One-mode – two-mode co-evolution for studying social influence on behaviour

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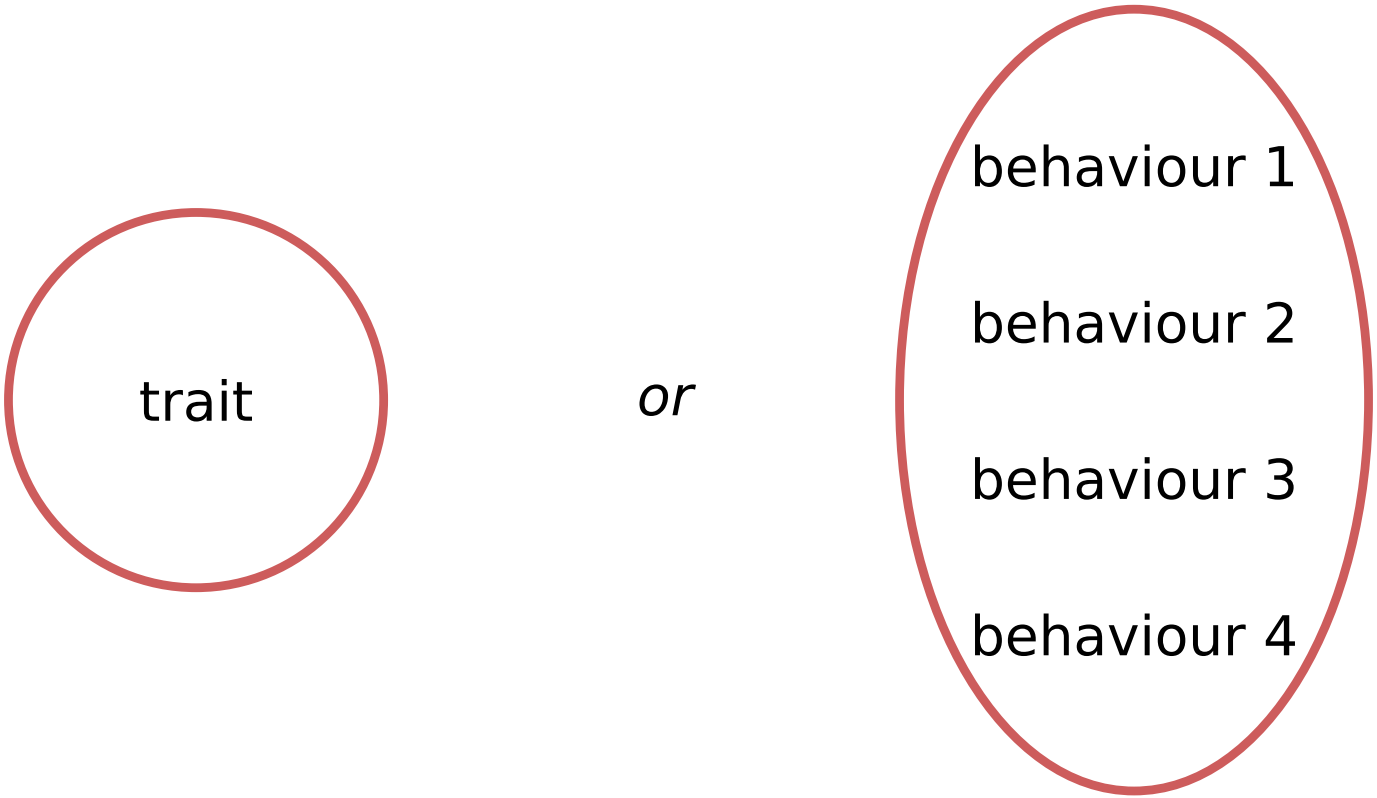
Social influence: at which level?

Question for this presentation:

Does social influence in a given domain take place
at the level of a general trait or
at the level of concrete behaviours?



1. Social influence: at which level?

Consider a set of items in the given domain,
for which the trait could be measured by a sum score,
but each item of which is also a meaningful concrete behaviour.

