Simultaneous Estimation of Reciprocal Parent-Child and Sibling Effects

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Family System Theory (Nichols 2007)

- Behaviour of all individuals within a family is interdependent
- Behaviour of one family member *causes* behaviour of another
  - Parent $\rightarrow$ child
  - Child $\rightarrow$ parent
  - Child $\rightarrow$ child (i.e. sibling effect)
  - Mother $\rightarrow$ father
  - Father $\rightarrow$ mother

Challenges for Causal Inference with Observational Data

- How to distinguish between causal effects attributable to different family members?
- How to disentangle effects of unmeasured individual and family characteristics?
  - E.g. apparent sibling effect could be due to shared family characteristics (genetic or environmental) influencing both children
- How to disentangle genetic and environmental influences without genetically-informative design?

Previous Research

- Focused on parent $\leftrightarrow$ child *or* child $\leftrightarrow$ child (not both)
- Dyadic relationships only
  - Parent $\leftrightarrow$ child based on 1 parent and 1 child
  - Child $\leftrightarrow$ child based on 2 children, and usually only older $\rightarrow$ younger 'training' effects
- No allowance for effects of unmeasured family characteristics

Our Approach

- Allows simultaneously for parent $\leftrightarrow$ child and child $\leftrightarrow$ child effects
- Includes families with different size sibships (including one-child families)
- Allows separation of occasion, individual and family effects

Illustrate method in application to maternal depression and child delinquency.

Preliminaries

Consider family with 1 parent and 2 children.

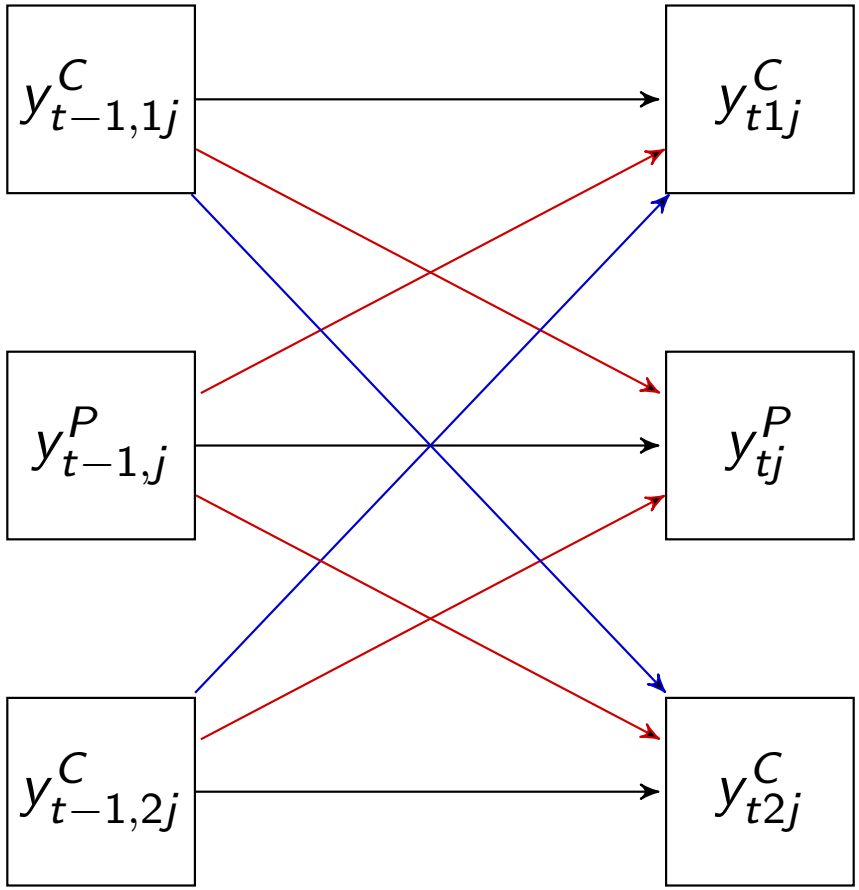
Responses

y_{tj}^P	response at time t for parent in family j
y_{tij}^C	response at time t of child i (=1,2) in family j

Residuals

e_{tj}^P and e_{tij}^C	time-varying parent and child
u_{ij}^C	time-invariant child
v_j^P and v_j^C	time-invariant family

