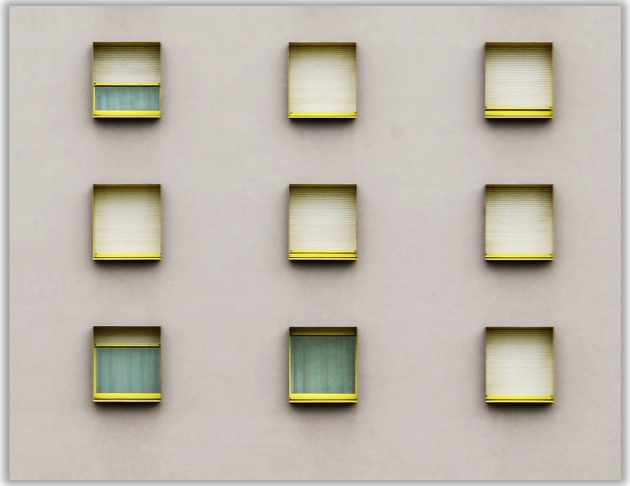
# Subgroup Analysis & Meta-Regression

- Outlier and influence analyses are performed **after seeing the data** (“post-hoc” procedure)
- They may tell us that some study does not properly follow the expectations of our model, but not **why this is the case**.
- Subgroup or moderator analyses analyses allow us to test **specific hypotheses** on ***why*** some type of study produces lower or higher effects than another.
- Often, this can be a way to **explain heterogeneity** in our study data



# Subgroup Analysis & Meta-Regression

## The Fixed-Effects (Plural) Model

(Borenstein et al. 2011, chap. 19)

- We hypothesize that studies do not stem from one overall population, but that they fall into **different subgroups** and that each subgroup has its **own true overall effect**.
- We want to reject the null hypothesis that there is **no difference in effect sizes between subgroups**.

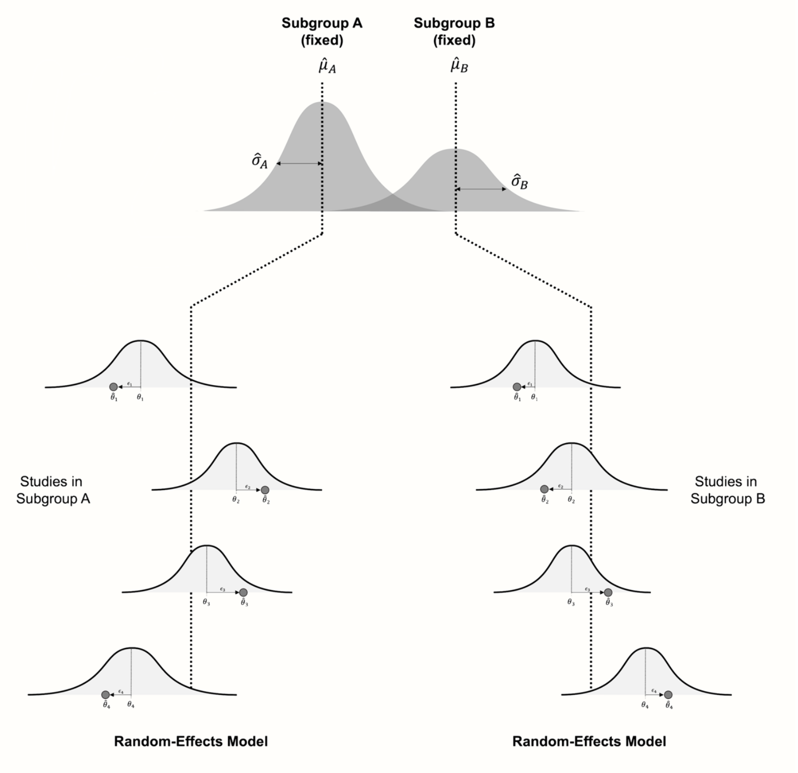
# Subgroup Analysis & Meta-Regression

## The Fixed-Effects (Plural) Model

(Borenstein et al. 2011, chap. 19)