Suppose that for a group, repeated measures are available about the network of interest and these items.

For influence at the level of a trait, the
Stochastic Actor-oriented Model for Network Dynamics (‘*SAOM*’)
can be used for network-behaviour co-evolution.

For influence at the level of the behaviours, the SAOM (RSiena)
can be used for one-mode – two-mode network co-evolution.

The second will be elaborated in this presentation
with as example delinquency in early secondary schools
(data collected by Andrea Knecht)

2. Delinquency

Andrea Knecht (supervision Chris Baerveldt) collected network data in 126 first-grade classrooms in 14 secondary schools.

The Netherlands, 2003-2004, 4 waves

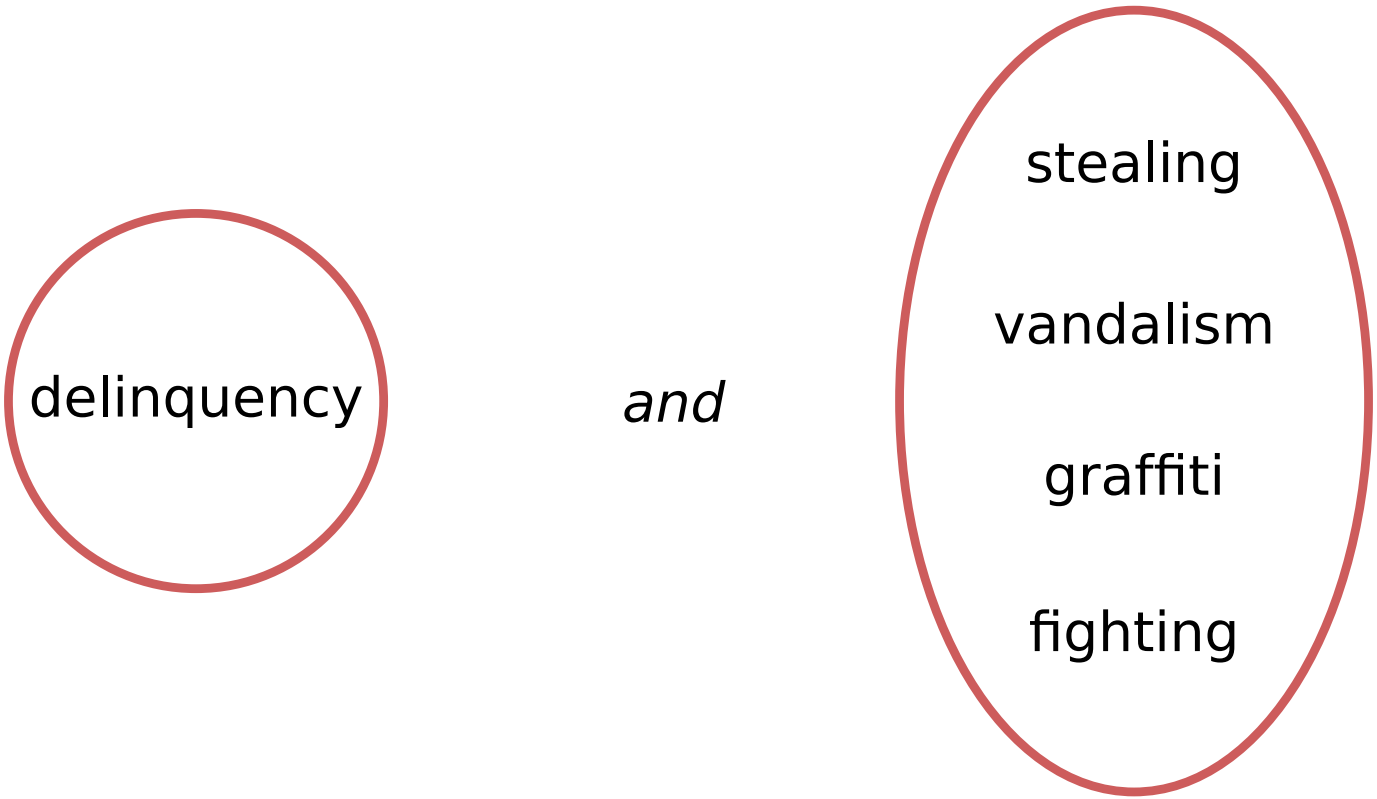
Four questions about delinquency were posed:
self-reported frequencies of stealing, vandalism, graffiti, fighting.

