Twins Studies

- Monozygotic (MZ; “identical”)
  - Fertilization of a single egg by a single sperm
  - Share 100% of their genetic material.
- Dizygotic (DZ, “fraternal” or “non-identical”)
  - Result from the independent fertilization of two eggs by two sperm
  - Share on average 50% of their genes (just like full siblings).

A Natural Experiment

- Twins reared apart
  - They did not experience the same environment
  - Gives a much stronger test of genetic and non-shared environmental contributions
  - But separated MZs are rare

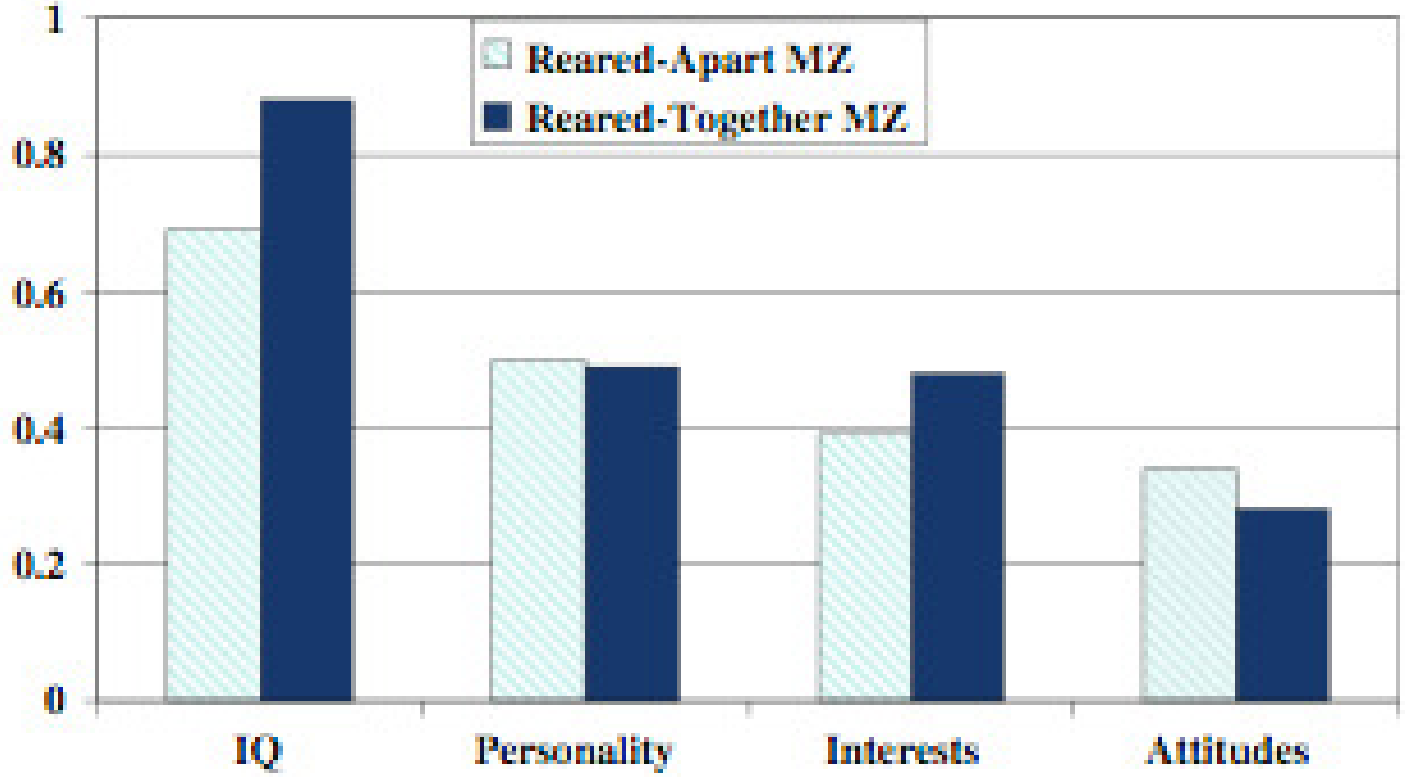
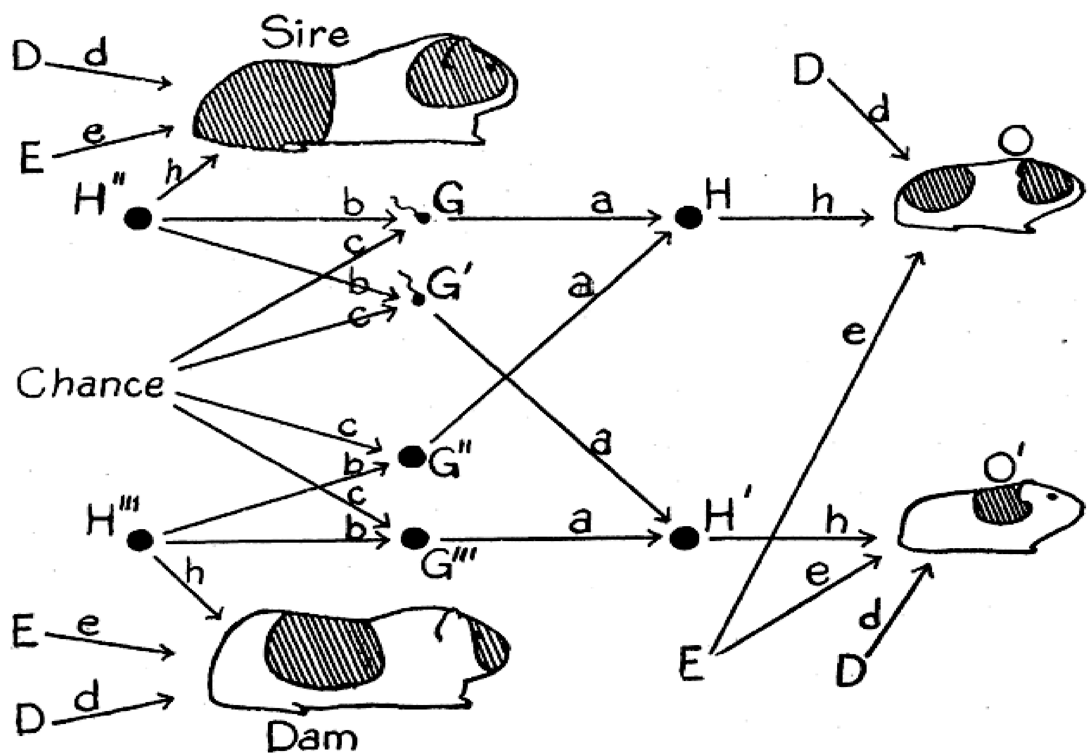