**The calculation of a subgroup analysis consists of two parts:**

1. Pool the effect in each subgroup using a random-effects model
2. Compare the effects in both groups using a statistical test

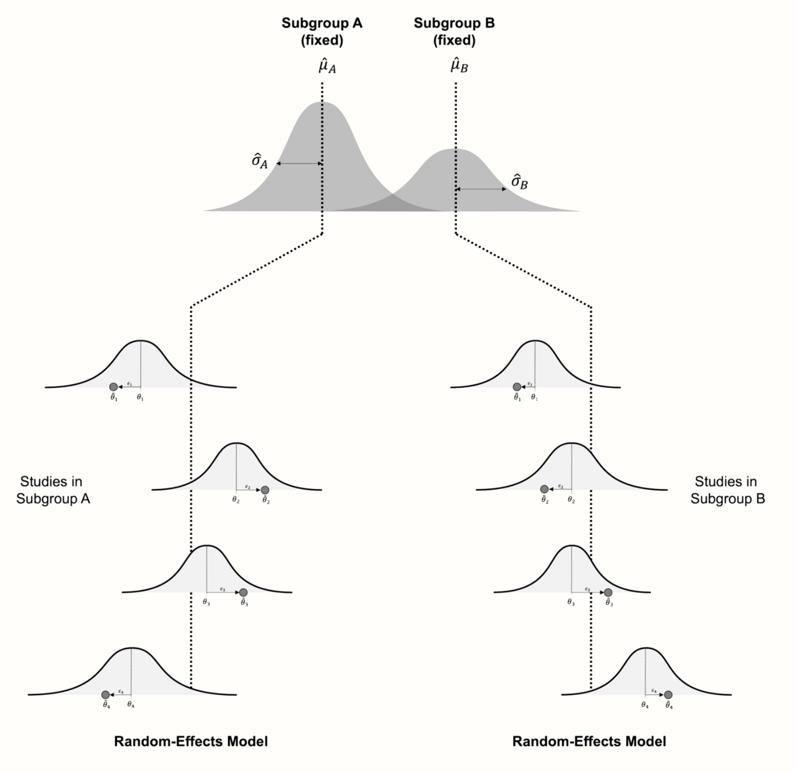


# Subgroup Analysis & Meta-Regression

## The Fixed-Effects (Plural) Model

(Borenstein et al. 2011, chap. 19)

- Since studies are pooled in separate subgroups using the random-effects model, we obtain **two $\tau^2$ estimates.**
- In practice, however, the individual heterogeneity values $\hat{\tau}_g^2$ are often replaced with a version of $\tau^2$ that was pooled across subgroups.
- This is mostly done for practical reasons. When the number of studies in a subgroup is small (e.g., <5) it is likely that the estimate of $\tau^2$ will be imprecise.
- In this case, it is better to calculate a pooled version of $\tau^2$ that is used across all subgroups.



