# Extending Simplex model to model Ph →E transmission

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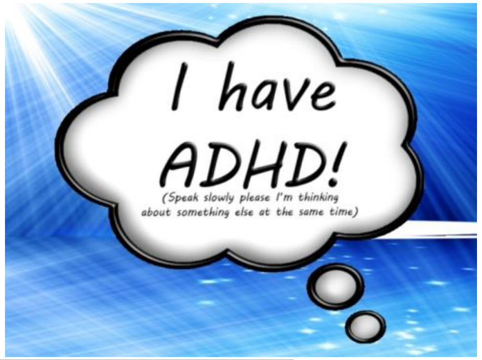
# Nature versus Nurture
## Role GEcov in Psychopathology




### ADHD diagnosis

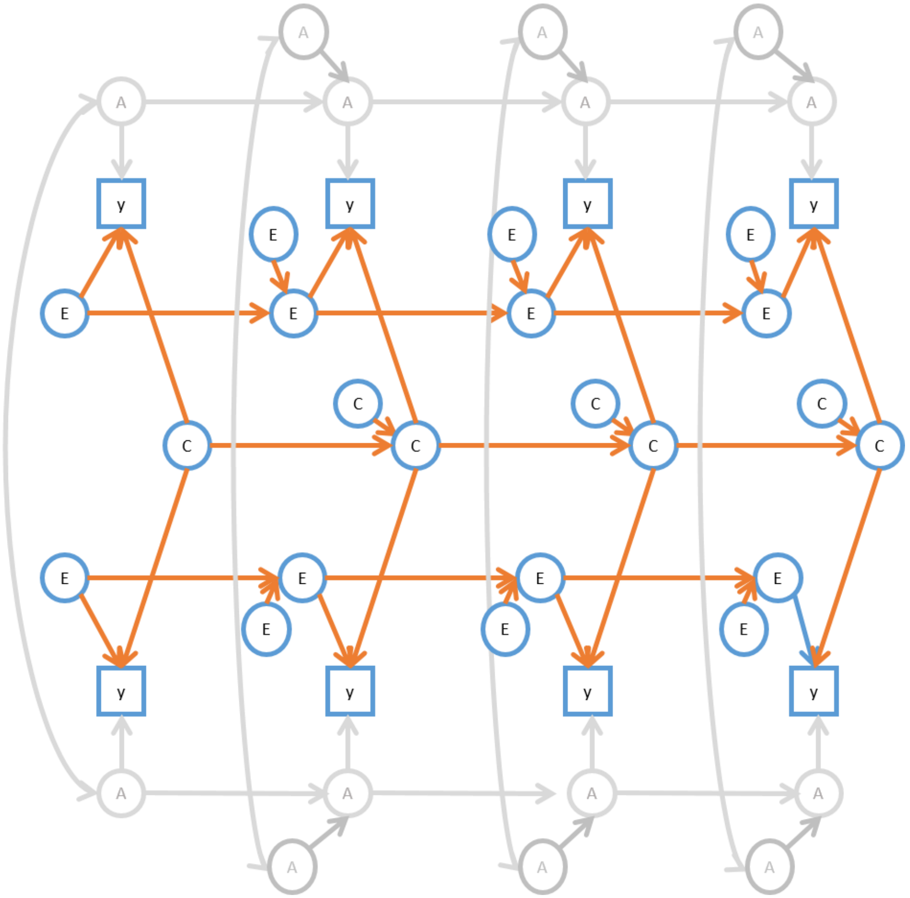
**GE covariance:** Genotypic control over environmental exposures

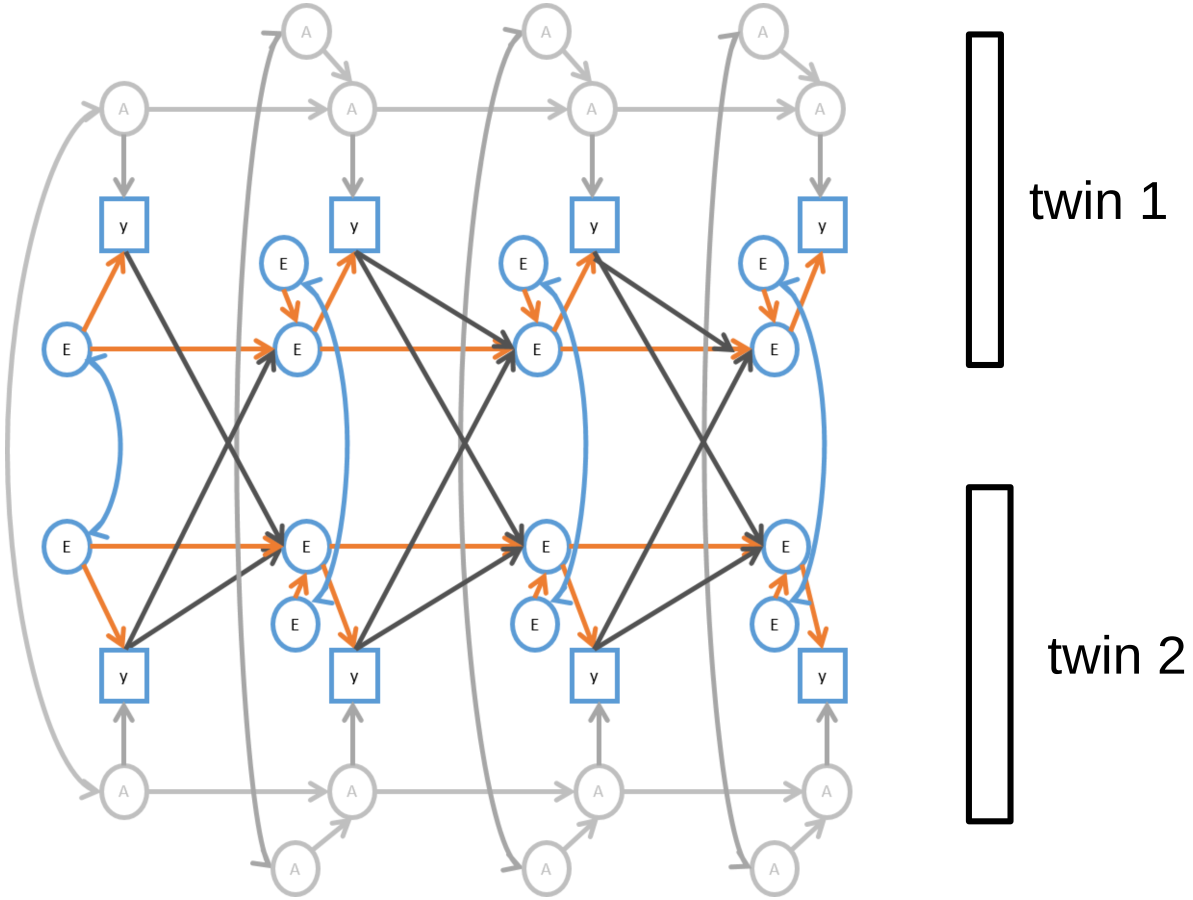
- ❑ **Evocative**: Behavior of individual evokes reaction from environment consistent with genotype
- ❑ **Do people with ADHD evoke different behavior in others?**
  - ➢ **ADHD child :** Intrudes on games more often
  - ➢ **ADHD adolescent :** Has more frequent school disciplinary actions
  - ➢ **ADHD adult**: more often has work conflicts
- ❑ **Active**: Individuals actively seek out environments consistent with their phenotype (e.g. Niche Picking)
- ❑ **Do people diagnosed with ADHD seek more risky environments**
  - ➢ **ADHD child :** climb more trees
  - ➢ **ADHD adolescent :** does more binge drinking and has casual sex more often
  - ➢ **ADHD adults**: has more driving violations, uses more drugs

