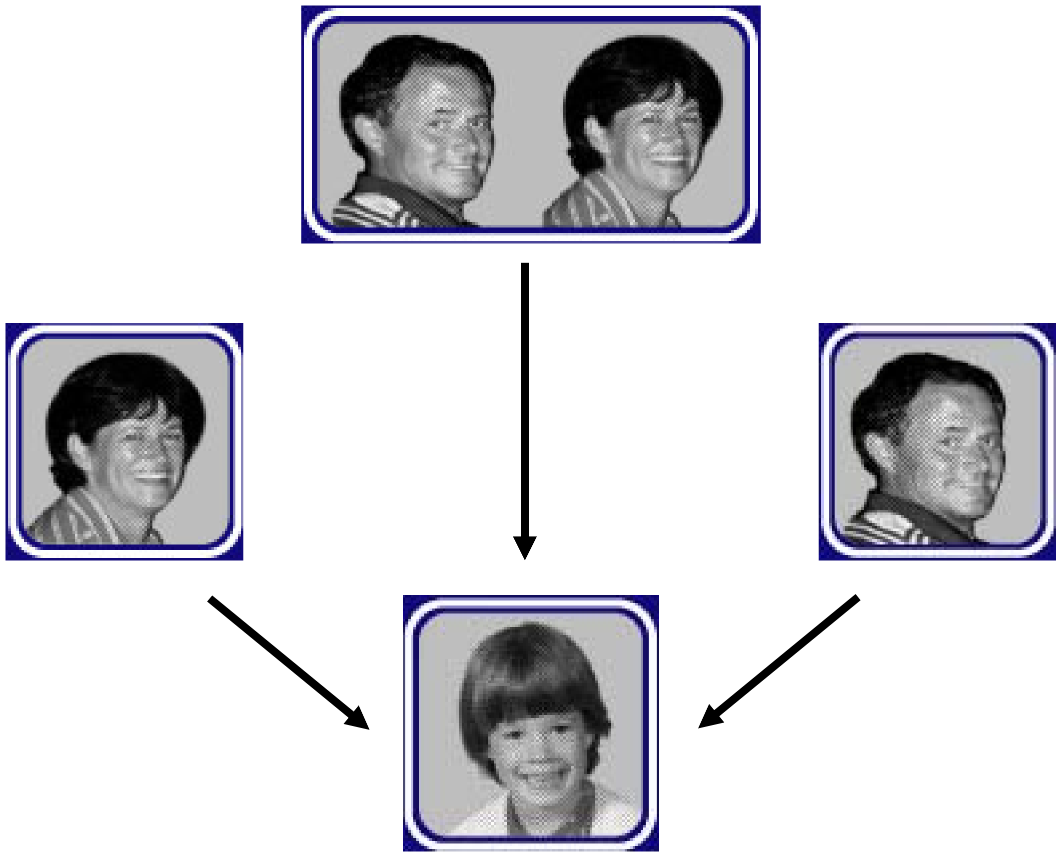
\nathan\RaterBias

Observer Ratings: Dealing with rater bias



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Multiple raters

Rather than measure individual's phenotypes directly, we often rely on observer ratings

Example Parent & teacher ratings of children

Problem How do you handle bias which is a tendency of a rater to over or underestimate scores consistently

Response Bias - stereotyping, different normative standards, response style

Projection Bias - psychopathology of the parent influences his/her judgement of the behavior of the child e.g. several studies suggest that depression in mothers may lead to overestimating their children's symptoms

Rater bias can inflate C

How to disentangle child's phenotype from rater bias?

Example of multiple rater data: Problem behavior

Data from Netherlands Twin Registry

Questionnaires

ages 3, 5, 7, 10 & 12
- maternal & paternal ratings

ages 7, 10, and 12
- teacher ratings

ages 12, 14, 16
- self report

Internalizing - Anxious/Depressed, Somatic Complaints & Withdrawn subscales

Externalizing - Aggressive & Rule Breaking subscales.

Mother's & father's ratings of aggressive behaviour in boys at 12 yrs

Multiple raters

Analysis of parent / teacher ratings depends on assumptions YOU make!

1. Biometric model – agnostic i.e. treat data as assessing different phenotypes. Good if mothers and fathers rate / observe kids in different situations!

2. Psychometric model – assume there is a common phenotype assessed by both parents + specific effects uniquely observed by each each parent

3. Rater bias model – Ratings of a child’s phenotype modeled as a function of child’s phenotype + bias introduced by the rater

1. Biometric model

Model mother's and father's ratings agnostically

The mother's and father's ratings may be correlated but for unspecified reasons.

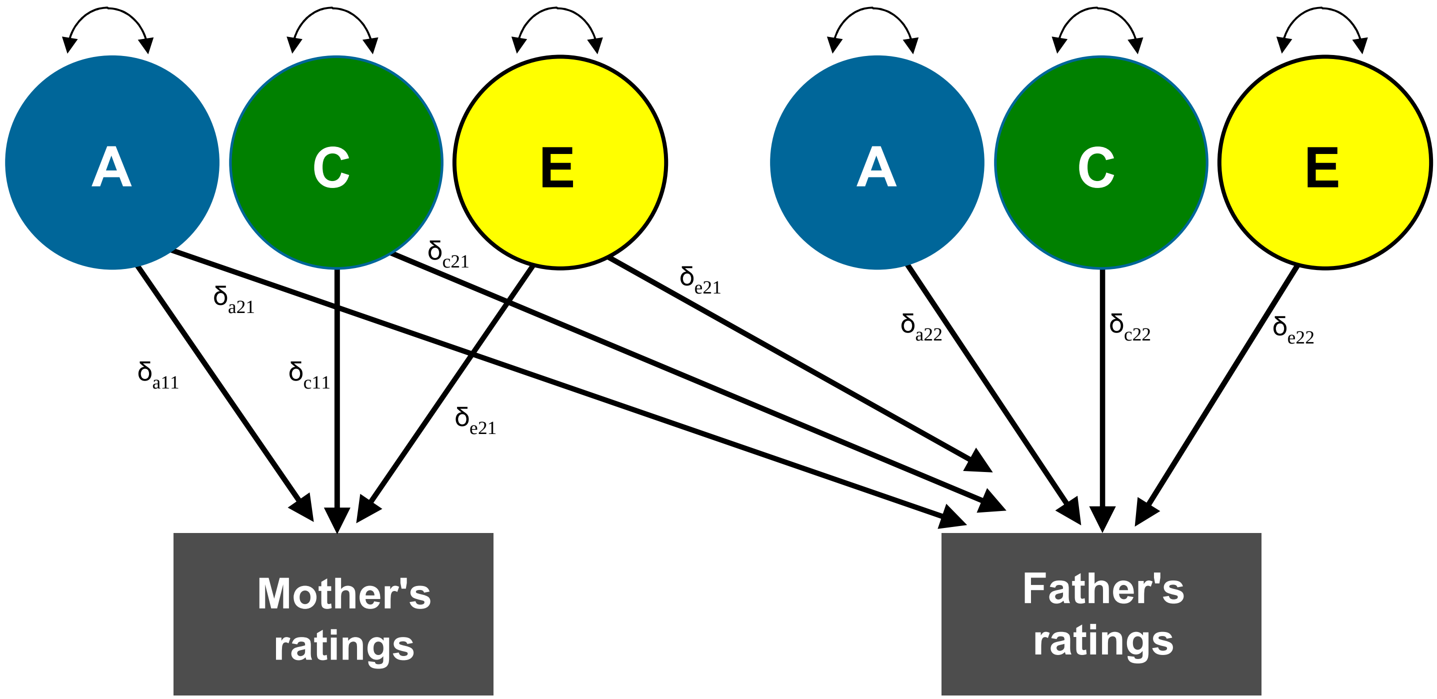
Mothers' and fathers' ratings are assessing different phenotypes.

