Heterogeneity in close and conceptual replications

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Context

- Replication crisis
- Replication projects
  - Close replications (Many Labs, Registered Replication Reports)
  - Keep design, materials, analyses, etc. as close to original as possible
- Meta-analyses
  - Conceptual replications
  - Different designs, materials, participants, analysis, etc.
- Heterogeneity – how much true effect sizes differ across studies

Why care about heterogeneity?

- Affects statistical power (McShane & Böckenholt, 2014; Shrout & Rodgers, 2018)
  - Heterogeneity decreases power
  - Power calculations should take this into account. But first we need a reliable estimate of heterogeneity, and what may be driving this.
  - Could this explain low success in 100 close replications from Open Science Collaboration (2015)?
- Design of practical applications
  - Heterogeneity can tell us something about the level of certainty around the result of the 'next study'
  - Successful translation of research into practice depends on consistency of findings

Aims

- Derive an estimate of heterogeneity in close replication studies
- Compare this to heterogeneity in a large sample of meta-analyses
- Investigate some possible causes of heterogeneity

Hypotheses

- Heterogeneity in close replications expected to be low
- Heterogeneity in conceptual replications
  - Higher in social than cognitive psychology
    - Higher replication success for cognitive than social psychology (Open Science Collaboration, 2015)
  - Higher in social than organisational psychology
    - Higher correlation between lab and field studies in organisational than social psychology (Mitchell, et al., 2012)

Methods

- 40 close replication studies (Many Labs and Registered Replication Reports)
- 147 meta-analyses sampled (cognitive, organisational, social psychology)
  - Cohen's *d* as measure of ES
  - τ as measure that quantifies heterogeneity
    - Generally assumed that population ES for a given phenomenon follow a normal distribution
    - τ is their standard deviation
- *d* and τ calculated by re-doing all meta-analyses

Methods – Two approaches to moderators

- 25 meta-analyses with $k \geq 60$, and with sufficient information to re-examine moderator analyses
  - Excluded 'broad' subsets (e.g. adults, children, mixed – mixed sample excluded)
- For meta-analysis as a whole, rated broadness/narrowness of inclusion criteria for studies on a 5-point scale
  - E.g. is the question addressed narrow/broad
  - Does manipulation of IV/DV follow standard protocol

How do meta-analyses address heterogeneity?

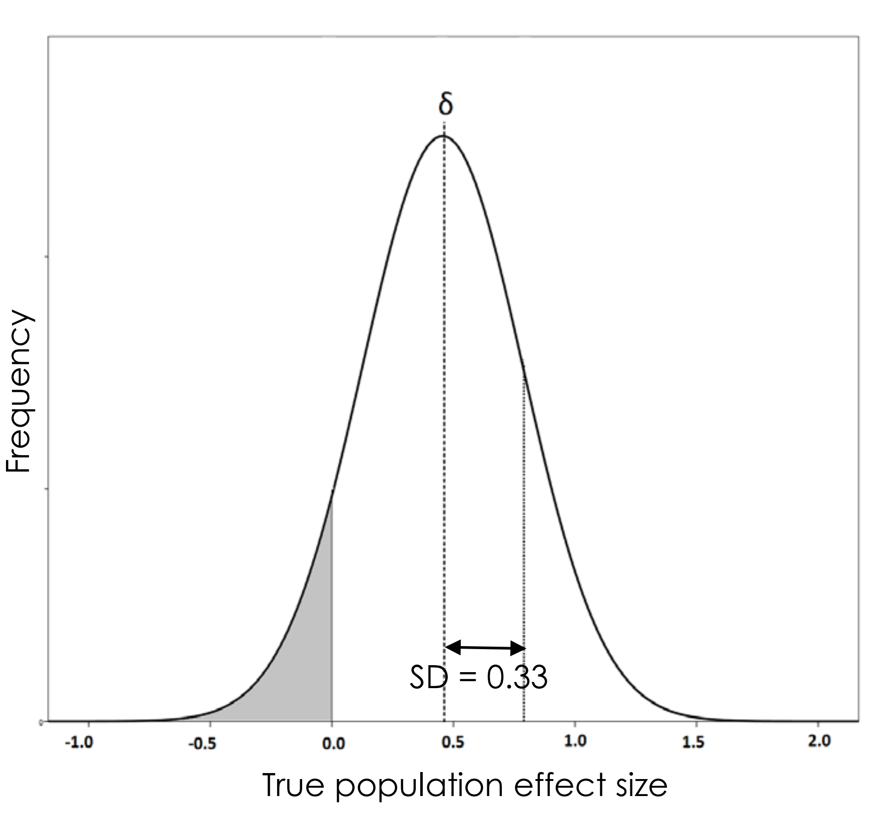
- Out of 147 meta-analyses…
  - 54% reported a measure of heterogeneity
  - Heterogeneity **quantified** in only 38 cases (26%)
- Post-PRISMA? (Preferred Reporting Items for Systematic Reviews and Meta-Analyses, 2009)
  - Heterogeneity only reported in 60% of cases