Fig. 2 Average reared-apart and reared-together monozygotic (MZ) twin correlations in four domains of psychological functioning. Adapted from Bouchard et al. (1990)

Path Diagram



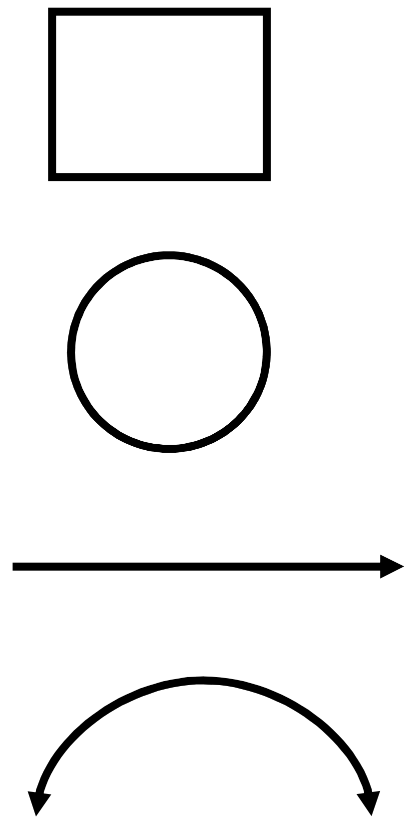
Path Analysis

- Derive predictions for the variances and covariances of the variables under the specified model
  - Present relationships between variables using **diagrams**
  - The relationships can also be represented as **structural equations** and **covariance matrices**
  - Structural equation modelling (SEM) represents a unified platform for path analytic and variance components models

Maximum Likelihood Estimation

- Likelihood: probability that an observation (data point) is predicted by specified model
- For MLE, determine most likely values of population parameter value (e.g, μ, σ, β) given observed sample value
  - define model
  - define probability of observing a given event conditional on a particular set of parameters
  - choose a set of parameters which are most likely to have produced observed results