# Translate path diagram into matrices

## ACE SIMPLEX    Ph->E SIMPLEX

Competing models





# OBJECTIVE: model the observed covariance matrix

S = 4 observed variables for twin 1, 4 for twin 2, thus 8 x 8

twin 1 twin 2

t = 1 t = 2 t = 3 t = 4 t = 1 t = 2 t = 3 t = 4

varP11

covP11P12 varP12

covP11P13 covP12P13 varP13

covP11P14 covP12P14 covP13P14 varP14

covP11P21 covP12P21 covP13P21 covP14P21 varP21

covP11P22 covP12P22 covP13P22 covP14P22 covP21P22 varP22

covP11P23 covP12P23 covP13P23 covP14P23 covP21P23 covP22P23

varP23

covP11P24 covP12P24 covP13P24 covP14P24 covP21P24 covP22P23

covP23P24 varP24

# Matrices used in Model

$$\Sigma = \Lambda(I-B)\text{-}\Psi\ (I-B)\ \text{-t}\ \Lambda\ \text{t} + \Theta$$

**ne = number of latent variables in the model**
**ny = number of observed variables**

∑ = Sigma = Expected covariance matrix observed variables y
= ny x ny
Λ = Lambda = Factor Loading Matrix = ny x ne
B = Beta = Matrix with regression coefficients between latent variables
= ne x ne
ϴ = Theta = Matrix with residuals = ny x ny
Ψ = Psy = Matrix with variances and covariance between latent variables = ne x ne

# Dimensions of matrices for 4 time points in normal simplex specification

∑MZ = Λ * solve(I- B) * ΨMZ * t(solve(I- B)) * t(Λ) + ϴMZ

∑DZ = Λ * solve(I- B) * ΨDZ * t(solve(I- B)) * t(Λ) + ϴDZ

- **Twins = 2**
- **Time points = 4**
- **ny = 4 time points for 2 twins = 8**
- **ne = latent variables A, C, E at each timepoint for each twin: 3**

| | | | |
|---|---|---|---|
| ∑ = Sigma | = | 8 x 8 | = ny x ny |
| Λ = Lambda | = | 8 x 24 | = ny x ne |
| B = Beta | = | 24 x 24 | = ne x ne |
| Ψ = Psy | = | 24 x 24 | = ne x ne |
| ϴ = Theta | = | 8 x 8 | = ny x ny |

Does not allow us to regress E on P

# PROBLEM: Regression from Observed to Latent variable

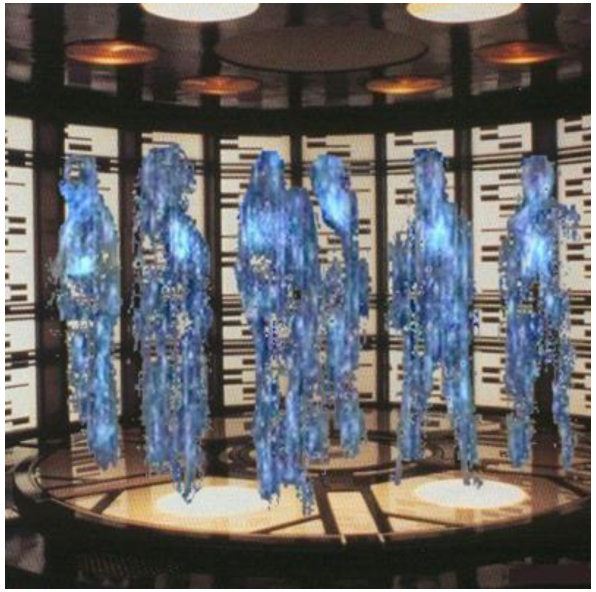
**Normally**

PSY matrix only has latent variables.
In case of twin modeling: the variables A, C, and E ➔ 24 x 24

**Problem**

Impossible to regress from observed to latent
For that we need all variables in Ψ, thus P, A, C, and E.

**Solution:** Change dimensions of matrices
Beam observed variables into Ψ space



# Dimensions of matrices for 4 time points in **our** simplex specification

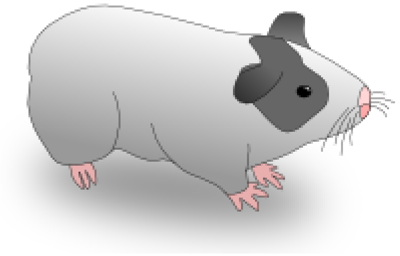
∑MZ = Λ * solve(I- B) * ΨMZ * t(solve(I- B)) * t(Λ) + ϴMZ
∑DZ = Λ * solve(I- B) * ΨDZ * t(solve(I- B)) * t(Λ) + ϴDZ

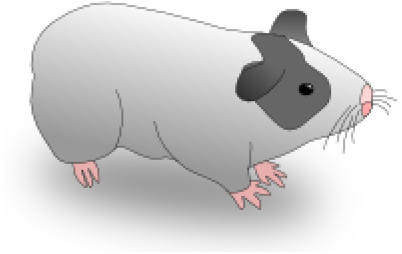
- **Twins = 2**
- **Time points = 4**
- **ny = 4 time points for 2 twins = 8**
- **ne = latent variables A, C, E plus observed P at each time point for each twin: 4 x 4 x 2 = 32**

| | | | |
|---|---|---|---|
| ∑ = Sigma | = | 8 x 8 | = ny x ny |
| Λ = Lambda | = | 8 x **32** | = ny x ne |
| B = Beta | = | 32 x **32** | = ne x ne |
| Ψ = Psy | = | 32 x **32** | = ne x ne |
| ϴ = Theta | = | 8 x 8 | = ny x ny |