Social influence and selection for the trait of delinquency was studied in

Andrea Knecht, Tom A.B. Snijders, Chris Baerveldt, Christian Steglich, and Werner Raub (2010). Friendship and delinquency: Selection and influence processes in early adolescence. *Social Development*, 19, 494—514,

using a sum score.

Here we shall study the influence and selection simultaneously for the trait and the behaviors:



3. One-mode – two-mode co-evolution

This is analyzed with the SAOM for co-evolution of one-mode and two-mode networks

Snijders, Lomi & Torlò in *Social Networks, 2013*.

X: one-mode friendship network;
Z: two-mode delinquency network,
where the 2nd mode consists of the four items
stealing, vandalism, graffiti, fighting

dichotomized: 'at least once in past 3 months', for fighting 'at least twice in past 3 months'.

X influences changes in Z, and Z influences changes in X.

The following slides present the main effects for representing the one-mode – two-mode selection and influence process.

Notation for the effects

x_{ij} : indicator that i mentions j as a friend;
z_{ih} : indicator that i mentions delinquent behaviour h;
s^X represents effects for friendship, s^Z effects for delinquency;

in the pictures:
circles are actors, squares delinquent behaviours;

means there is a friendship tie from i to j;

means i mentions delinquent behaviour h.

I shall be using also the “shortNames” as used in RSiena.

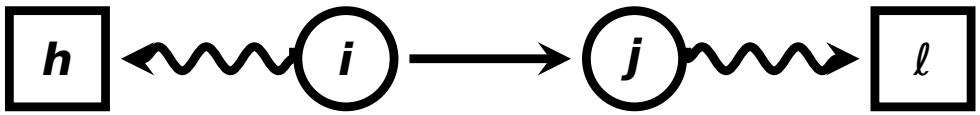
Influence at the level of the sum score

average Z-outdegree of i's X-friends $\Rightarrow$ Z_i

Effect for influence at the level of the sum score:
outOutAvIntn, the total number of delinquent behaviours reported by i multiplied by the average number of delinquent behaviours (centered) reported by all i's friends,

$$s^{Z}_{\text{od\_av},i}(x,z) = \sum_h z_{ih} \frac{\sum_j x_{ij}\{\sum_\ell (z_{j\ell} - \bar{z})\}}{\sum_j x_{ij}}$$

where $\bar{z}$ is the average observed outdegree for Z in the group.

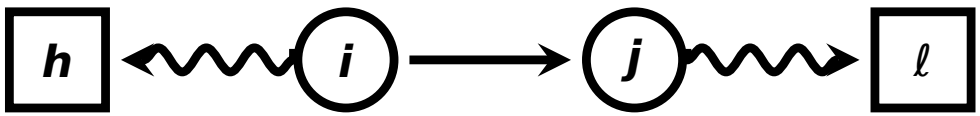


Selection at the level of the sum score

higher $Z_i \Rightarrow$ i will prefer X-friends with higher Z_j

Effect for selection at the level of the sum score:
outActIntn × *outPopIntn*, interaction between friendship activity and friendship popularity based on delinquency outdegree,

$$s^X_{\mathrm{oa}\times\mathrm{op},i}(x,z) = \sum_j x_{ij}\{\sum_h (z_{ih}-\bar{z})\}\{\sum_\ell (z_{j\ell}-\bar{z})\}$$



(same picture)