Findings in our sample

- Average τ was low (M = 0.08) in **close** replications
- Average τ was much higher (M = 0.33) in **conceptual** replications
- Overall ES for average close replication was d = 0.24; for meta-analysis this was d = 0.45
- Heterogeneity in conceptual replications
  - No significant differences between the 3 sub-disciplines (cognitive, social, organisational)
  - The distinctive success rates of these sub-disciplines in terms of replication is not reflected in heterogeneity levels

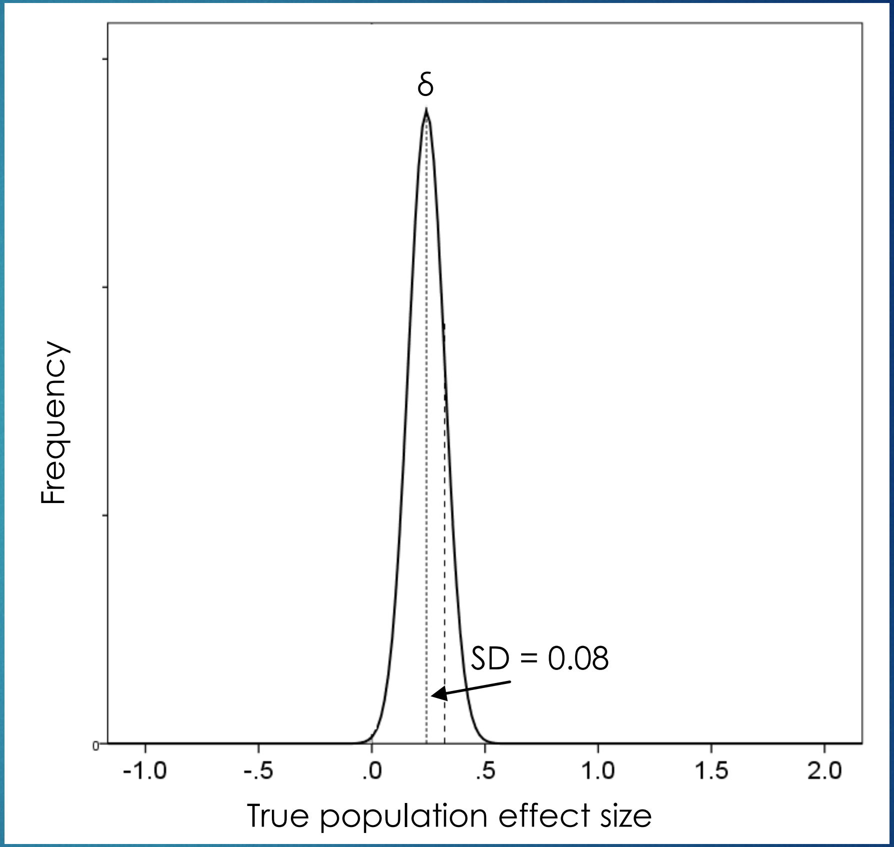
What does this level of heterogeneity mean?

- Average τ = 0.33
- Cohen's *d* of 0.2/0.5/0.8 are often used as benchmarks for small/medium/large effects
  - All of these occur frequently in the distribution of true effect sizes
  - Can expect replications to find results in the opposite direction



Close replications

- Average τ = 0.08
- High consistency in results



Variability in heterogeneity – why?

- Mixing apples and oranges
  broad versus narrow inclusion criteria

- Looked at moderators in a sub-set of 25 large meta-analyses
  - Looked at one moderator in each case

- No significant difference in heterogeneity between overall meta-analyses (*M* = 0.34) and subset based on moderators (*M* = 0.36)

- Broad/narrow inclusion criteria?
  - Narrow sub-sample, heterogeneity still high (*M* = 0.29)

Variability in heterogeneity – why?
Exploratory analyses

- Research areas with larger ES have greater heterogeneity (Kenny & Judd)
  - Strong relationship between mean *d* and τ
  - For close replications (r = .70, p <.001)
  - For conceptual replications (r = .45, p <.001)

