:

$$w_{i\mathrm{RE}} = 1/(v_i + v_\theta)$$

# Shifting unit of analysis

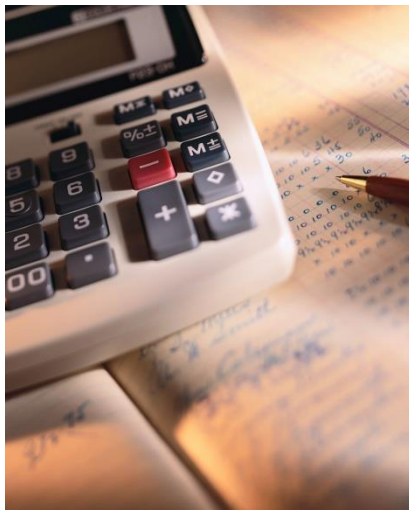
- To help minimise violations of assumption of independence in fixed and random effects analyses, Cooper's (1998) shifting unit of analysis was used
- Effect sizes are aggregated based upon the particular moderator variable, such that each study only includes one effect size per outcome on that particular variable

# Multilevel meta-analysis

- Levels
  - Level 3: publication level component
  - Level 2: study/intervention level component
  - Level 1: effect size outcome level component
- Intercept-only model gives overall mean effect size
- $d_{ijk} = \beta_{000} + v_{0k} + u_{0jk} + e_{ijk}$
  - $v_{0k}$ is the random error at level 3,
  - $u_{0jk}$ is the random error at level 2, and
  - $e_{ijk}$ is the random error (residual) at Level 1.

# Software

- Fixed and random effects: macros for SPSS (Lipsey & Wilson, 2001) using method of moments
- Multilevel: MLwiN using restricted maximum likelihood estimation (see Hox, 2002)



# Results summary – 'empty model'

| Model | Fixed effects | Random effects | Multilevel |
|---|---|---|---|
| δ/intercept (SE) | .31(.02) | .51(.07) | .47(.06) |
| 95% confidence interval | .28,.35 | .38,.64 | .37,.61 |
| *p*-value $\chi^2$ test (*df* = 144) | $p < .001$ | $p < .001$ | $p < 0.001$ |

Heterogeneous outcomes: need to model moderator & predictor variables

# Multilevel: Wald test & ICC

- Other ways of showing heterogeneity between studies in MLM
  - The intercepts for the different studies (level 3 residuals, $v_{0jk}$) have a variance, $\sigma^2_{v0}$, of .186 (SE = .085)
  - ICC = .271.

# Construct validation

- Target self-concept domains - self-concept domains with focal relevance to the intervention's goals
- Target-related - logically related to the intervention's goals, but are not primary
- Non-target - not expected to be enhanced by the intervention
- Example: Reading self-concept intervention
  - Target = Reading self-concept
  - Target-related = School self-concept
  - Non-target = Physical appearance self-concept

# Predictor variable – outcome relevance

| Model | Fixed | Random | Multilevel |
|---|---|---|---|
| Target | .49 | .55 | .55 |
| Target-relevant | .11 | .49 | .47 |
| Non-target | .08 | .21 | .26 |
| *p*-value $\chi^2$ test | $p < .001$ | $p < .001$ | $p < 0.001$ |

Reference variable

Self-selected behaviors are relevant to intervention goals

# Implications

- Demonstrates importance of substantive/methodological synergies
  - Multidimensional constructs require MLM
- Use of multilevel modelling in meta-analysis
  - Results differ from previous meta-analyses using fixed effects model and random effects model
  - Similar to random effects when not too heterogeneous
  - Slight differences likely due to estimation procedures for calculating random error variance components (non-iterative vs. iterative)
  - Less likely to reach significance (larger confidence intervals)

# Limitations and future directions

- Fine-tuning multivariate approach using response variables (e.g., Kalaian & Raudenbush, 1996; Goldstein, 1995)
- Multilevel missing data imputation in MLwiN
- Simulation

# Analyses not discussed here…

- Other moderator variables
  - E.g., random assignment, control group type
- Follow-up data analysis
- Inter-rater reliability (Cohen's kappa)
- Publication bias
  - Fail safe *N*
  - Trim and fill procedure (Duval & Tweedie, 2000a, 2000b)
  - Power analysis

# Questions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