SIMPLEX
matrix explanation

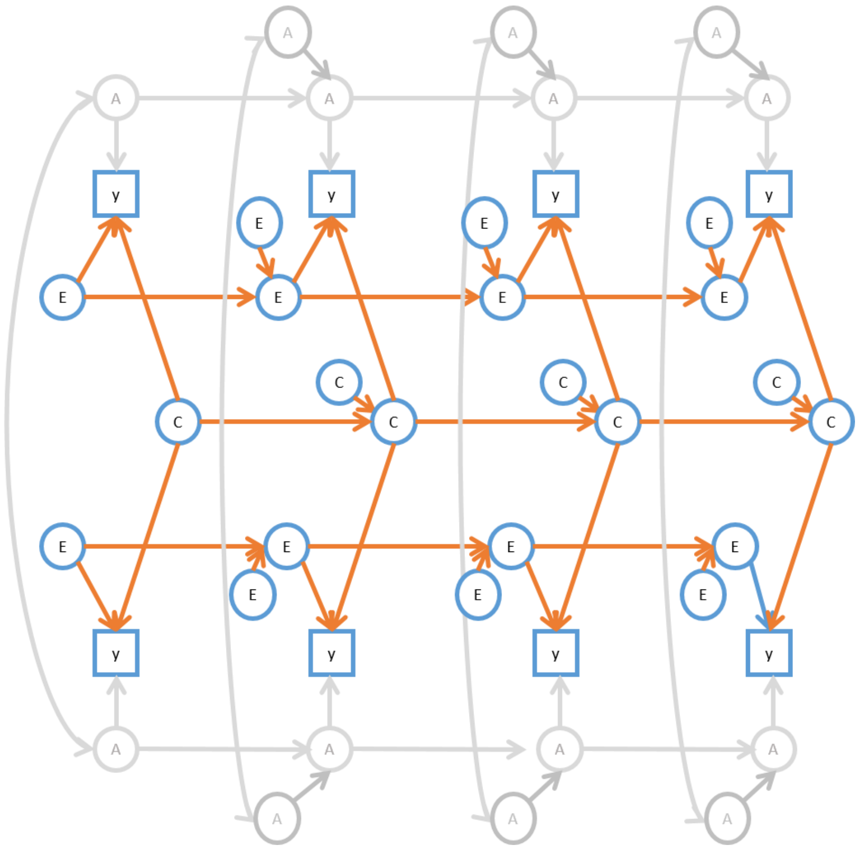
# Specification SIMPLEX in OpenMx

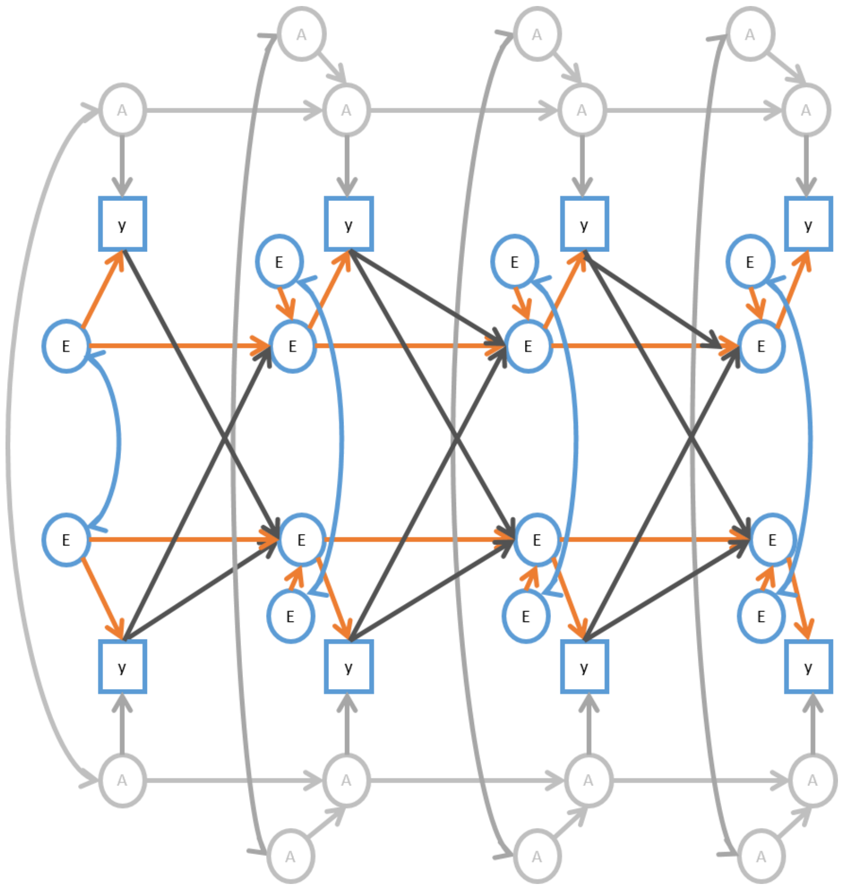




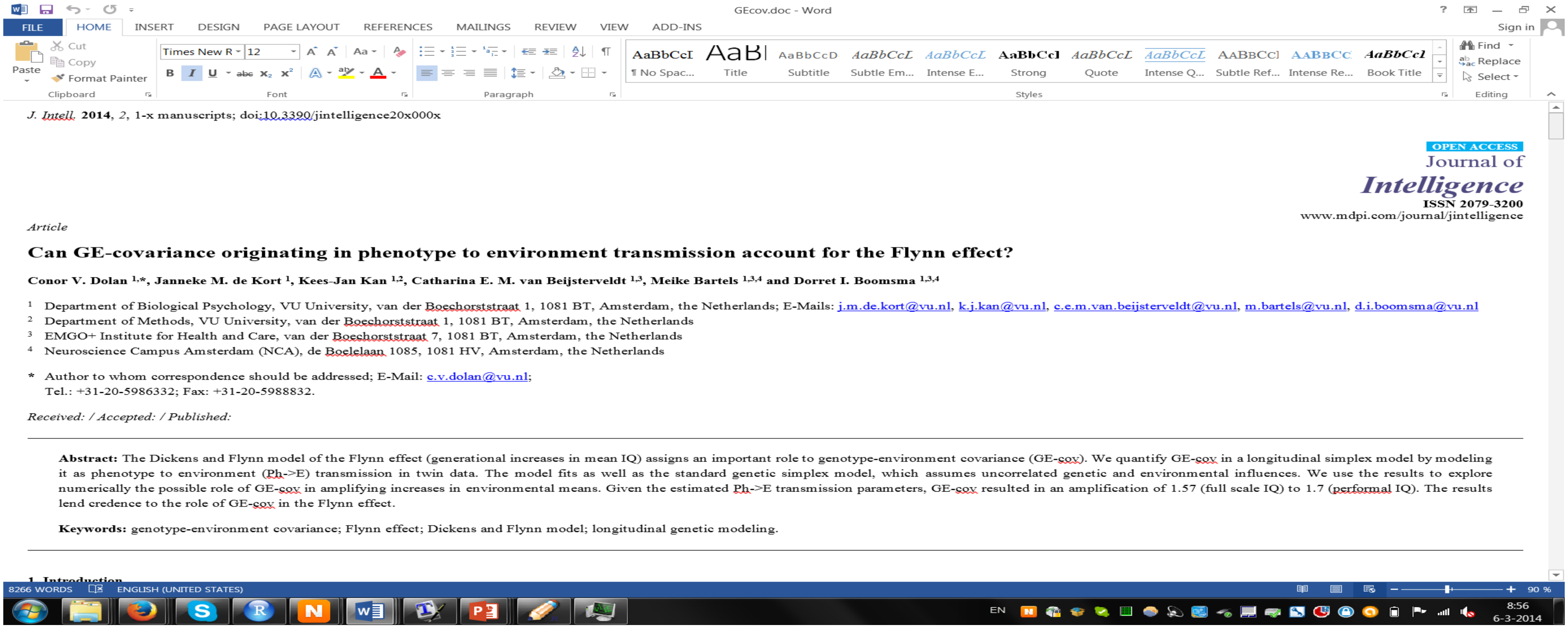
# General code

Open:
SIMPLEX practical



# PRACTICAL
# Replicate findings in following article



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*Article*

**Can GE-covariance originating in phenotype to environment transmission account for the Flynn effect?**

**Conor V. Dolan [1,*], Janneke M. de Kort [1], Kees-Jan Kan [1,2], Catharina E. M. van Beijsterveldt [1,3], Meike Bartels [1,3,4] and Dorret I. Boomsma [1,3,4]**