- ratings are taken across different situations
- mums and dad don't have a common understanding of the behavioural description

In this case we would simply model the ratings in terms of a standard bivariate analysis

1. Biometric model

Treat parental ratings as separate phenotypes



The Mx script

Script Cholesky1.mx

Data: TAD.dat

Task Fix error & calculate standardized variance components

Variance-covariance matrices in Mx

```
MZ      (A+C+E | A+C_
             A+C | A+C+E ) ;

DZ      (A+C+E | H@A+C_
        H@A+C | A+C+E ) ;
```

Polychoric correlations

	1.	2.	3.	4.
1. Mother T1	1.00			
2. Father T1	.72	1.00		
3. Mother T2	.71	.57	1.00	
4. Father T2	.57	.71	.73	1.00

Variance Decomposition

	Mother's ratings	Father's ratings
A	.59	.58
C	.23	.28
E	.18	.14

-2LL	df
3243.16	1816

2. Psychometric Model

More restrictive assumptions

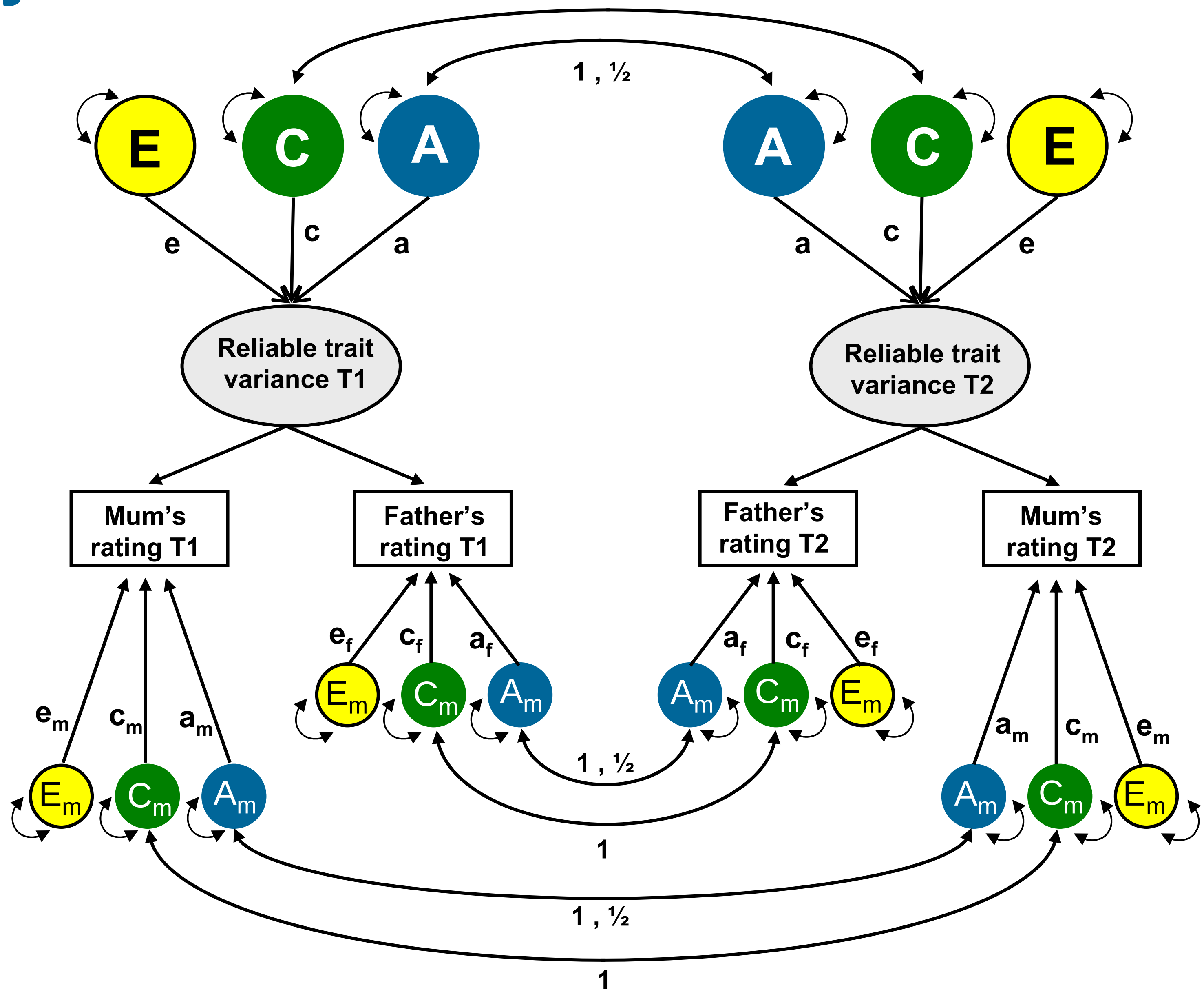
There is a common phenotype which is being assessed by mothers and fathers

AND

There is a component of the each parent's ratings which assesses an independent aspect of the children's behaviour.