Path Diagram Conventions



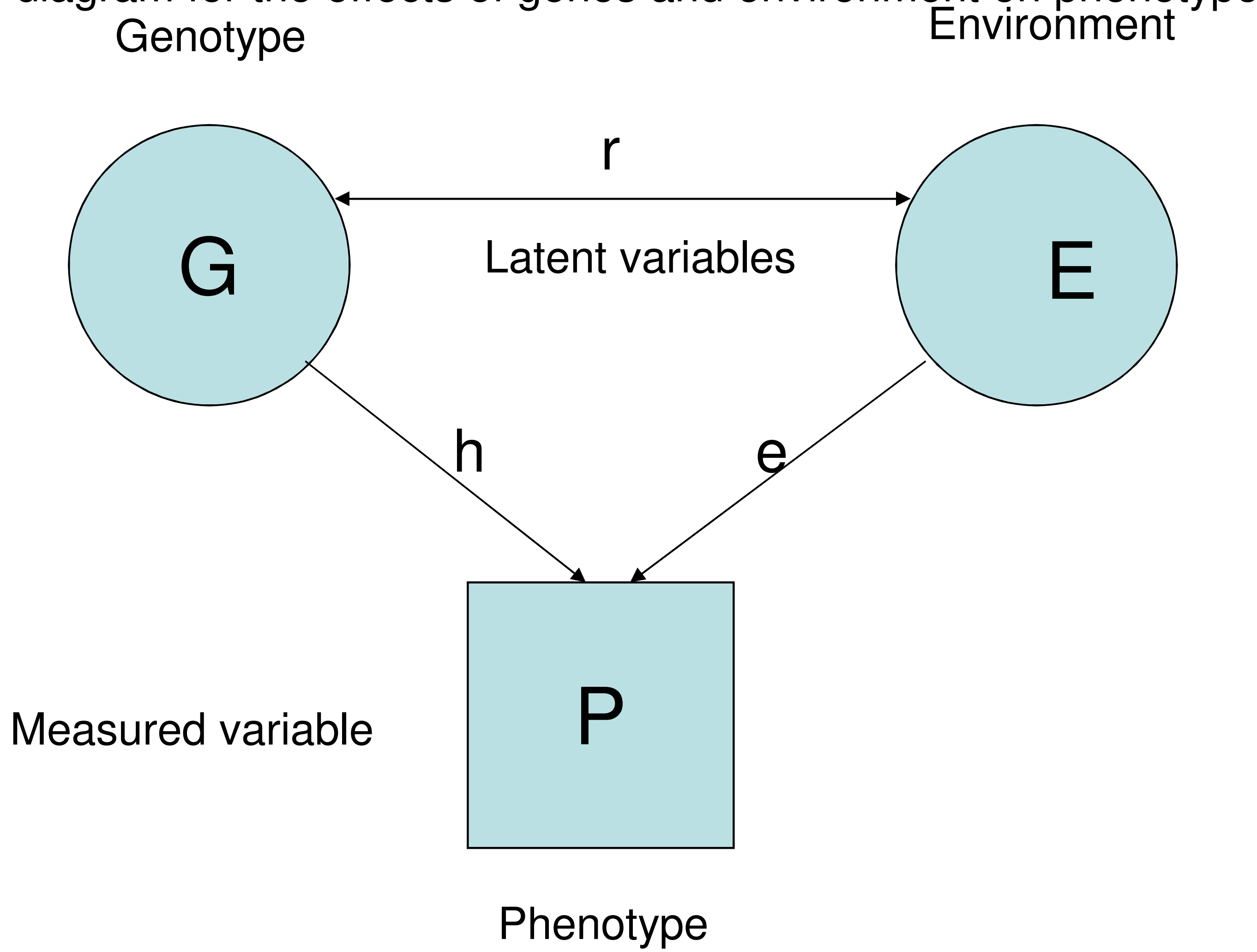
Observed Variable

Latent Variable

Causal Path

Covariance Path

Path diagram for the effects of genes and environment on phenotype



Variance Components

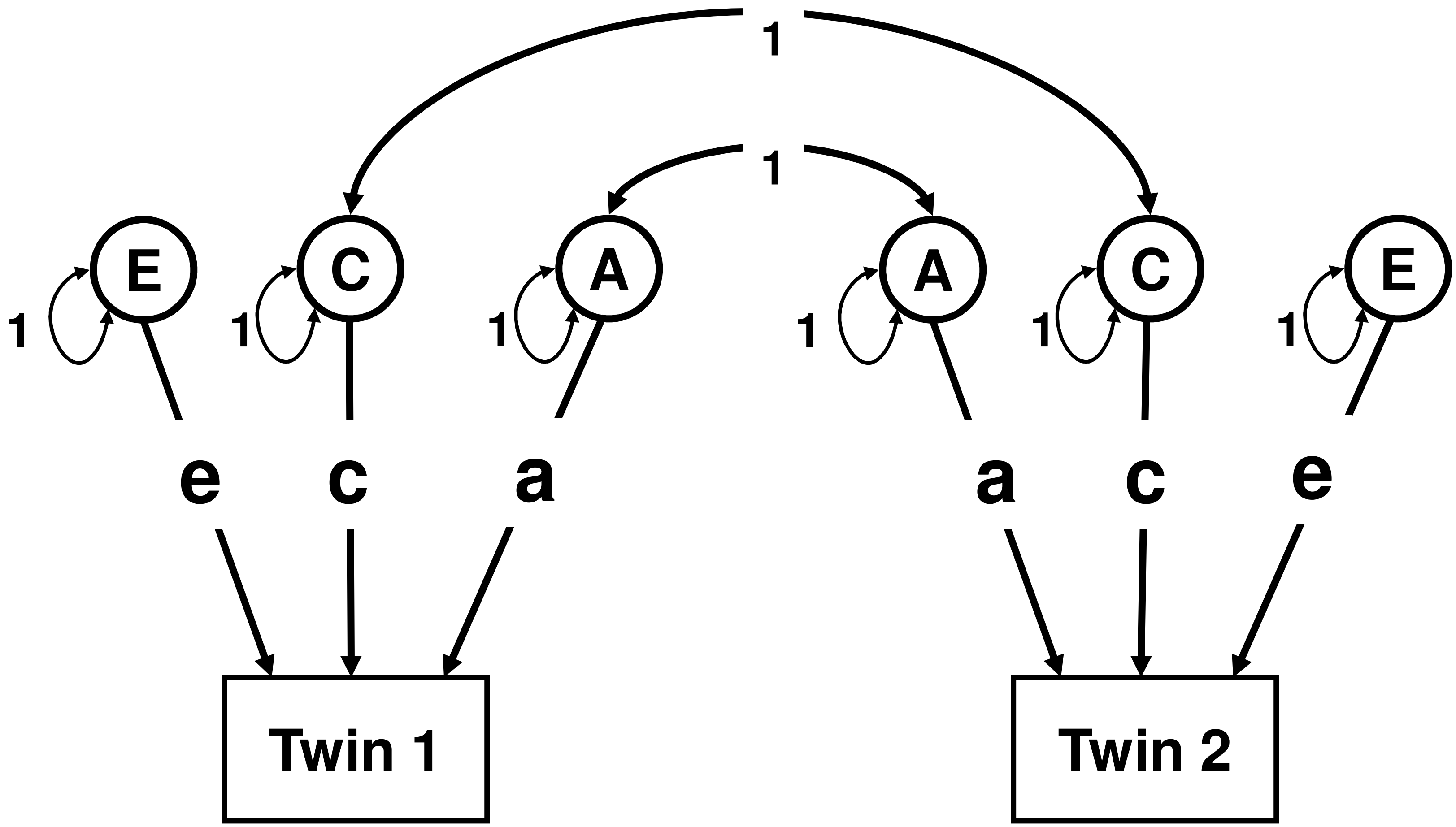
- Heritability (narrow-sense, A or a^2; broad-sense, H or h^2): phenotypic variance in a sample that can be attributed to genotypic variance.
- Shared or common environment (C or c^2): experiences that makes individuals more similar to one another, regardless of genetic similarity
- Non-shared or Unique environment and Error (E or e^2): What is left over

IDENTICAL TWINS

- MONOZYGOTIC:
- Have IDENTICAL genes (A)
- Come from the same family (C)
- Have unique experiences during life (E)