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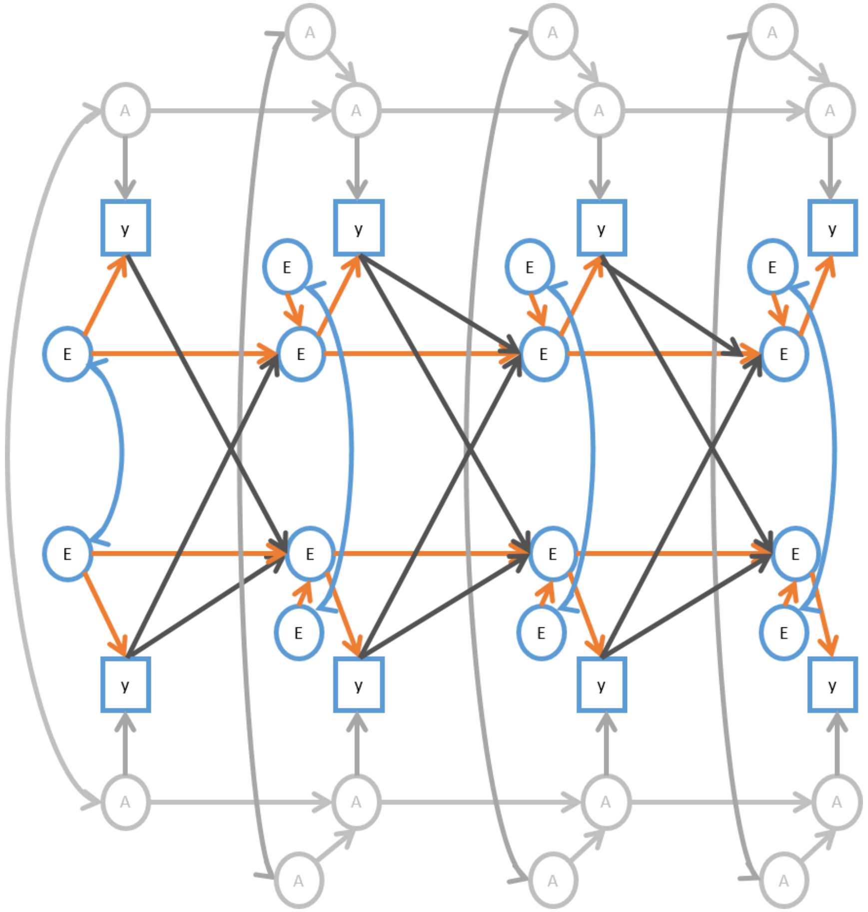
**Abstract:** The Dickens and Flynn model of the Flynn effect (generational increases in mean IQ) assigns an important role to genotype-environment covariance (GE-cov). We quantify GE-cov in a longitudinal simplex model by modeling it as phenotype to environment (Ph->E) transmission in twin data. The model fits as well as the standard genetic simplex model, which assumes uncorrelated genetic and environmental influences. We use the results to explore numerically the possible role of GE-cov in amplifying increases in environmental means. Given the estimated Ph->E transmission parameters, GE-cov resulted in an amplification of 1.57 (full scale IQ) to 1.7 (performal IQ). The results lend credence to the role of GE-cov in the Flynn effect.