Mother and father ratings would therefore correlate because they are making assessments based on shared observations and shared understanding of the behavioural descriptions

2. Psychometric Model[1]



Total variance for an individual

$$\begin{pmatrix} MRT1 \\ FRT1 \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \end{pmatrix} \mathbf{x} \left((a) \times (\mathbf{A}) + (c) \times (\mathbf{C}) + (e) \times (\mathbf{E}) \right) +$$

$$\begin{pmatrix} a_m & 0 \\ 0 & a_f \end{pmatrix} \mathbf{x} \begin{pmatrix} A_m \\ A_f \end{pmatrix} + \begin{pmatrix} c_m & 0 \\ 0 & c_f \end{pmatrix} \mathbf{x} \begin{pmatrix} C_m \\ C_f \end{pmatrix} + \begin{pmatrix} e_m & 0 \\ 0 & e_f \end{pmatrix} \mathbf{x} \begin{pmatrix} E_m \\ E_f \end{pmatrix}$$

The Mx script

Script Psychometric1.mx

Data TAD.dat

Task Fix error & note variance components

Variance-covariance matrices in Mx

```
MZ      (G+S+F | G+S_
             G+S  | G+S+F)  +     L * (A+C+E | A+C_
                                          A+C | A+C+E ) * L' ;

DZ      (G+S+F | H@G+S_
        H@G+S  | G+S+F)  +     L * (A+C+E | H@A+C_
                                       H@A+C | A+C+E ) * L' ;
```

Variance decomposition

	Mother's ratings	Father's ratings
	Latent factor	
A	.42	.39
C	.14	.13
E	.03	.03
	Residuals	
A_{res}	.17	.19
C_{res}	.09	.14
E_{res}	.14	.11

-2LL	df
3243.16	1816

Rater Bias Model

Even more restrictive

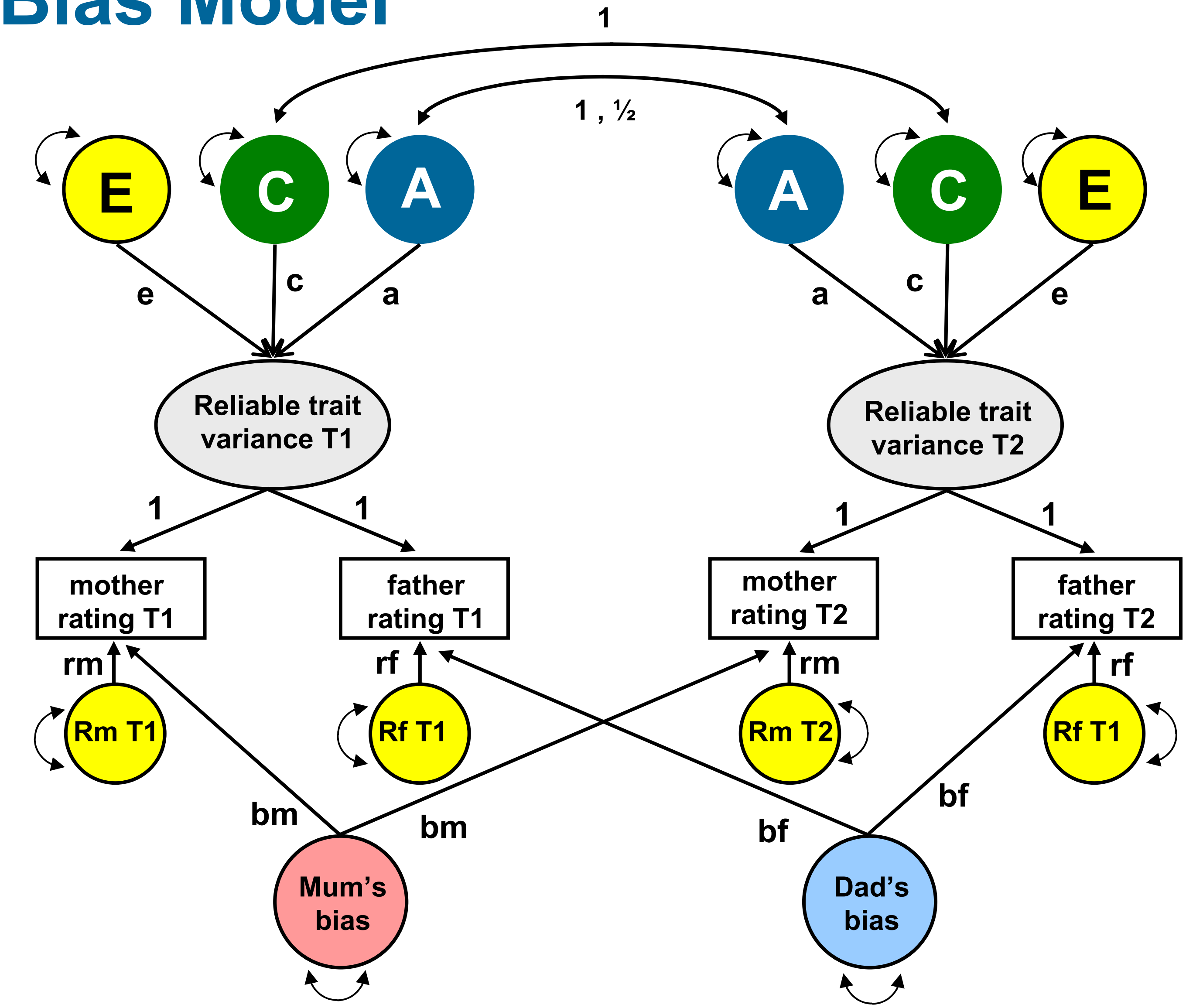
Assumes that there is a common phenotype which is being assessed by mothers and fathers

Phenotype is again a function of three latent factors underlying the ratings of both mothers *and* fathers: a genetic factor (A), a shared environmental factor (C), and a non-shared environmental factor (E).