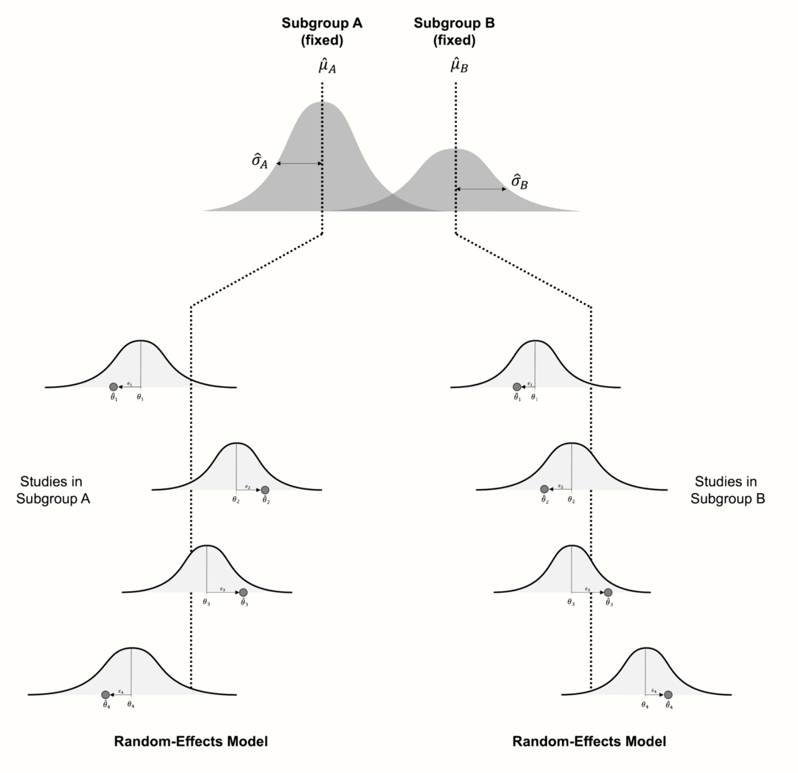
# Subgroup Analysis & Meta-Regression

## The Fixed-Effects (Plural) Model

(Borenstein et al. 2011, chap. 19)

- Next, we test if there is a **significant difference between the true effects** of the two subgroups
- An elegant way to test this is to **"pretend"** that the pooled effect of a subgroup is just the **observed effect size of one large study**
- The question we ask ourselves is quite **like when we assess the heterogeneity** of a normal meta-analysis:

→ **We want to know if differences in effect sizes exist only due to sampling error, or because of true differences in the effect sizes.**



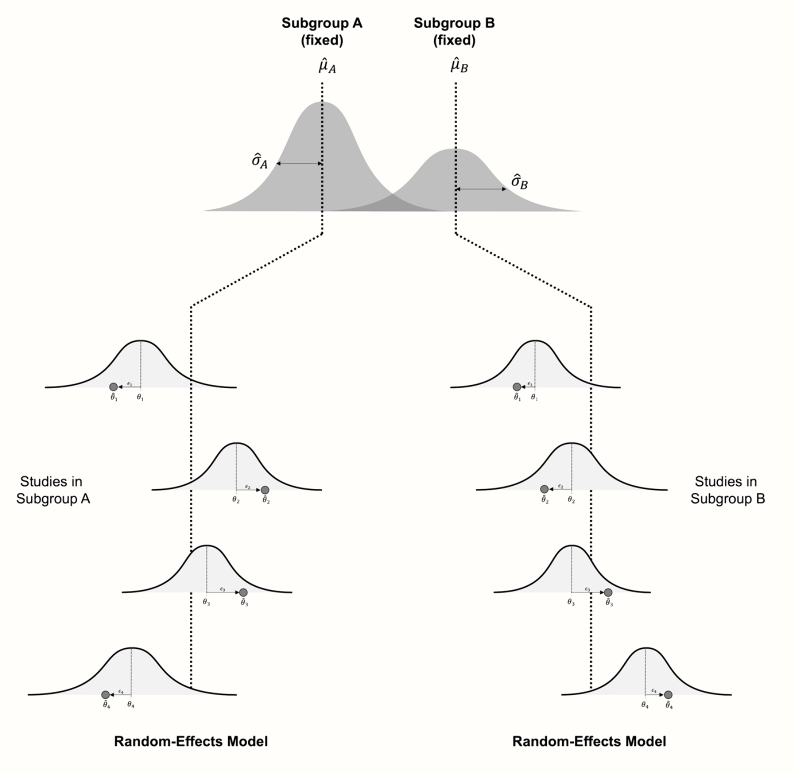
# Subgroup Analysis & Meta-Regression

## The Fixed-Effects (Plural) Model

(Borenstein et al. 2011, chap. 19)

- Therefore, we can use the $Q$**-test** again to determine if the subgroup differences are **large enough to <u>not</u> be explainable by sampling error alone.**
- If the $Q$-test is significant, we can conclude that the subgroups explain some excess variability (heterogeneity) in our data
- In this case, we assume our **subgroups *themselves*** are not random draws from a "universe" of subgroups, represent represent **fixed levels** of a characteristic we want to examine