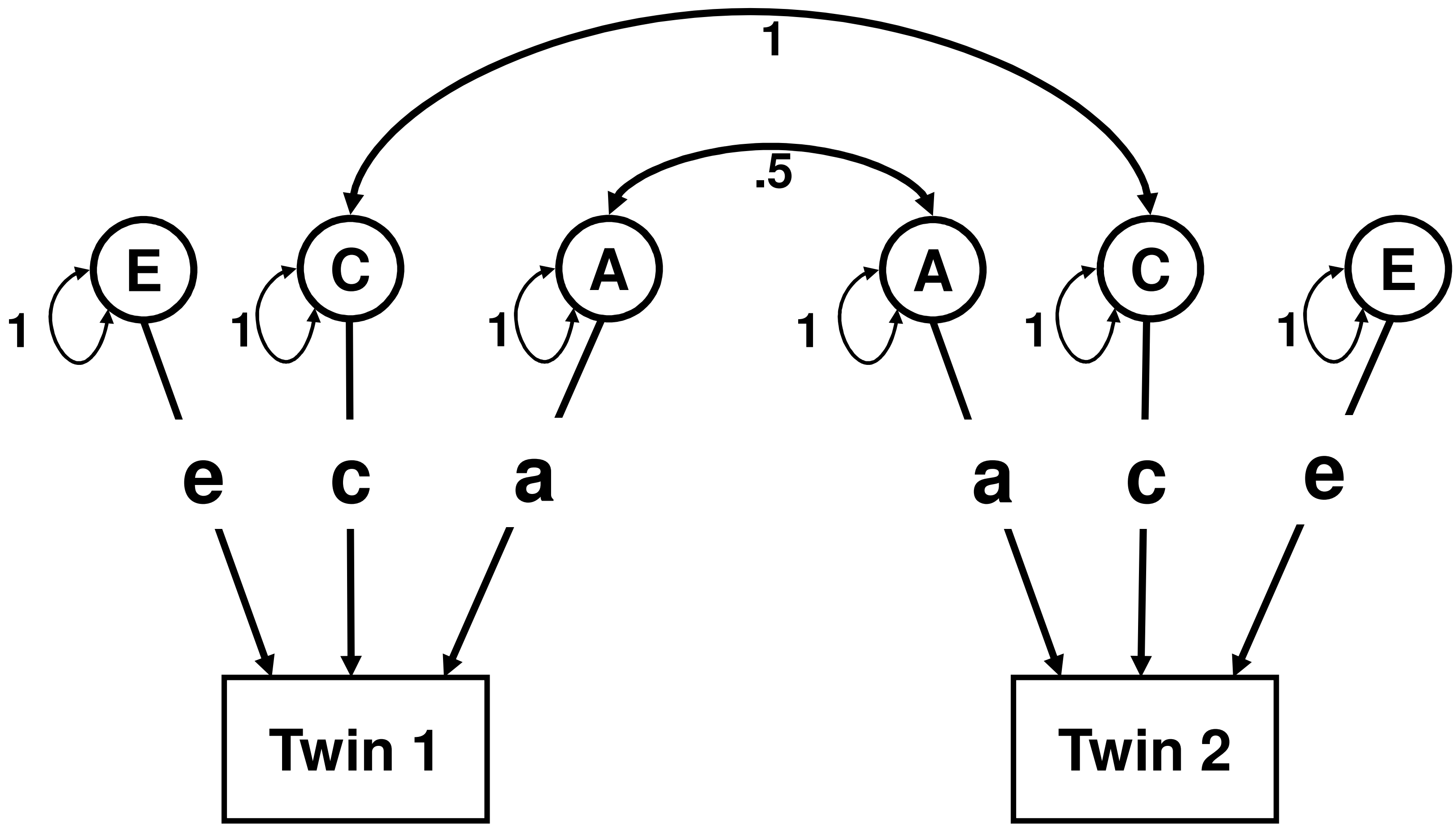
FRATERNAL TWINS

- DIZYGOTIC: Have DIFFERENT genes (A)
- Come from the same family (C)
- Have unique experiences during life (E)



Model for an MZ PAIR

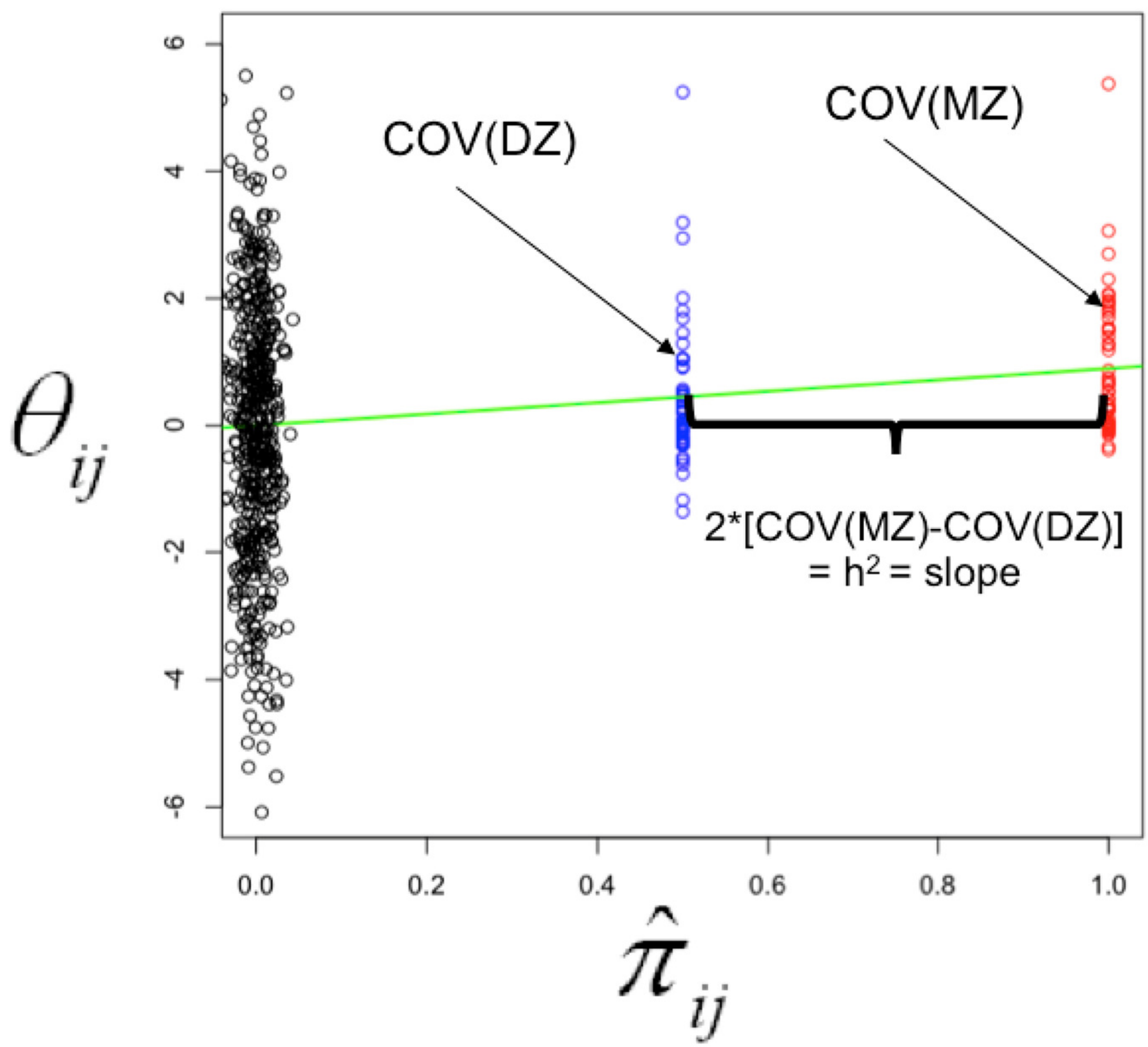
Note: a, c and e are the same cross twins