Rater-specific factors are modeled: a maternal rater bias factor, a paternal rater bias factor, & residual (unreliability) factors affecting each rating.

The influence of the common factors is assumed to be independent of the maternal and paternal rater bias and unreliability factors.

Rater Bias Model



Total variance for an individual

$$\begin{pmatrix} MRT1 \\ FRT1 \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \end{pmatrix} \times \left((a) \times (\mathbf{A}) + (c) \times (\mathbf{C}) + (e) \times (\mathbf{E}) \right) +$$

$$\begin{pmatrix} bm & 0 \\ 0 & bf \end{pmatrix} \times \begin{pmatrix} Bm \\ Bf \end{pmatrix} + \begin{pmatrix} rm & 0 \\ 0 & rf \end{pmatrix} \times \begin{pmatrix} Rm \\ Rf \end{pmatrix}$$

The Mx script

Script	Raterbias1.mx
Data	TAD.dat
Task	Fix error & note variance components

Variance-covariance matrices in Mx

MZ

```
(S+F | S_
 S  | S+F)  +        L * (A+C+E | A+C_
                             A+C | A+C+E ) * L' ;
```

DZ

```
(S+F | S_
 S  | S+F)  +        L * (A+C+E | H@A+C_
                         H@A+C | A+C+E ) * L' ;
```

Variance decomposition

	Mother's ratings	Father's ratings
	Latent factor	
A	.53	.51
C	.05	.05
E	.00	.00
	Residuals	
Rater Bias	.23	.29
E_{res}	.19	.15

-2LL	df
3257.37	1818

Results: Model comparison

	-2LL	df	BIC
Cholesky	3243.16	1816	-1171.22
Psychometric	3243.16	1816	-1171.22
Rater Bias	3257.37	1818	-1167.19

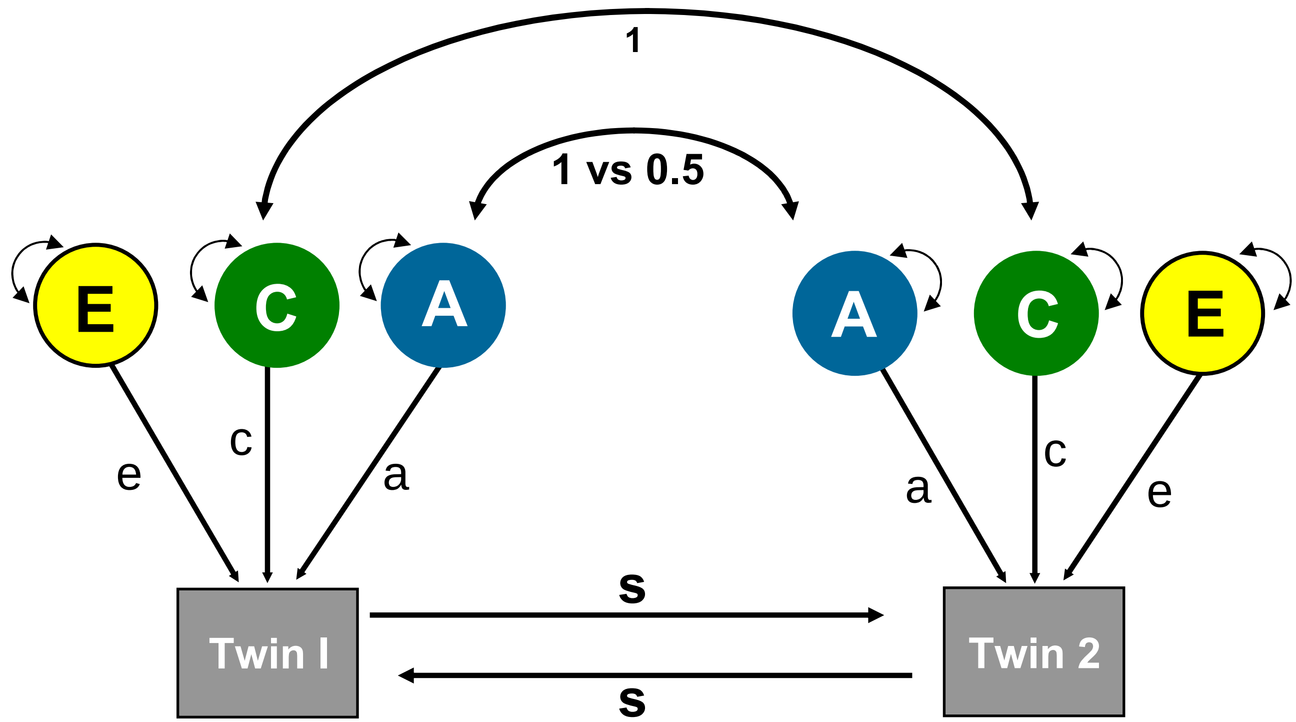
Conclusions

1. Rater bias, if not controlled for, ends up in shared environment

2. Besides rater bias, rater specific views are a source of rater disagreement > multiple rater design valuable

3. Psychometric model provides most information on sources of rater disagreement

Sibling Interaction / Rater Contrast



Path *s* implies an interaction between phenotypes

Sibling Interaction

Social Interaction between siblings (Carey, 1986; Eaves, 1976)

Behaviour of one child has a certain effect on the behavior of his or her co-twin:

- Cooperation - behavior in one twin leads to like-wise behavior in the co-twin
- Competition - increased behavior in one twin leads to decreased behavior in co-twin

Rater Contrast

Behavioural judgment / rating of one child of a twin pair is NOT independent of the rating of the other child of the twin pair.

Rate compares the twins behaviour against one another

The behaviour of the one child becomes a ‘standard’ by the which the behaviour of the other co-twin is judged / rated.