**Keywords:** genotype-environment covariance; Flynn effect; Dickens and Flynn model; longitudinal genetic modeling.

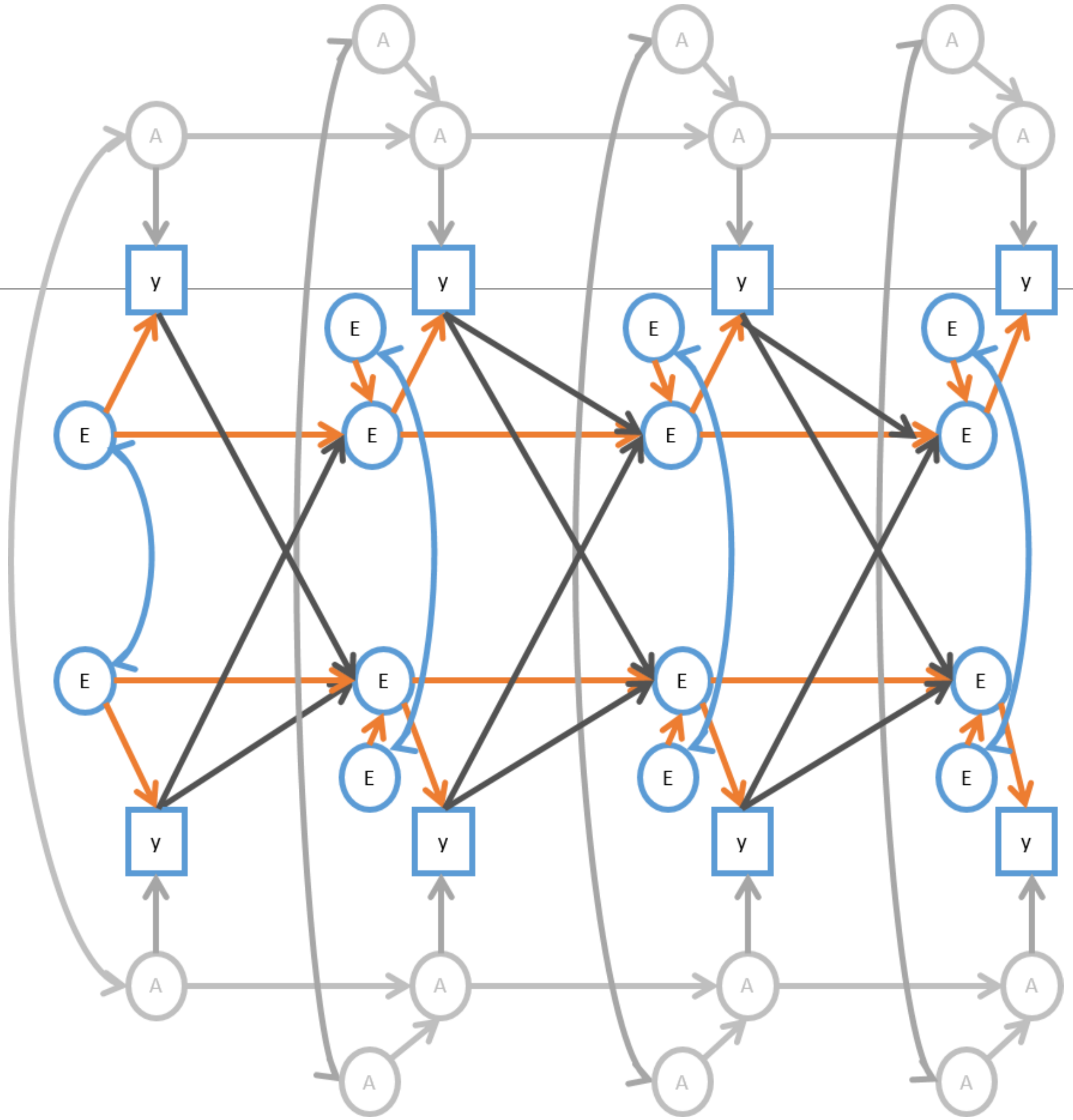
**1. Introduction**

# Model fitting: Ph -> E SIMPLEX MODEL

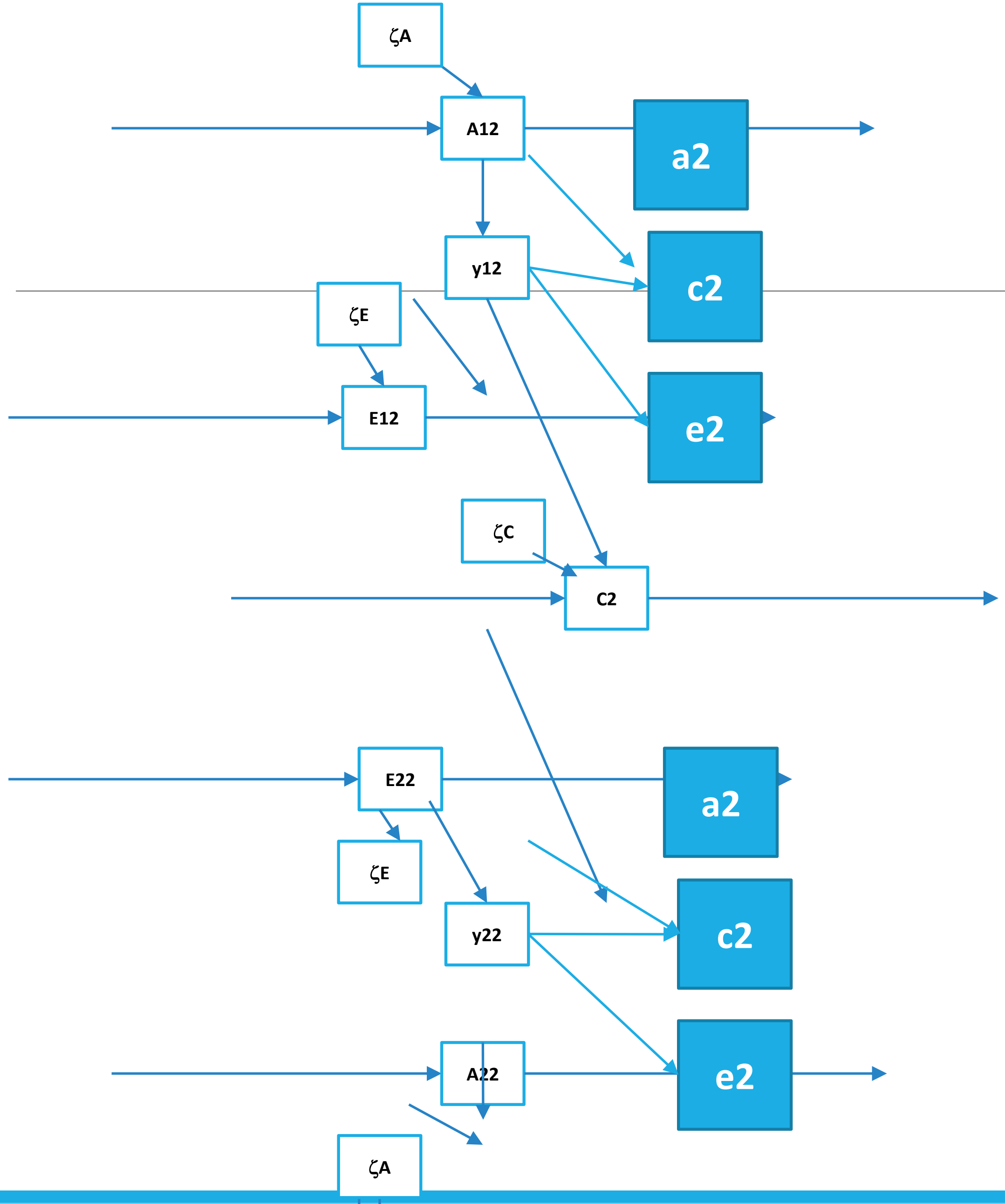
DATA: Full scale Intelligence
In MZ and DZ twins
Measured 4 time points
NTR data