Model for a DZ PAIR

Note: a, c and e are also the same cross groups

Heritability among unrelateds



$$V_P = a^2 + c^2 + e^2$$

Falconer's model

Assumes all genetic effects are additive ($h^2 = a^2$)

$$r_{MZ} = a^2 + c^2$$

$$r_{DZ} = 0.5a^2 + c^2$$

$$1.0 = a^2 + c^2 + e^2$$

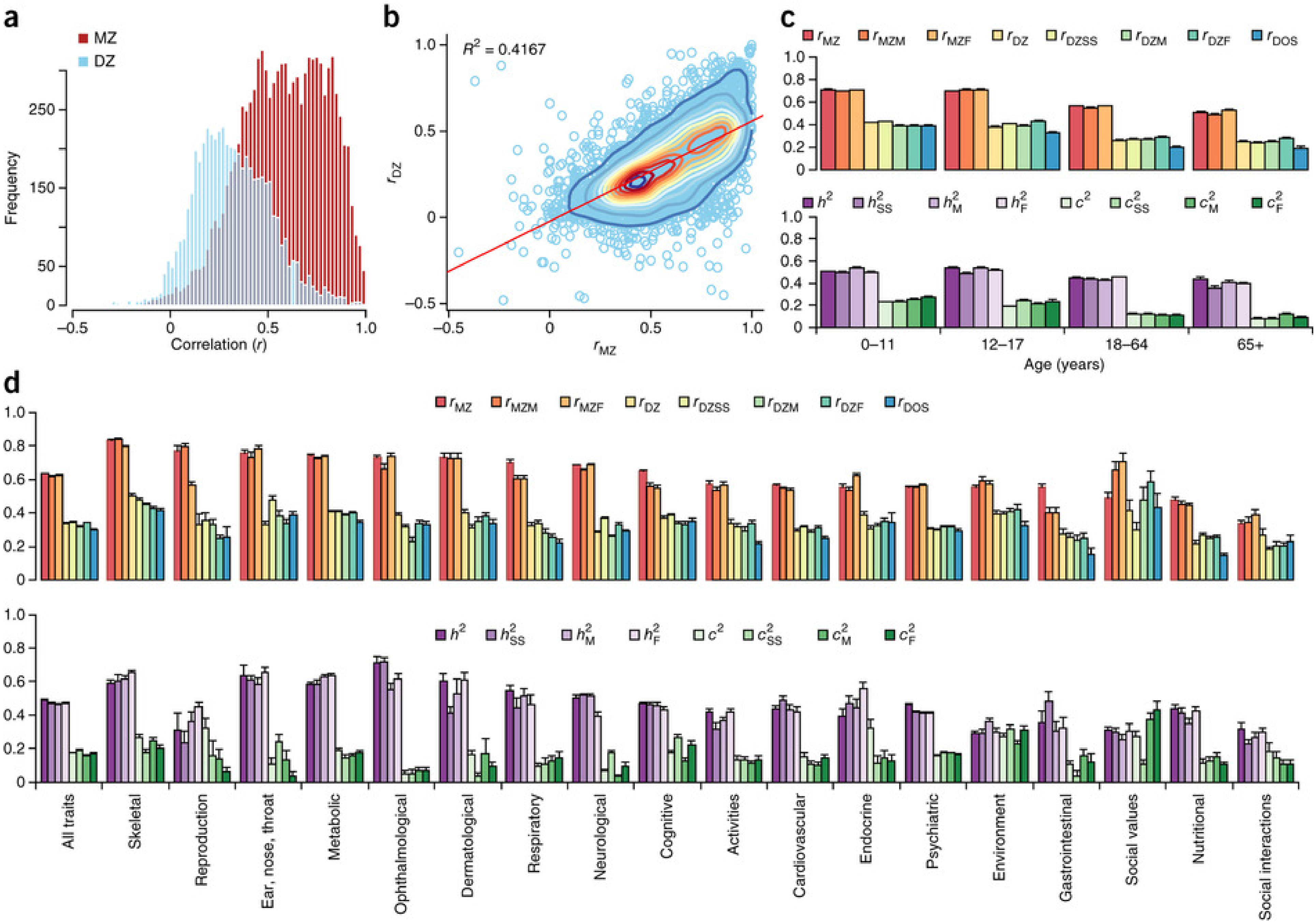
Falconer estimates

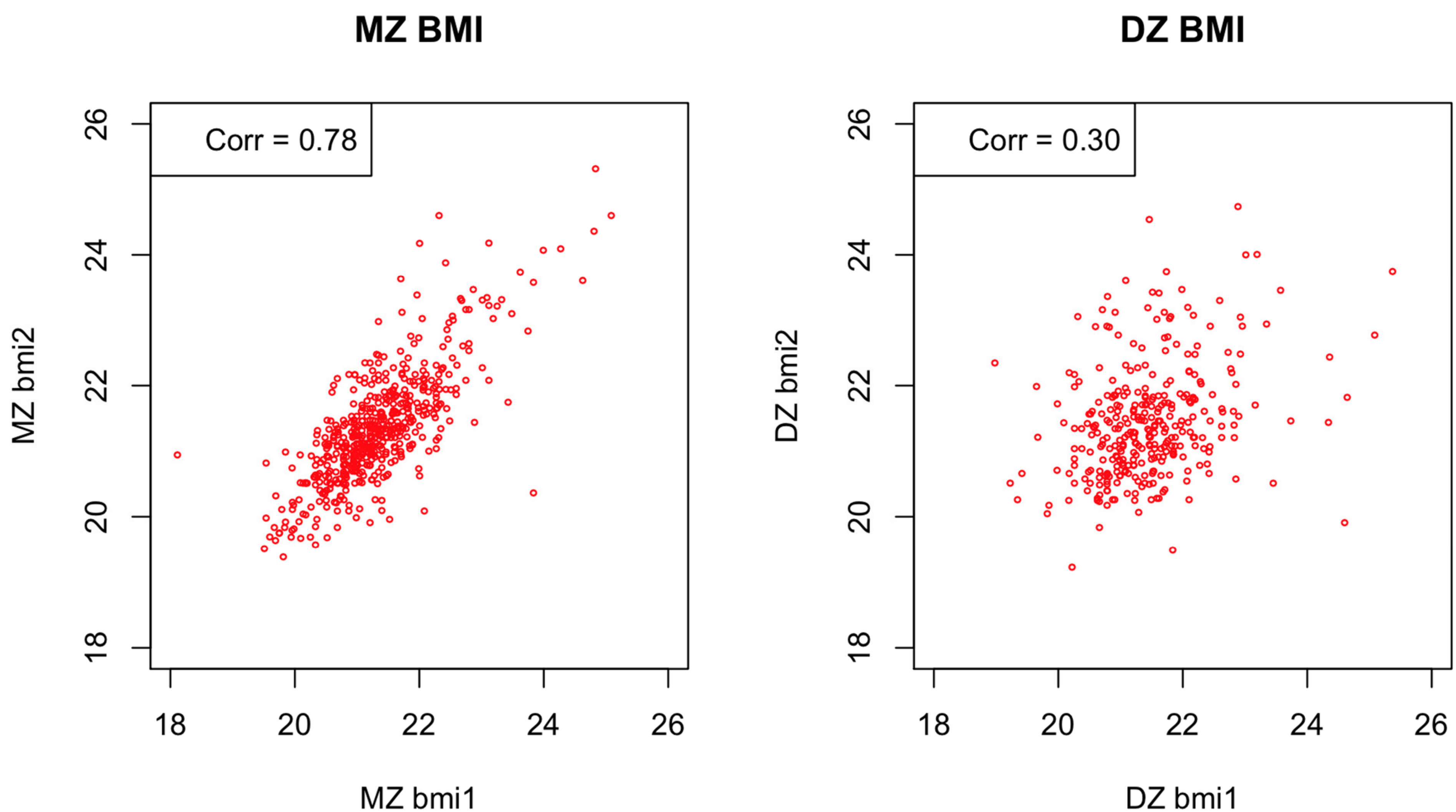
$$a^2 = 2(r_{MZ} - r_{DZ})$$

$$c^2 = 2r_{DZ} - r_{MZ}$$

$$e^2 = 1 - r_{MZ}$$

Polderman et al. 2015, *Nature Genetics*





MZ BMI
Corr = 0.78
MZ bmi2
MZ bmi1
18
20
22
24
26
DZ BMI
Corr = 0.30
DZ bmi2
DZ bmi1

What about “dominance”* effects?

$$V_P = a^2 + d^2 + c^2 + e^2$$

* Dominance defined statistically as individuals being more similar on the basis of genetic overlap alone than would be predicted by a linear model – i.e., **any** non-linear genotype “dosage” effects