Parents may either stress the similarities or differences between the children

Effects of rater contrast

Phenotypic cooperation / positive rater contrast

Mimics the effects of shared environment

Increases the variance of more closely related individuals

(var MZ >> var DZ)

Phenotypic competition / negative rater contrast

Mimics the effects of non-additive genetic variance

Increases the variance of more closely related individuals the least

(var MZ << var DZ)

Numerical Illustration

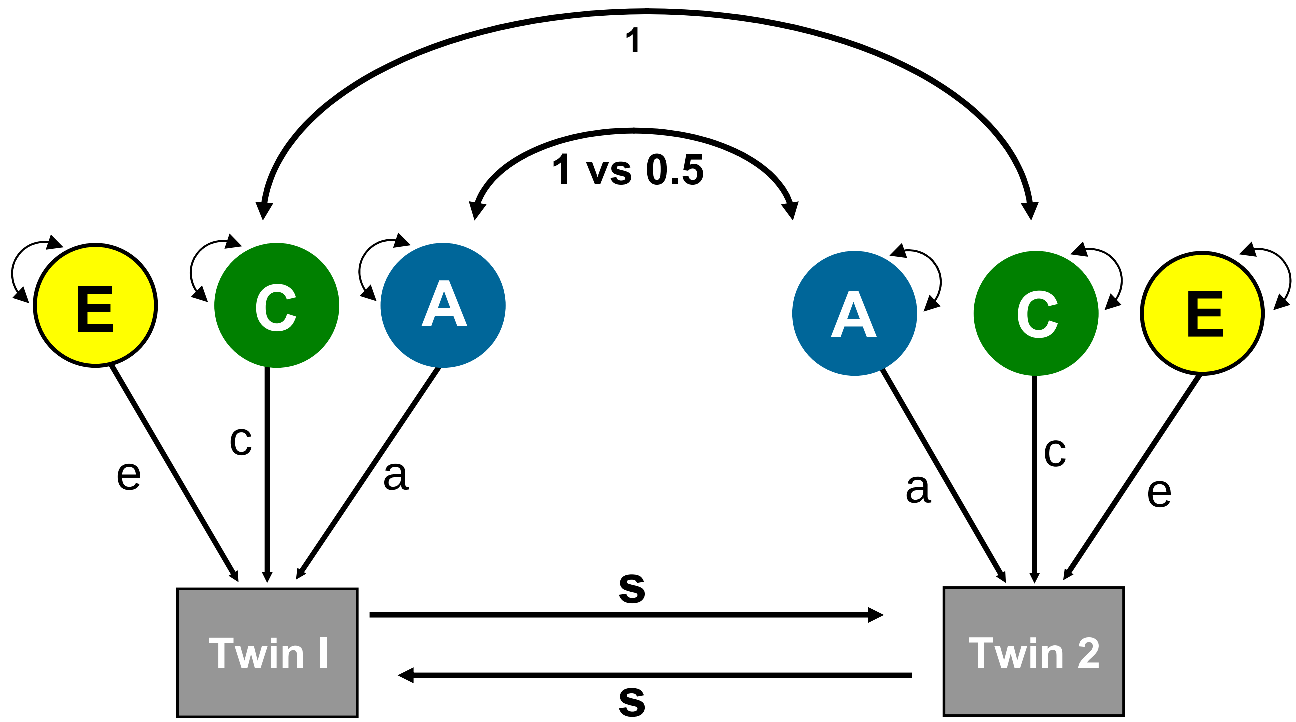
a^2=0.5, d^2=0, c^2=0, e^5=0.5

S = 0; cooperation >> s = 0.5; competition >> s = -0.5

	MZ			DZ			Unrelated		
	Var	Cov	r	Var	Cov	r	Var	Cov	r
None	1	.50	.50	1	.25	.25	1	0	0
Cooperation	3.11	2.89	.93	2.67	2.33	.88	2.22	1.78	.80
Competition	1.33	.44	.33	1.78	-.67	-.38	2.22	-1.78	-.80

Social interactions cause the variance of the phenotype to depend on the degree of relationship of the social actors

Contrast Effect



$$P_1 = sP_2 + aA_1 + cC_1 + eE_1 \qquad P_2 = sP_1 + aA_2 + cC_2 + eE$$

Contrast Effect

$$\begin{pmatrix} P_1 \\ P_2 \end{pmatrix} = \begin{pmatrix} 0 & s \\ s & 0 \end{pmatrix} \begin{pmatrix} P_1 \\ P_2 \end{pmatrix} + \begin{pmatrix} a & c & e & 0 & 0 & 0 \\ 0 & 0 & 0 & a & c & e \end{pmatrix} \begin{pmatrix} A_1 \\ C_1 \\ E_1 \\ A_2 \\ C_2 \\ E_2 \end{pmatrix}$$

P1 = sP2 + aA1 + cC1 + eE1

P2 = sP1 + aA2 + cC2 + eE2

Matrix expression

$$y = By + Gx$$

$$y - By = Gx$$

$$(I-B)\, y = Gx$$

$$(I-B)^{-1} (I-B)y = (I-B)^{-1}\, Gx$$

$$y = (I-B)^{-1}\, Gx$$

Mx

```
Begin Matrices;
B full 2 2                    ! constrast effect
End Matrices;

Begin Algebra;
P = (I-B)~;
End Algebra
```