Cross-lag SEM, 1 Parent and 2 Children, Times $t-1$ and t

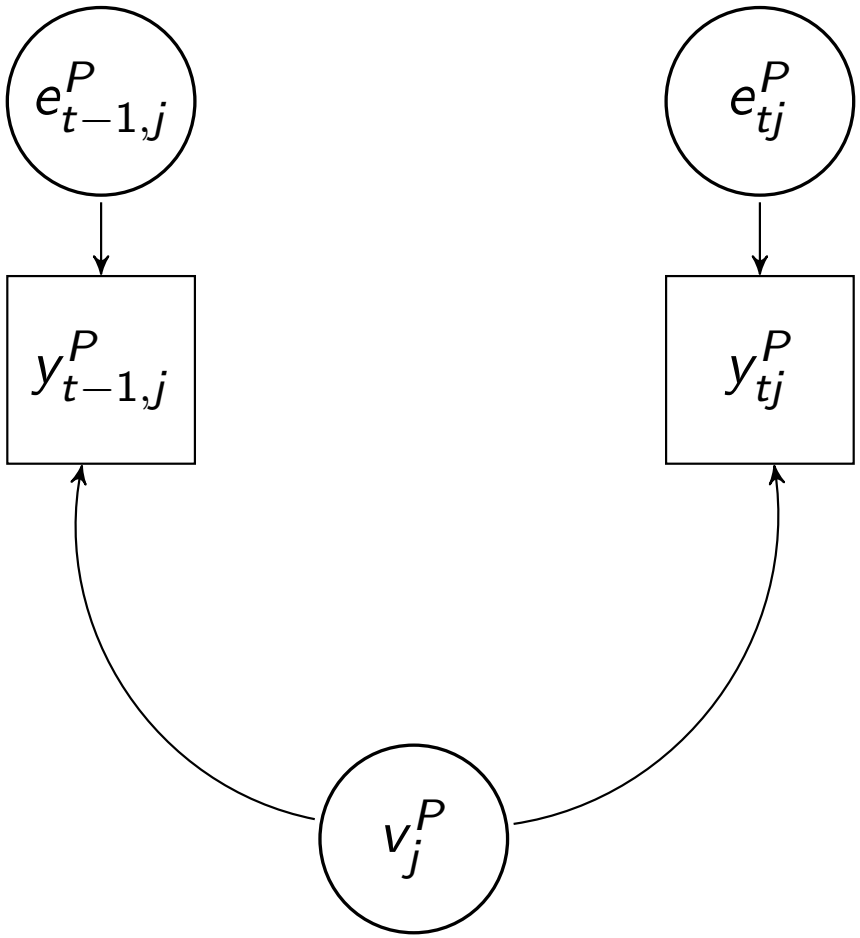


$\rightarrow$ individual lag

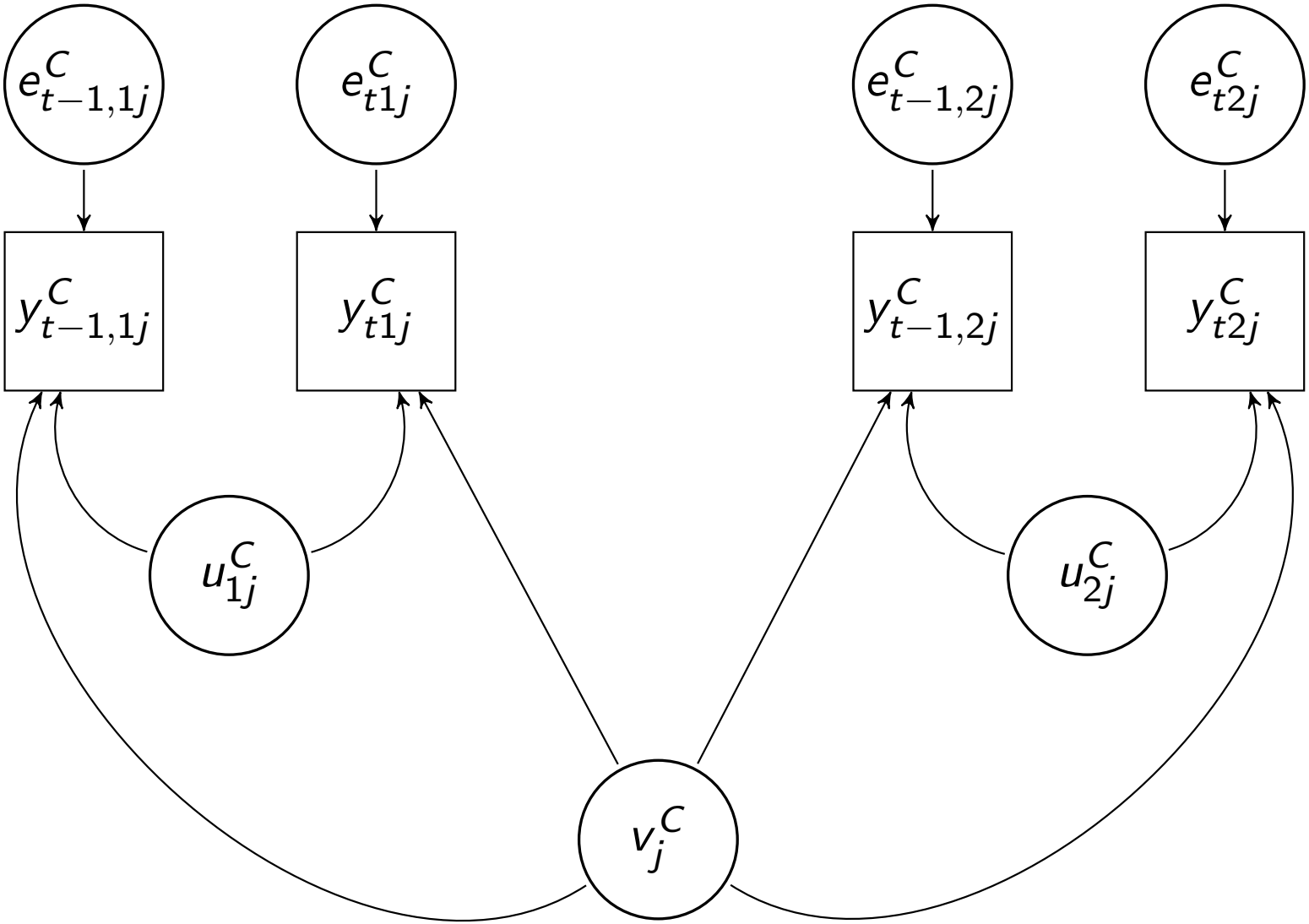
$\rightarrow$ sibling cross-lags

$\rightarrow$ parent $\leftrightarrow$ child cross-lags

Residual Structure of Multilevel SEM: Parent Model



Residual Structure of Multilevel SEM: Child Model



Basic Parent $\leftrightarrow$ Child Model

$$
\begin{aligned}
y_{tj}^{P} &= \beta_0^{P} + \beta_1^{P} y_{t-1,j}^{P} + \beta_2^{P} y_{t-1,+j}^{C} + v_j^{P} + e_{tj}^{P} \\
y_{tij}^{C} &= \beta_0^{C} + \beta_1^{C} y_{t-1,j}^{C} + \beta_2^{C} y_{t-1,j}^{P} + v_j^{C} + u_{ij}^{C} + e_{tj}^{P}
\end{aligned}
$$

where $y_{t-1,+j}^{C} = y_{t-1,1j}^{C} + y_{t-1,2j}^{C}$

Assume $(v_j^{P}, v_j^{C}) \sim$ bivariate normal to allow for unmeasured family characteristics affecting parent and child outcomes.

Allowing for Sibling (Child $\leftrightarrow$ Child) Effects

Add sum of lagged responses for siblings of child i to model for y^C_{tij}.

Assumptions about parent $\leftrightarrow$ child and child $\leftrightarrow$ child effects:

- Each child has same effect on the parent
- Parent has same effect on each child
- Each child has same effect on each sibling

Can allow all of the above effects to depend on characteristics of child (e.g. age, sex), sibling pair (e.g. age difference) and parent/family - see application.

Estimation

- Multilevel SEM is a type of multivariate response model, but need flexibility to allow for different hierarchical structures for parent and children
- Options include MLwiN and aML
- Need also to allow for 'initial conditions' by jointly modelling y^P and y^C at $t = 1$ with outcomes for $t > 1$

Application to Maternal Depression and Child Delinquency

- Avon Brothers and Sisters Study (ABSS): 175 families, 416 children, 1381 children
- 3 waves spaced 2 years apart
- Parent outcome (y^P): maternal depression (malaise inventory)
- Child outcome (y^C): delinquency (child behaviour checklist)