Return to:
SIMPLEX practical



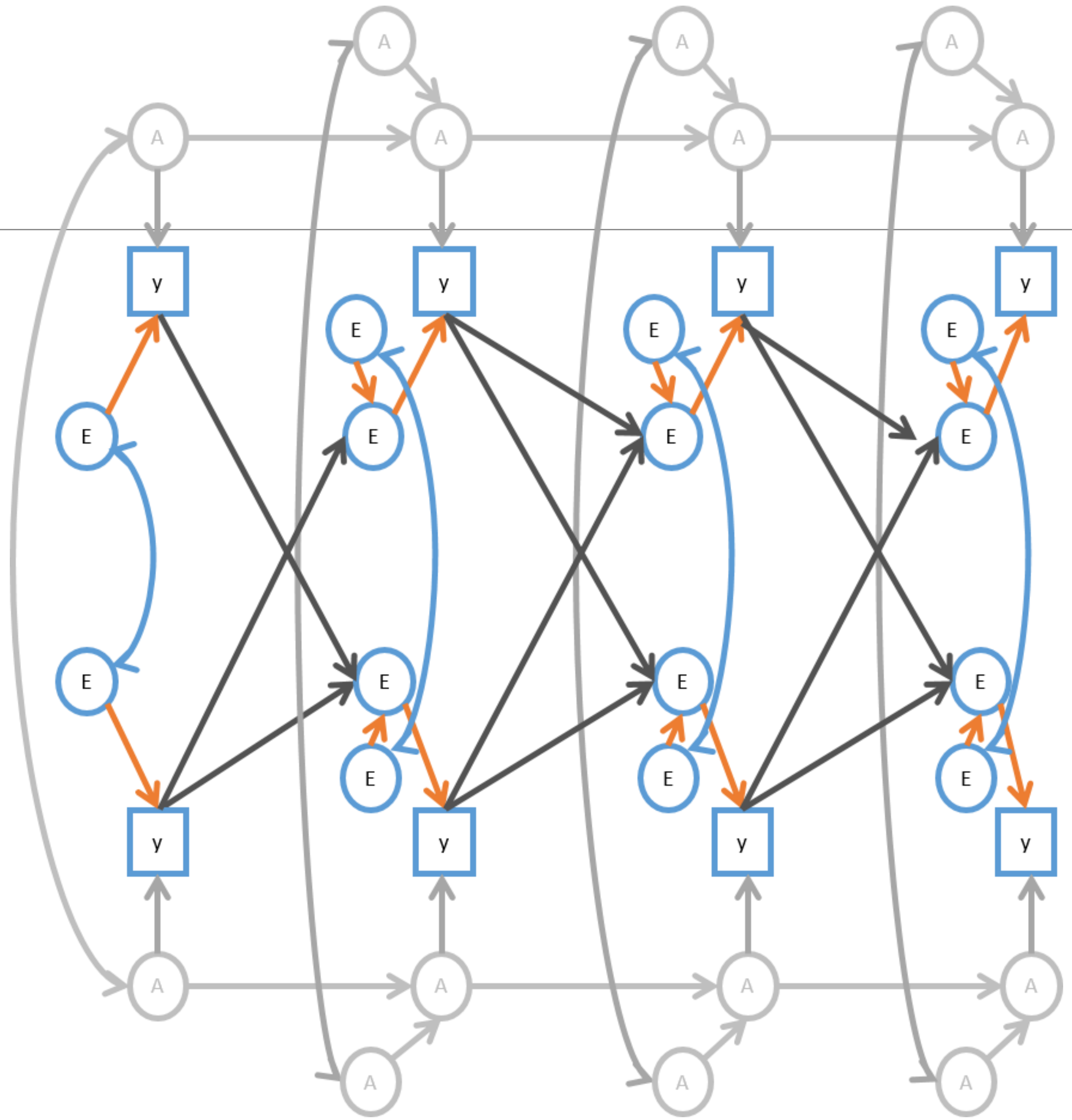

FIT 0



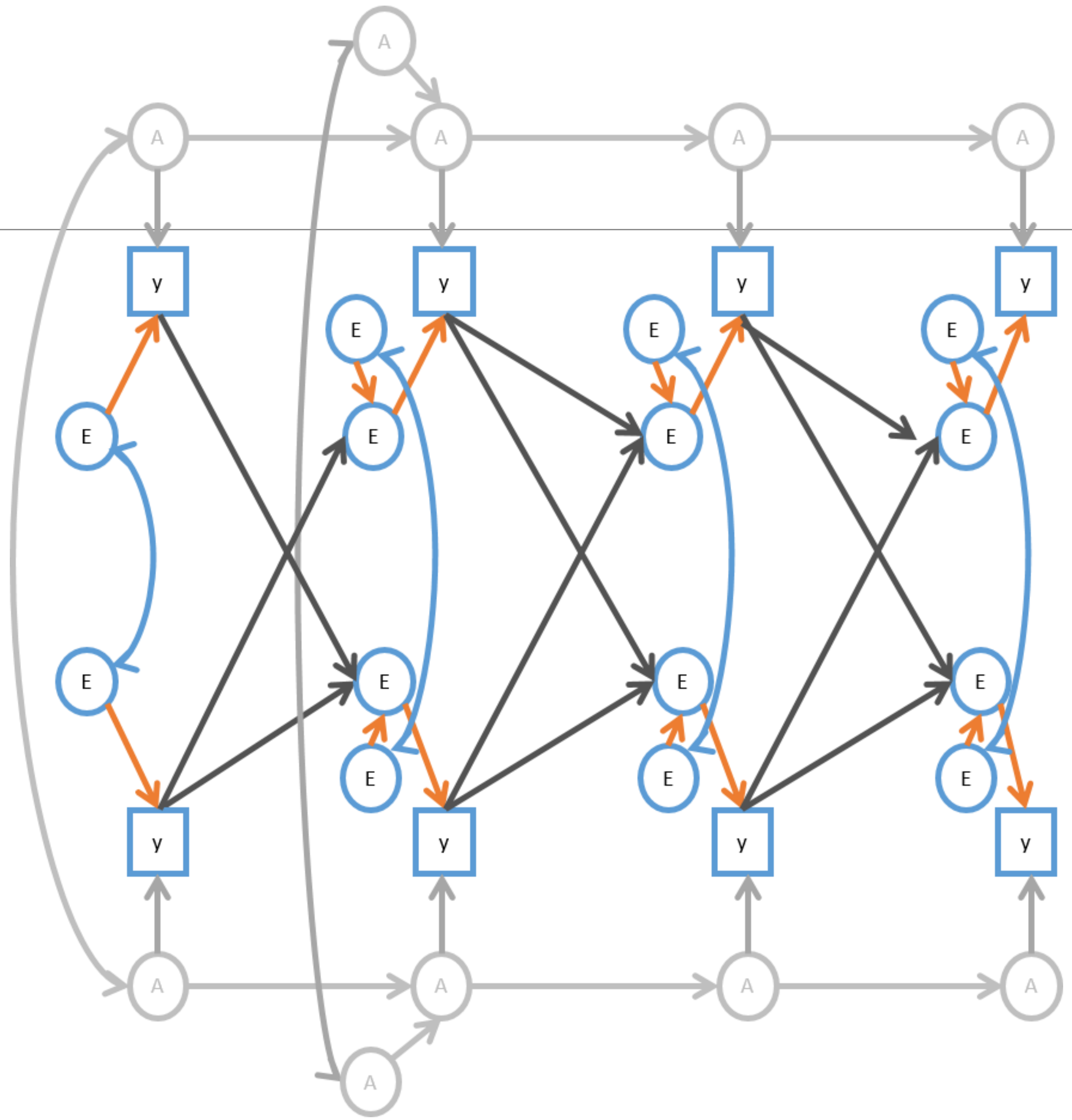

DROP a time specific

FIT 1

DROP E TRANSMISSION

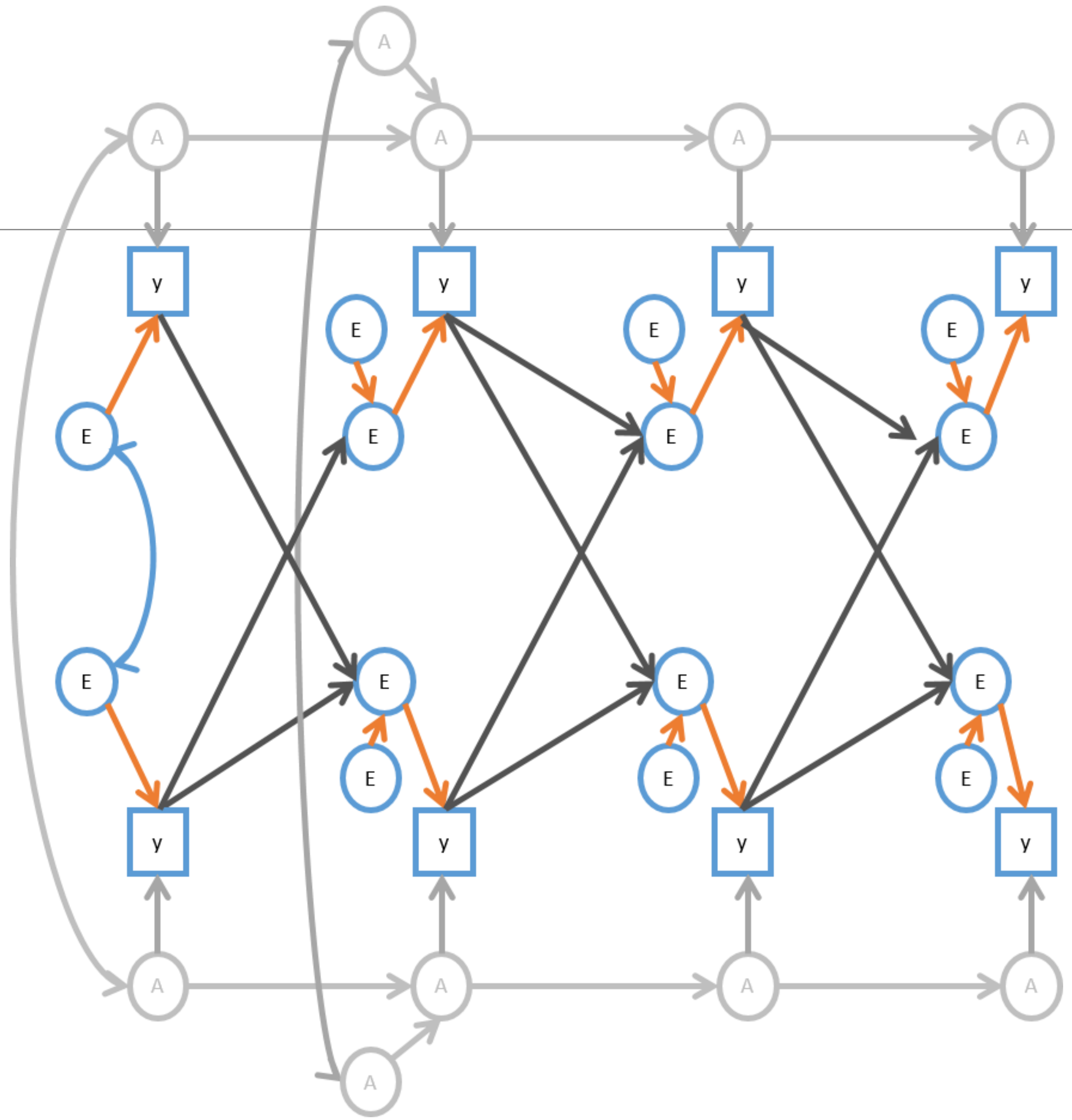



FIT 2




DROP A
innovation
Time 3 and time 4

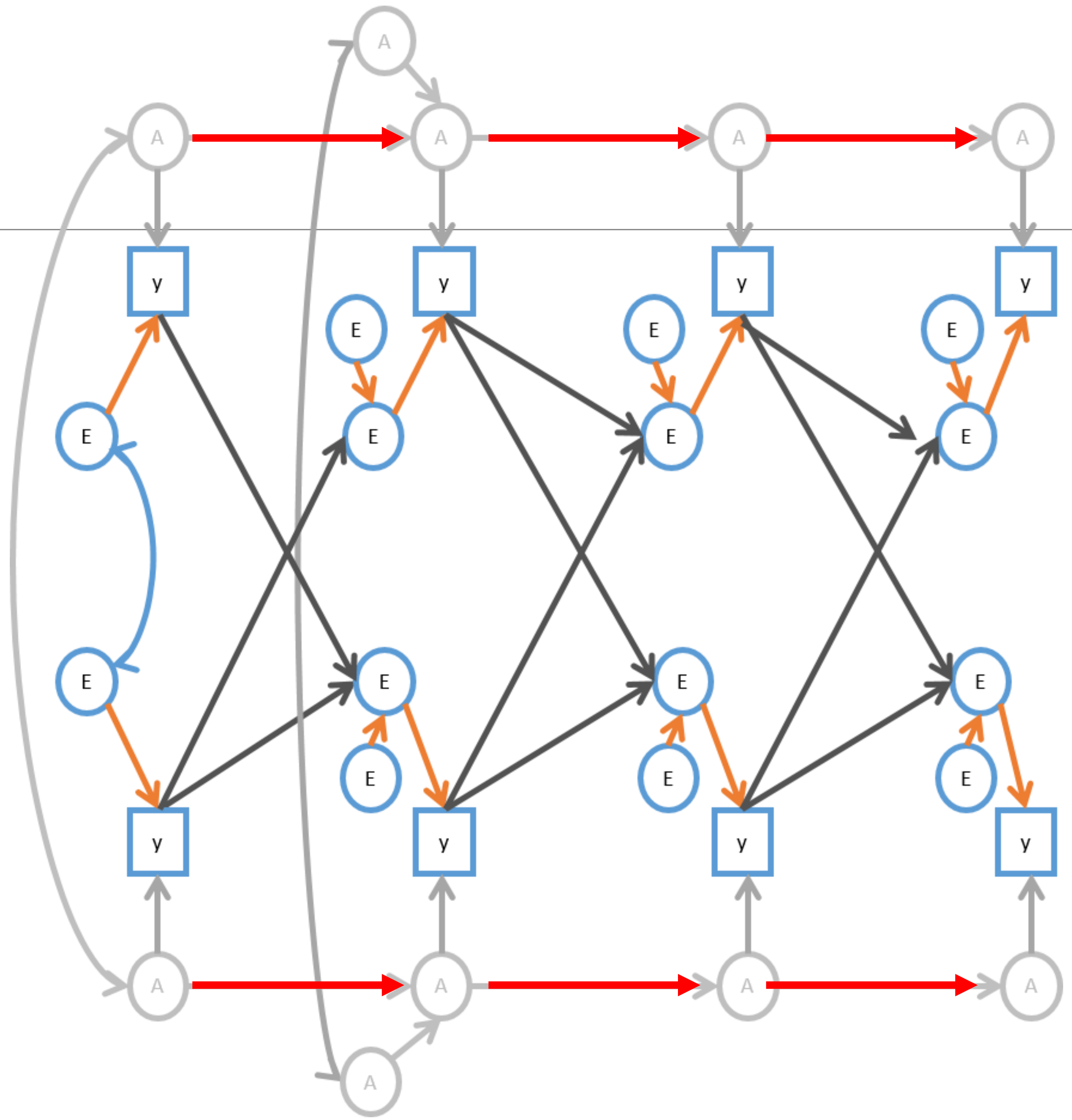
FIT 3




DROP covariance between E

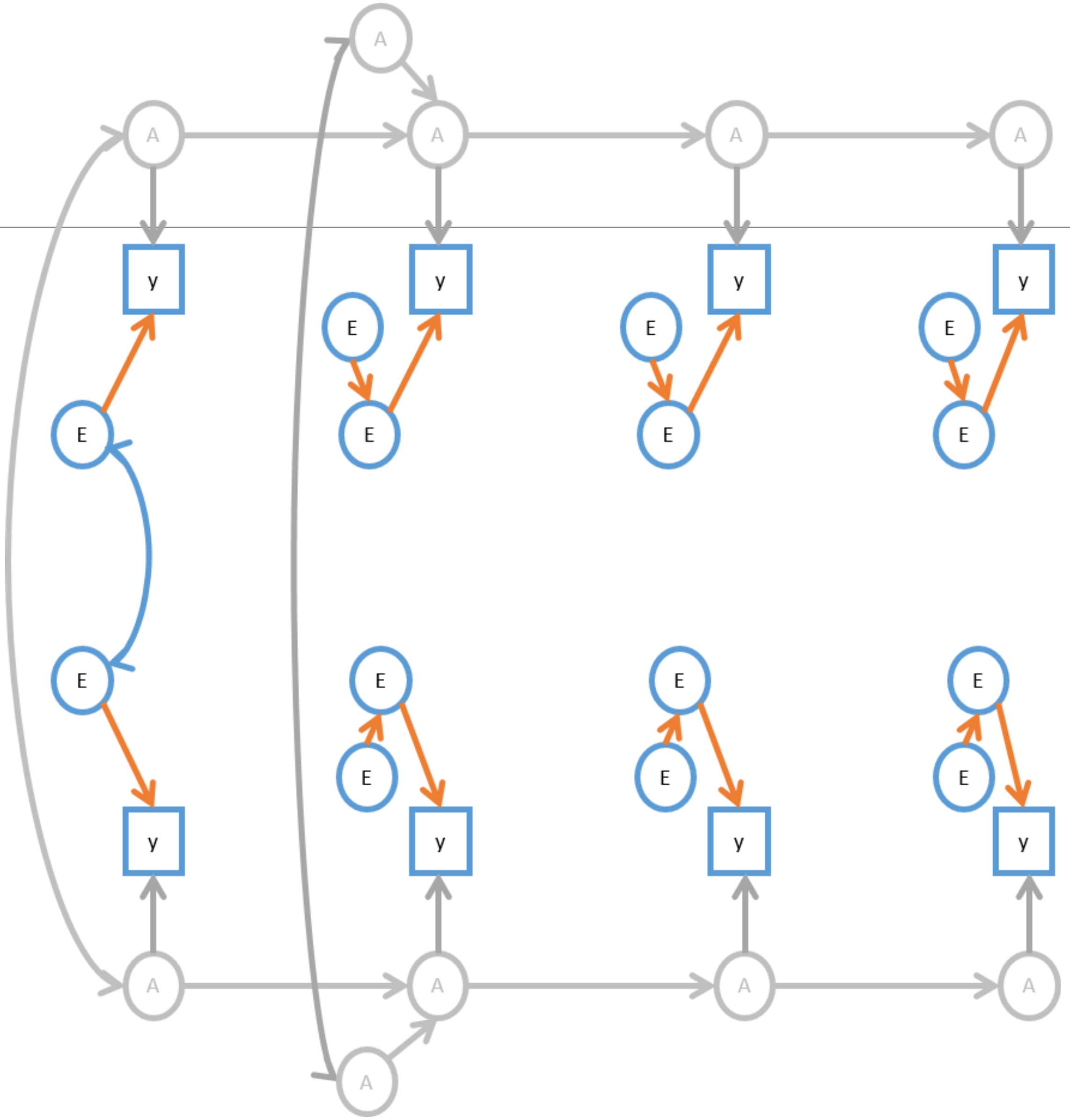
FIT 4

SET bA equal over time



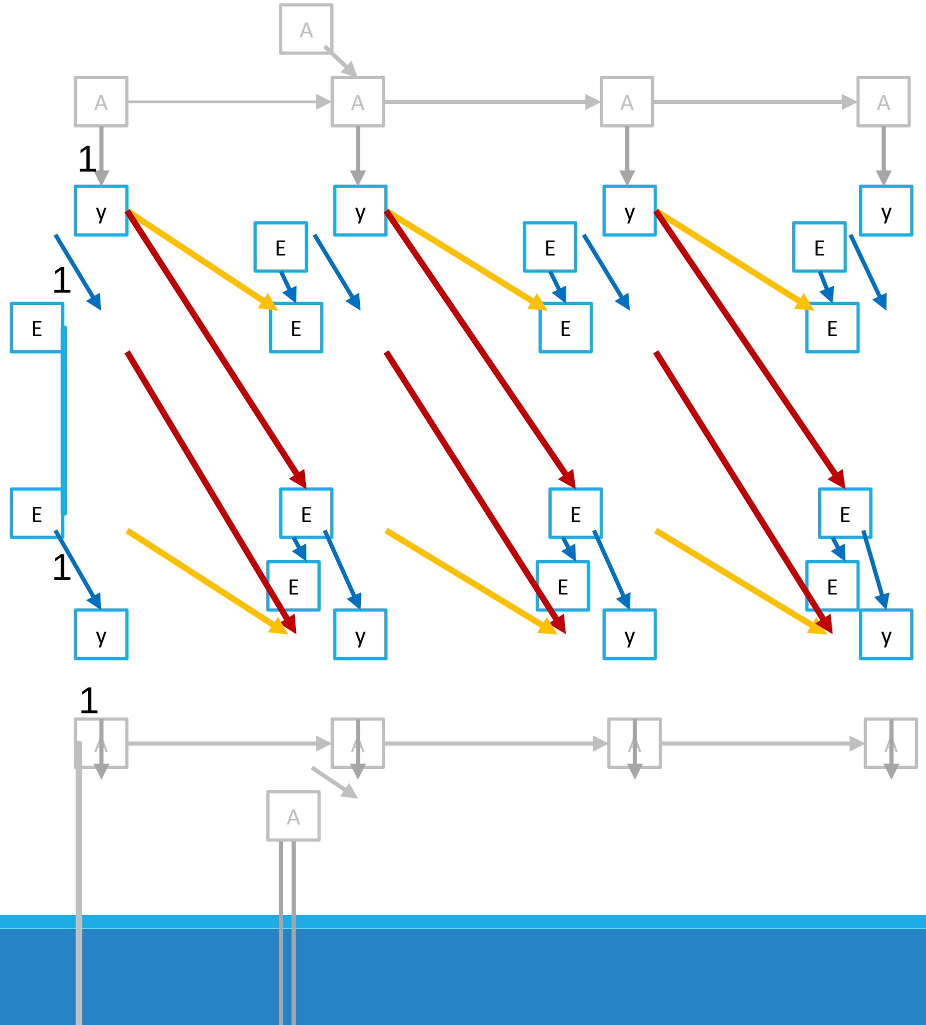

FIT 5

TEST PH->E transmission




FIT 6

# Final model




| | A1 | E1 |