Variance – Covariance Matrix

MZs

P & (A + C + E | A + C_

A + C | A + C + E) /

DZs

P & (A + C + E | H@A + C_

H@A + C | A + C + E) /

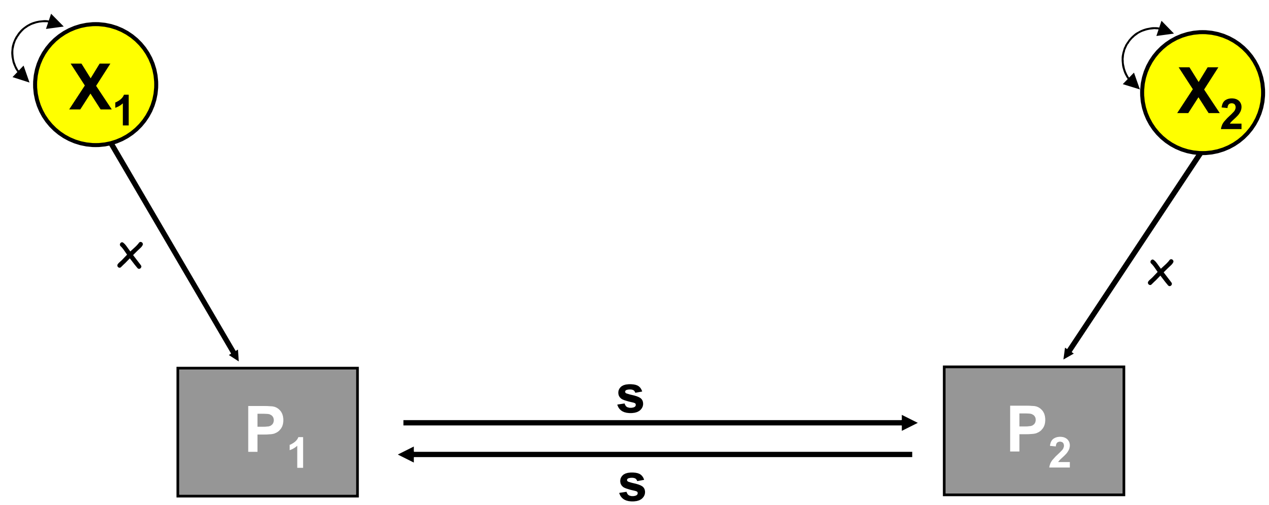
The Mx script

Script: Contrast.mx

Data: TAD.dat

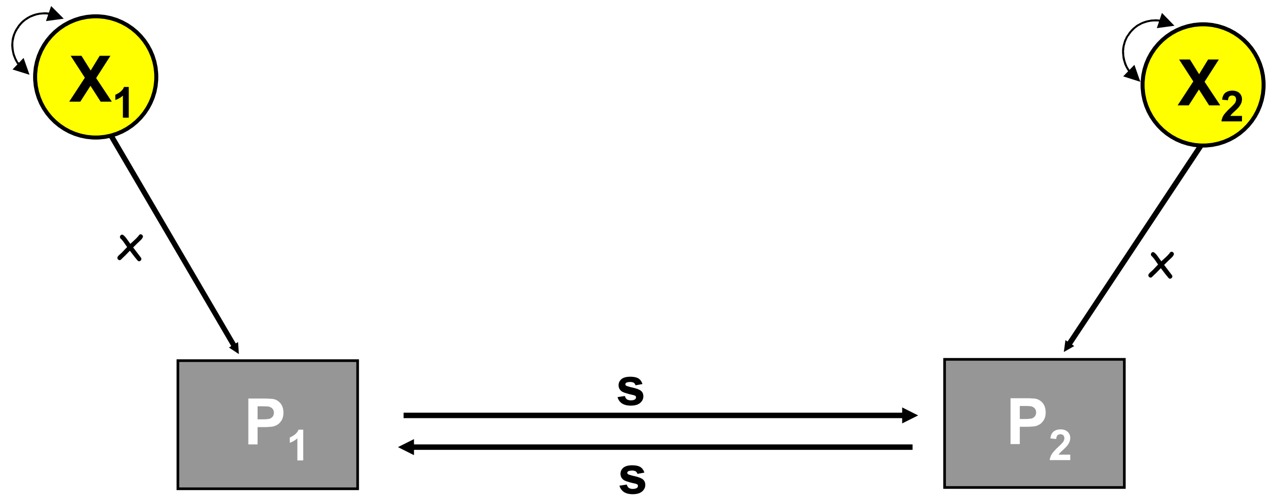
Consequences for variation & covariation

Basic model



$P_1 = sP_2 + xX_1$ $\qquad$ $P_2 = sP_1 + xX_2$

In matrices



$$\begin{bmatrix} P_1 \\ P_2 \end{bmatrix} = \begin{bmatrix} 0 & s \\ s & 0 \end{bmatrix} \begin{bmatrix} P_1 \\ P_2 \end{bmatrix} + \begin{bmatrix} x & 0 \\ 0 & x \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix}$$

$$\mathbf{y = By + Gx}$$

Matrix expression

$$y = By + Gx$$

$$y - By = Gx$$

$$(I-B)\, y = Gx$$

$$(I-B)^{-1} (I-B)y = (I-B)^{-1} Gx$$

$$y = (I-B)^{-1} Gx$$

Matrix expression

y = (I-B)$^{-1}$ Gx

where (I-B) is

$$\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} - \begin{pmatrix} 0 & s \\ s & 0 \end{pmatrix} = \begin{pmatrix} 1 & -s \\ -s & 1 \end{pmatrix}$$

Which has determinant: (1*1-s*s) = 1-s^2 , so (I-B)$^{-1}$ is

$$\frac{1}{1-s^2} @ \begin{pmatrix} 1 & s \\ s & 1 \end{pmatrix}$$

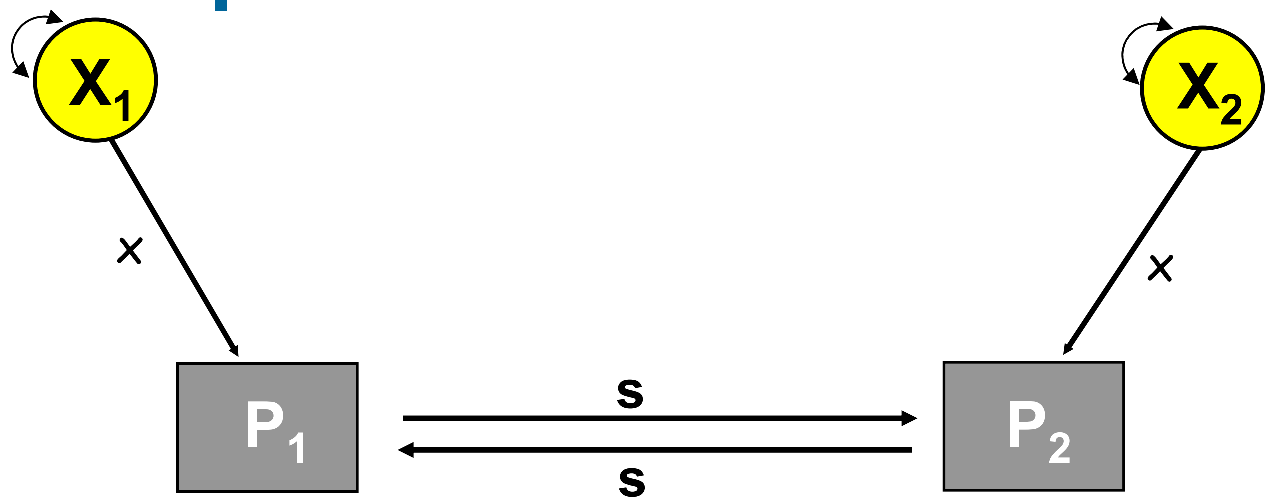
Matrix expression

Variance-covariance matrix for P1 and P2

$$\Sigma\{yy'\} = \{(I-B)^{-1} Gx\}\{(I-B)^{-1} Gx\}'$$
$$= (I-B)^{-1} G\, \Sigma\{xx'\}\, G' (I-B)^{-1\prime}$$