- All measures based on maternal report

Results: Child Effects on Maternal Depression

	Model 1	Model 2
Lag child delinquency	-0.003	-0.058^{*}
Family-level correlation		
$\text{corr}(v_j^P, v_j^C)$	0	0.721^{***}

Model 1: equations for y^P and y^C separately estimated
Model 2: equations estimated simultaneously

Notes: (i) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.001$; (ii) adjusting for maternal lags, time and family size.

Results: Mother and Sibling Effects on Child Delinquency

	Estimation of y^P and y^C equations	
	Separate	Simultaneous
Girl	0.022	0.024
Mother effects		
Lag maternal depression	0.192***	−0.007
Lag maternal depression × girl	−0.230***	−0.242***

Tested for sibling effects, allowing effect to depend on whether sibling is younger and older and on age difference.

No evidence of any sibling effect in either model.

Further Investigation of Sibling Effects

Previous research has found 'training' effects from older to younger child.

Standard SEM includes a single residual term, while multilevel approach decomposes residual variation into occasion, individual and family components.

Compare standard SEM with multilevel SEM in analysis of sibling pairs (2-child families only).

Sibling Effects on Child Delinquency

	Standard SEM	Multilevel SEM
Lag younger sib y †	0.110	−0.038
Lag younger sib × | age diff |	0.047	−0.045
Lag older sib y †	0.246**	0.107
Lag older sib × | age diff |	−0.010	−0.004

† Age difference centred at 3 years.

So apparent training effect explained by shared dependency of both siblings' behaviour on unmeasured family characteristics.

Note: Both models allow for residual correlation between siblings at any t.

Discussion

- Important to jointly model parent and child outcomes, especially when using single-informant data
- Important to allow for unmeasured family characteristics
- Valuable to apply methods to more comprehensive data: larger sample size, more measurements, closer together in time, and from multiple informants