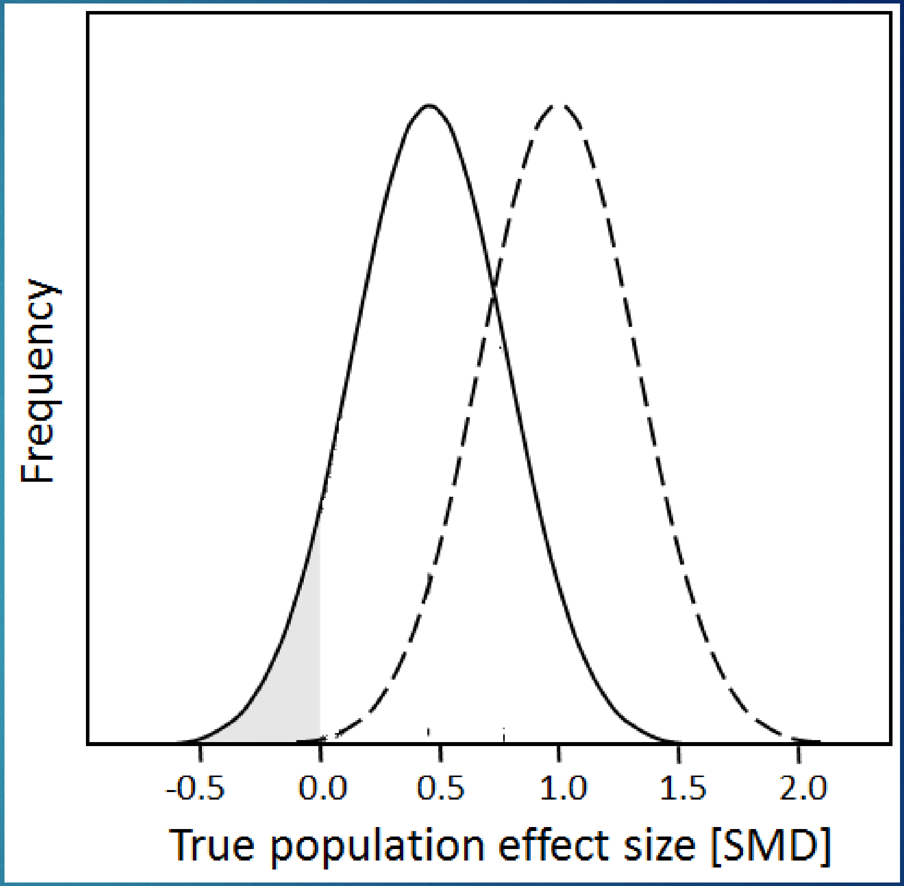
- Maturity of a research field, or broader inclusion criteria?
  - Relationship between *k* and τ (r = 0.30, p <.001)
  - Establishing an effect -> exploring boundaries
    - Used a median date split
  - No significant difference in τ between the earlier and later dates

Conclusions

- Heterogeneity in close replications proved low – producing reliable results is possible
- Heterogeneity in close replications reduces power only marginally - for sample sizes that generate 80% power at zero heterogeneity…
  - For τ = 0.08, power
    - Does not reduce for large effects
    - Drops to 78% for medium effects
    - Drops to 71% for small effects
- For Open Science Collaboration (2015), mean effect size was large (*d* =0.87)
  - Power therefore not affected
  - 'Hidden moderators' typically of no concern

Conclusions

- Heterogeneity in meta-analyses is large (and not strongly affected by bias)
  - Mean ES reported in MA with large heterogeneity have limited use
- Research Planning
  - Difficult to estimate efficacy of an intervention (effect could be in opposite direction)
  - Heterogeneity and effect size determine how predictable the result of the 'next study' is



Conclusions

- ꞁ = 0.33 has a more dramatic effect on power
  - Drops to 71% for large effects
  - Drops to 66% for medium effects
  - Drops to 57% for small effects

Implications

- Cumulative knowledge
  - Science = quest to explain apparent complexity in observations through simpler fundamental principles
  - (Unexplained) heterogeneity is a measure of how much this quest fails

- Falsifiability of theories
  - Say test of theory *X* requires induction of good mood. We use mood induction procedure *Y*
  - When effectiveness of *Y* is debatable (large heterogeneity), failed test of theory *X* becomes meaningless
  - Weak tools undermine falsification and thereby good theoretic progress
  - When knowledge *Y* is used as a tool, we need to replicate as closely as possible

Limitations

- Difference in effect size between close replications (*d* = 0.24) and conceptual replications (*d* = 0.45)
  - How does low heterogeneity in close replications generalise to psychological research findings?
- We used Hunter-Schmidt meta-analysis model
  - Similar results for Hedges, and DerSimonian-Laird models
  - HS estimates of heterogeneity were slightly more conservative

Thank you

- Questions…