where $\Sigma\{xx'\}$ is covariance matrix of the x variables

Matrix expression



We want to standardize variables X_1 and X_2 to have unit variance and correlation r, therefore

$$\Sigma\ \{xx'\} = \begin{pmatrix} 1 & r \\ r & 1 \end{pmatrix}$$

To compute the covariance matrix recall that…

$$\mathbf{G} = \begin{pmatrix} x & 0 \\ 0 & x \end{pmatrix}$$

$$\mathbf{(I\text{-}B)\text{-}1} = \frac{1}{1-s^2} \mathbf{@} \begin{pmatrix} 1 & s \\ s & 1 \end{pmatrix}$$

$$\mathbf{\Sigma\ \{xx'\}} = \begin{pmatrix} 1 & r \\ r & 1 \end{pmatrix}$$

To compute the covariance matrix recall that…

$$\Sigma\{yy'\} = \frac{x^2}{(1-s^2)^2} @ \begin{pmatrix} 1 + 2sr + s^2 & r+2s + rs^2 \\ r+2s + rs^2 & 1 + 2sr + s^2 \end{pmatrix}$$

The effects of sibling interaction on variance and covariance components between pairs of relatives

Source	Variance	Covariance
Additive genetic	$\omega(1+2sra+s2)a2$	$\omega(r_a+2s+r_a s^2)a^2$
Dominance	$\omega(1+2sr_d+s^2)d^2$	$\omega(r_d+2s+r_d s^2)d^2$
Shared env	$\omega(1+2sr_c+s^2)c^2$	$\omega(r_c+2s+r_c s^2)c^2$
Non-shared env	$\omega(1+2sr_e+s^2)e^2$	$\omega(r_e+2s+r_e s^2)e^2$

where ω = scalar $1/(1-s^2)^2$

Rater Bias

Influence shared environmental variance!

Independent of zygosity

Response Bias

- stereotyping, different normative standards, response style

Projection Bias

- Psychopathology of the parent influences his/her judgement of the behavior of the child e.g. several studies suggest that depression in mothers may lead to overestimating their children's symptomology

Multiple raters

Rather than measure individual's phenotypes directly, we rely on observer ratings.

Example: Parent & teacher ratings of children's behaviour

Problem: How to disentangle child's phenotype from rater bias?

Rater bias can influence C (independent of zygosity)

Parental Disagreement

Rater bias / error (e.g. response style, different normative standards)

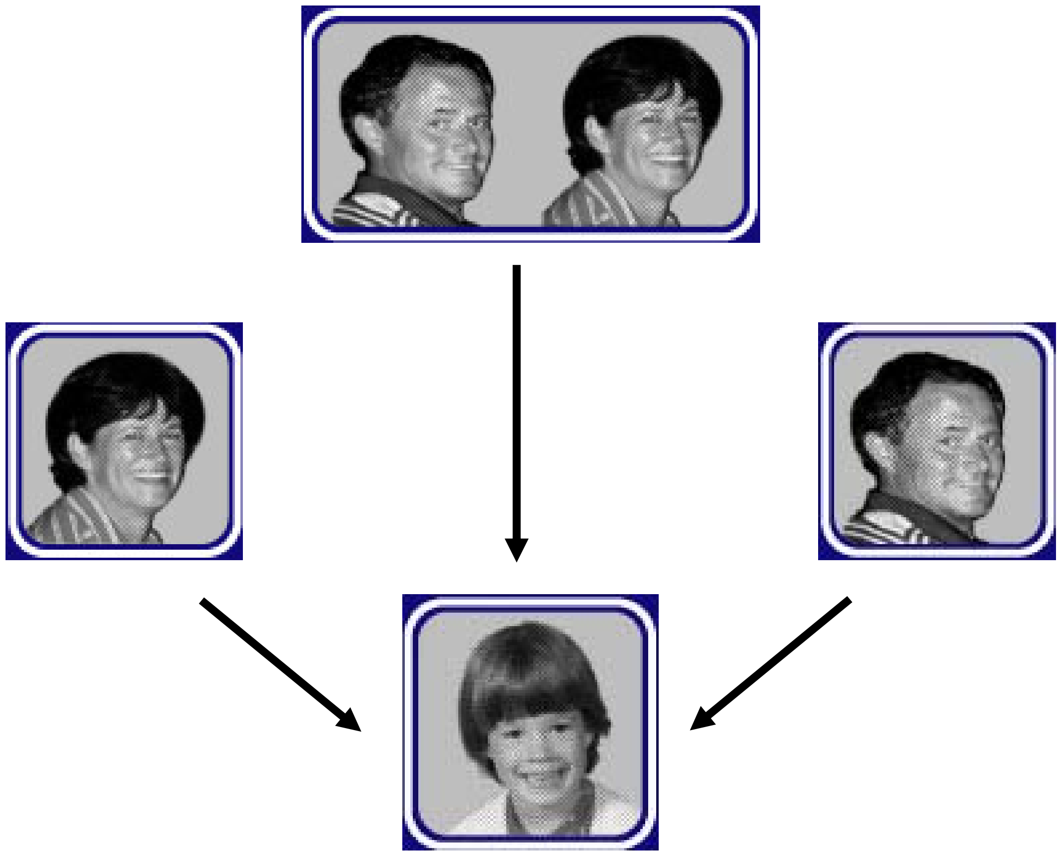
Mother or father provide specific information