Influence and selection at the behaviour level

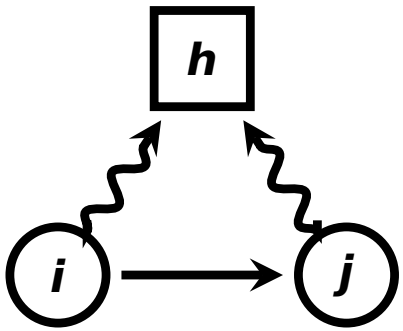
X-friends i and j will do the same delinquent acts z_{ih}, z_{jh}

'Regular' influence and selection effects for one–two co-evolution:

to and *from*, the number of friendships of i weighted by the number of delinquent behaviours i and j have in common,

$$s^V_{\text{triad},i}(x, z) = \sum_{j,h} x_{ij}\, z_{ih}\, z_{jh} \ ,$$

for $V = X$ (selection) and $V = Z$ (influence).



Further cross-network effects

Hierarchy requires control for lower-order effects

In the first place, the regular mixed degree effects:

outActIntn, mixed outdegree activity, the product of the number of outgoing friendships and the number of delinquent behaviours of i,

$$s^X_{\mathrm{oa},i}(x,z) = \sum_j x_{ij} \sum_h \left(z_{ih} - \bar{z}\right),$$

$$s^Z_{\mathrm{oa},i}(x,z) = \sum_j z_{ij} \sum_h \left(x_{ih} - \bar{x}\right),$$

Further cross-network effects (2)

The product of the number of incoming friendships and the number of delinquent behaviours is effect *outPopIntn* for friendship:

$$s^{X}_{\mathrm{ia},i}(x,z) = \sum_j x_{ij} \sum_h \left(z_{ih} - \bar{z}\right) ,$$

and *inActIntn* for delinquency (where i and j are reversed),

$$s^{Z}_{\mathrm{op},i}(x,z) = \sum_j x_{ji} \sum_h \left(z_{ih} - \bar{z}\right) .$$

Further effects (3)

Group mean of delinquency

In addition, there is the effect *avDeg* of the group average of the delinquency outdegree on delinquency:

$$s^z_{\mathrm{ga},i}(x,z) = \sum_j z_{ij}\left(\frac{1}{n}\sum_h z_{h+} - p\right)$$

where p is a parameter for centering.

This is the effect of the average of the entire group.
It could be regarded as a group norm;
since z_{h+} can be regarded as an unreliable measurement of 'delinquency' of actor h, this effect, with a negative parameter, will also reflect *regression to the mean* ($\Rightarrow$ stability).

Overview of effects

The one-mode – two-mode selection and influence model contains the following effects. Between square brackets are the analogous effects for network–behaviour co-evolution.
For friendship:

1. *outActIntn* (degrees) [*egoX*]
2. *outPopIntn* (degrees) [*altX*]
3. *outActIntn* × *outPopIntn* (degrees for selection) [*egoXaltX*]
4. *from* (triadic) (selection on specific behaviours)

For delinquency:

1. *outActIntn* (degrees) [*outdeg*]
2. *inActIntn* (degrees) [*indeg*]
3. *outOutAvIntn* (influence from average friends' sum score) [*avAlt*]
4. *to* (triadic) (influence from specific behaviours)
5. *avDeg* (group average outdegree) [*avGroup*]

Results for the example

The model was estimated by a random coefficient multilevel model (function *sienaBayes*), using 3 parallel chains of 70,000 steps. Convergence was good.

Waves 2-3-4 were used, selection based on missing data and enough stability (Jaccard coeff.) led to including 82 classrooms.

Prior distributions were specified
according to the advice in the RSiena manual.

Descriptive statistics 1

Overall means and similarity coefficients of delinquent acts

	mean	*Jaccard similarity*			
		stealing	vandalism	graffiti	fighting
stealing	0.13	–	0.29	0.22	0.27
vandalism	0.20	0.29	–	0.27	0.33
graffiti	0.17	0.22	0.27	–	0.23
fighting	0.21	0.27	0.33	0.23	–

Delinquency is present but low;
the four delinquent behaviours are weakly positively associated.