→ **Thus, the name fixed-effects (plural) model!**



# Subgroup Analysis & Meta-Regression

## Subgroup Analysis: Summary of the Dos & Don'ts

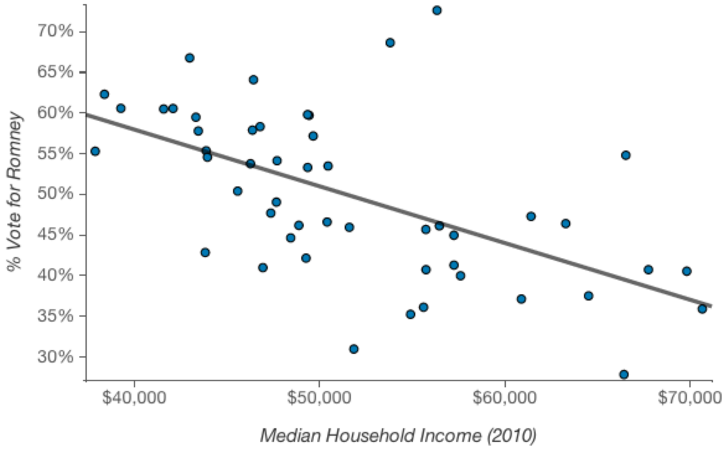
- Subgroup analyses depend on the **statistical power**, so it usually makes no sense to conduct one when the number of studies is small (i.e., $K < 10$).
- If you do **<u>not</u> find a difference** in effect sizes between subgroups, this does **not automatically mean** that the subgroups produce **equivalent results**.
- Subgroup analyses are **purely observational**, so we should always keep in mind that effect differences may also be caused by confounding variables.
- It is a bad idea to **use aggregate study information (e.g. mean age) in subgroup analyses**, because this may introduce ecological bias.

# Subgroup Analysis & Meta-Regression

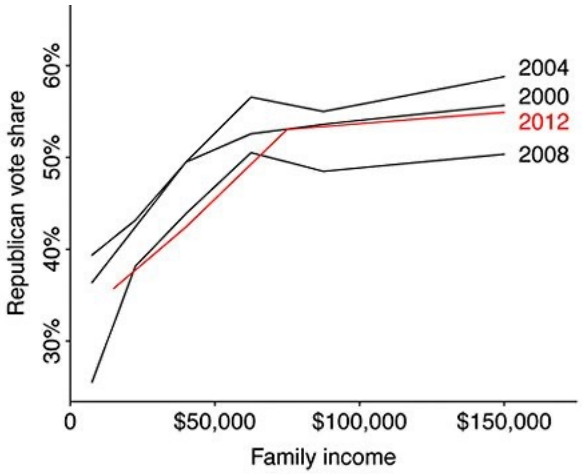
## “Democrats Are The Party of The Rich”: On Ecological Fallacies

Tendency to vote republican in the 2012 presidential race

### By US State




### By Family Income



# Subgroup Analysis & Meta-Regression

## Meta-Regression

- Subgroup analysis is a special case of meta-regression with subgroup-specific tau^2 values!
- Since both include fixed and random-terms, they are also known as mixed-effects models, or simply mixed models
- In meta-regression, we extend the original REM formula by fixed predictors, often with the hope that this will explain heterogeneity in our effects

## Categorical Predictor

$$\hat{\theta}_k = \theta + \beta D_g + \zeta_k + \epsilon_k \qquad D_g = \begin{cases} 0: \text{Subgroup A} \\ 1: \text{Subgroup B} \end{cases}$$

$$D_g = \begin{cases} 0: & \hat{\theta}_k = \theta_A + \zeta_k + \epsilon_k \\ 1: & \hat{\theta}_k = \theta_A + \theta_\Delta + \zeta_k + \epsilon_k \end{cases}$$