- distinct situations, parent-specific relation with child

Rater Bias

Parental ratings

Agreements versus Disagreements



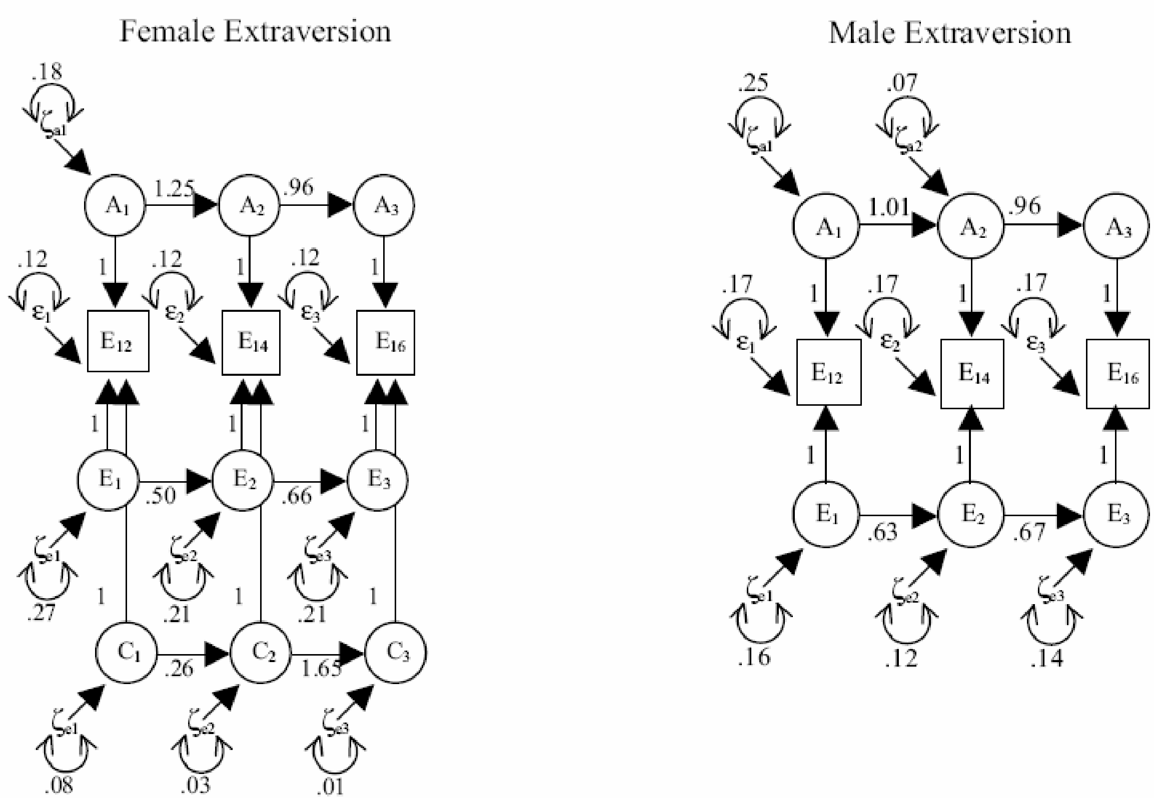


Figure 2

Best fitting genetic simplex model for female and male extraversion.

E_{12-16} = extraversion 12–16 yrs

A_{1-3}, E_{1-3}, C_{1-3} = additive genetic and nonshared and shared environmental effects

ζ_{a1-3}, ζ_{e1-3}, ζ_{c1-3} = additive genetic innovations, nonshared and shared environmental innovations

ε_{1-3} = error parameters 12–16 yrs

double/single headed arrows = variance components/path coefficients

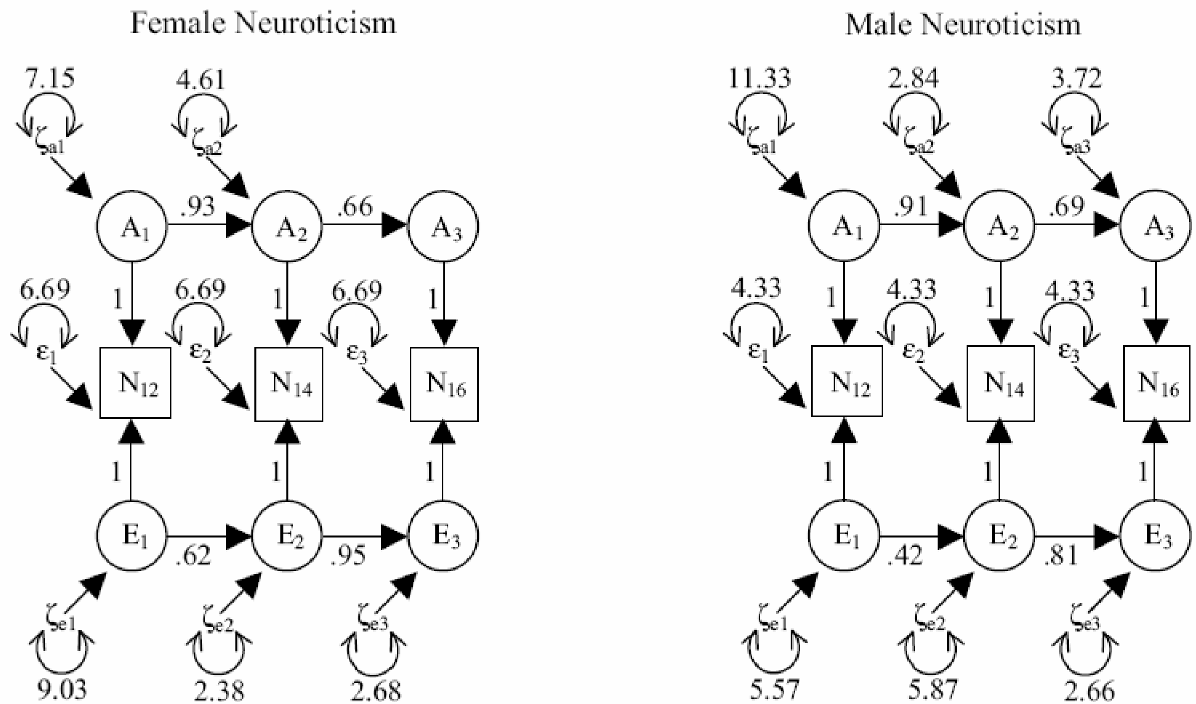


Figure 3

Best fitting genetic simplex model for female and male neuroticism.

N_{12-16} = neuroticism 12–16 yrs

A_{1-3}, E_{1-3} = additive genetic and nonshared environmental effects

ζ_{a1-3}, ζ_{e1-3} = additive genetic innovations and nonshared environmental innovations

ε_{1-3} = error parameters 12–16 yrs

double/single headed arrows = variance components/path coefficients