ACE **or** ADE

$$\mathrm{Cov(mz)} = a^2 + c^2 \quad \textbf{or} \quad a^2 + d^2$$

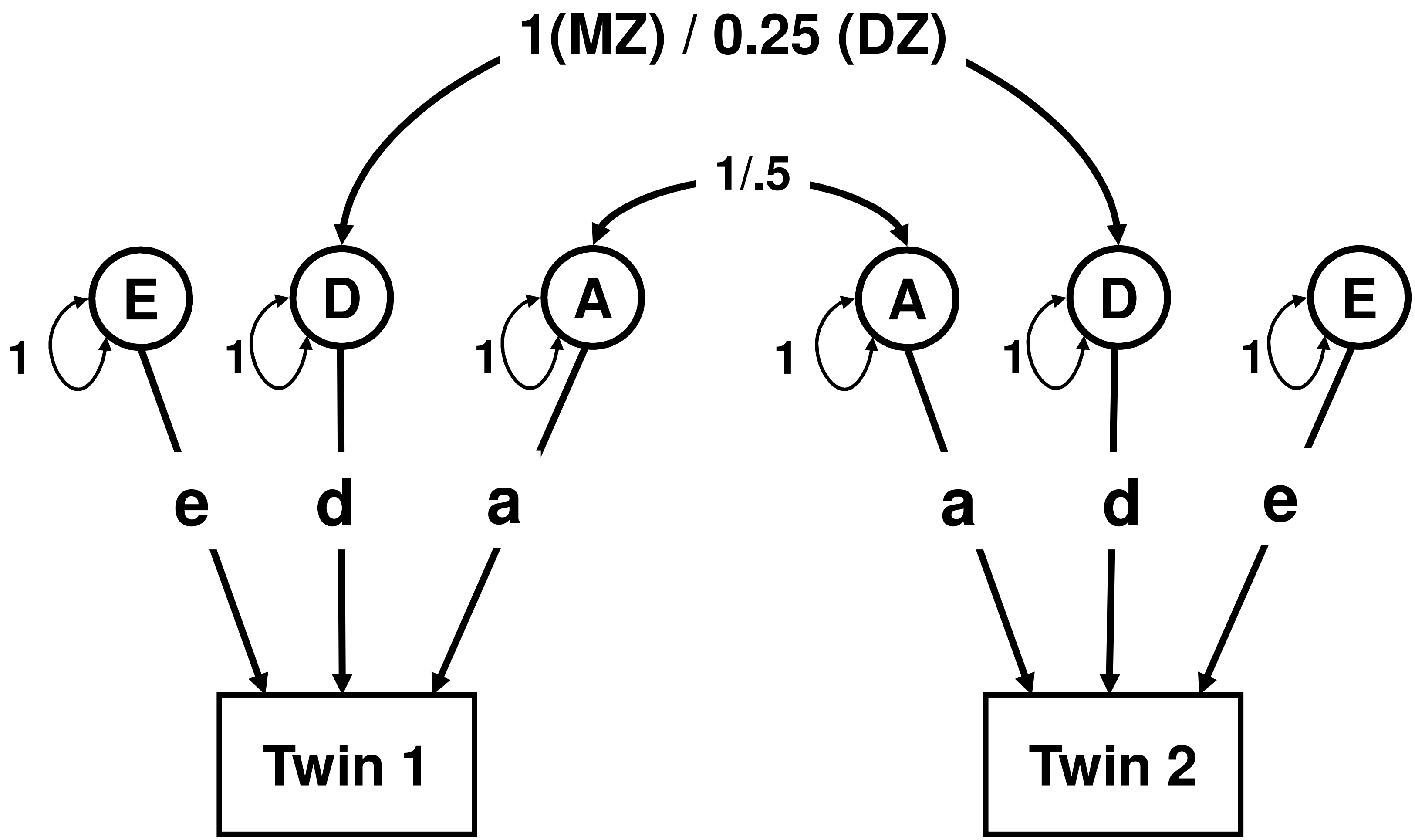
$$\mathrm{Cov(dz)} = \tfrac{1}{2} a^2 + c^2 \quad \textbf{or} \quad \tfrac{1}{2} a^2 + \tfrac{1}{4} d^2$$

$$V_P = a^2 + c^2 + e^2 \quad \textbf{or} \quad a^2 + d^2 + e^2$$

3 unknown parameters (a, c, e or a, d, e), and only **3** distinctive predicted statistics:

Cov MZ, Cov DZ, Vp)

this model is **just identified**



1(MZ) / 0.25 (DZ)
1/.5
E
D
A
A
D
E
1
1
1
1
1
1
e
d
a
a
d
e
Twin 1
Twin 2

Twin Correlations → Sources of Variance

rMZ > rDZ	A
rMZ = 2 rDZ	only A (no C,D)
rMZ = rDZ	only C (no A,D)
rMZ < 2 rDZ	A & C
rMZ > 2 rDZ	A & D

Classical Twin Study Assumptions

- Equal means/variances in Twin 1 and Twin 2
- Equal means/variances in MZ and DZ twins
- Random Mating
- Equal Environments of MZ and DZ pairs
- No GE Correlation
- No G x E Interaction
- No Sex Limitation