|---|---|---|

within

G-E covariance

A1

| | | | |
|---|---|---|---|
| **1** | | | |
| **0.86** | 1 | | |
| **0.86** | 1.00 | 1 | |
| **0.86** | 1.00 | 1.00 | 1 |

E1

| | | | |
|---|---|---|---|
| **0.00** | **0.00** | **0.00** | **0.00** |
| **0.35** | **0.30** | **0.30** | **0.30** |
| **0.50** | **0.53** | **0.53** | **0.53** |
| **0.53** | **0.59** | **0.59** | **0.59** |

| | | | |
|---|---|---|---|
| **1** | | | |
| **0.41** | 1 | | |
| **0.20** | 0.43 | 1 | |
| **0.09** | 0.30 | 0.47 | 1 |

between

Correlated E – But not C!

A2

| | | | |
|---|---|---|---|
| **0.50** | **0.43** | **0.43** | **0.43** |
| **0.43** | 0.50 | 0.50 | 0.50 |
| **0.43** | 0.50 | 0.50 | 0.50 |
| **0.43** | 0.50 | 0.50 | 0.50 |

E2

| | | | |
|---|---|---|---|
| **0.00** | **0.00** | **0.00** | **0.00** |
| **0.22** | 0.19 | 0.19 | 0.19 |
| **0.33** | 0.35 | 0.35 | 0.35 |
| **0.36** | 0.40 | 0.40 | 0.40 |

| | | | |
|---|---|---|---|
| **0.63** | **0.36** | **0.18** | **0.09** |
| **0.36** | 0.29 | 0.26 | 0.21 |
| **0.18** | 0.26 | 0.30 | 0.31 |
| **0.09** | 0.21 | 0.31 | 0.32 |