Descriptive statistics 2

Network descriptives: means and between-group standard deviations

	wave 1		wave 2		wave 3	
	mean	(s.d.)	mean	(s.d.)	mean	(s.d.)
Friendship						
outdegree	4.01	(0.66)	4.17	(0.60)	4.03	(0.68)
Jaccard with next wave	0.50	(0.09)	0.52	(0.08)		
proportion missings	0.03	(0.03)	0.07	(0.06)	0.06	(0.04)
Delinquency						
outdegree	0.76	(0.29)	0.91	(0.34)	0.92	(0.35)
Jaccard with next wave	0.39	(0.09)	0.43	(0.10)		
proportion missings	0.01	(0.02)	0.06	(0.05)	0.06	(0.05)

Parameter estimates: friendship

del = delinquency

Effect	par.	(psd)	betw. sd
outdegree (density)	–2.194	(0.066)	0.362
reciprocity	2.052	(0.065)	0.387
transitive triplets	0.465	(0.016)	0.103
transitive reciprocated triplets	–0.159	(0.017)	.
indegree - popularity	–0.072	(0.012)	0.092
outdegree - activity	0.036	(0.008)	0.055
reciprocal degree - activity	–0.184	(0.015)	0.099
same non-Dutch language	0.698	(0.209)	.
same sex	0.662	(0.025)	.
log classroom size	–0.264	(0.225)	.
advice similarity	0.100	(0.085)	0.255
outdegree del popularity	0.008	(0.018)	.
outdegree del activity	–0.033	(0.019)	.
outdeg. del activity x outdeg. del popularity	0.018	(0.017)	.
triadic: same delinquent behaviors	–0.011	(0.059)	.

par = posterior mean; psd = posterior standard deviation of the mean;
betw. sd = posterior between-groups stand. deviation.

Parameter estimates: delinquency

del = delinquency

Effect	par.	(psd)	betw. sd
outdegree (density)	–2.420	(0.130)	0.550
indegree - popularity	0.016	(0.018)	0.081
outdegree - activity	0.440	(0.020)	0.100
classroom average outdegree	–0.945	(0.166)	.
sex ego	0.202	(0.042)	.
advice ego	0.028	(0.022)	.
classroom mean advice	–0.127	(0.044)	.
indegree friends activity	–0.004	(0.013)	.
outdegree friends activity	–0.065	(0.017)	.
average friends' del outdegree	–0.057	(0.059)	.
triadic: behaviors mentioned by friends	0.241	(0.042)	.

par = posterior mean; psd = posterior standard deviation of the mean;
betw. sd = posterior between-groups stand. deviation.

Parameter estimates: focus on selection and influence

del = delinquency

Effect	par.	(psd)
friendship		
outdegree del popularity	0.008	(0.018)
outdegree del activity	–0.033	(0.019)
outdeg. del activity x outdeg. del popularity	0.018	(0.017)
triadic: same delinquent behaviors	–0.011	(0.059)
delinquency		
classroom average outdegree	–0.945	(0.166)
indegree friends activity	–0.004	(0.013)
outdegree friends activity	–0.065	(0.017)
average friends' del outdegree	–0.057	(0.059)
triadic: behaviors mentioned by friends	0.241	(0.042)

Conclusion

This data set on delinquency gives strong evidence for
social influence on the level of specific delinquent behaviours,
and not on the level of the aggregate measure of delinquency.

Furthermore, there is regression to the mean w.r.t delinquency.

There is no evidence for friendship selection based on delinquency,
neither on the aggregate measure
nor on doing the same behaviours.

Discussion

When there is a set of binary items
indicating specific behaviours in a given domain,
for which the trait could be measured by a sum score,
then this method of one-mode – two-mode co-evolution
can be used in studies where selection and influence
are considered simultaneously
at the level of the sum score and
at the level of the specific individual behaviours.

The issue of regression to the mean merits further thought.

Johan Koskinen and Tom A.B. Snijders (2023).
Multilevel Longitudinal Analysis of Social Networks.
Journal of the Royal Statistical Society, Series A, 186:376—400.