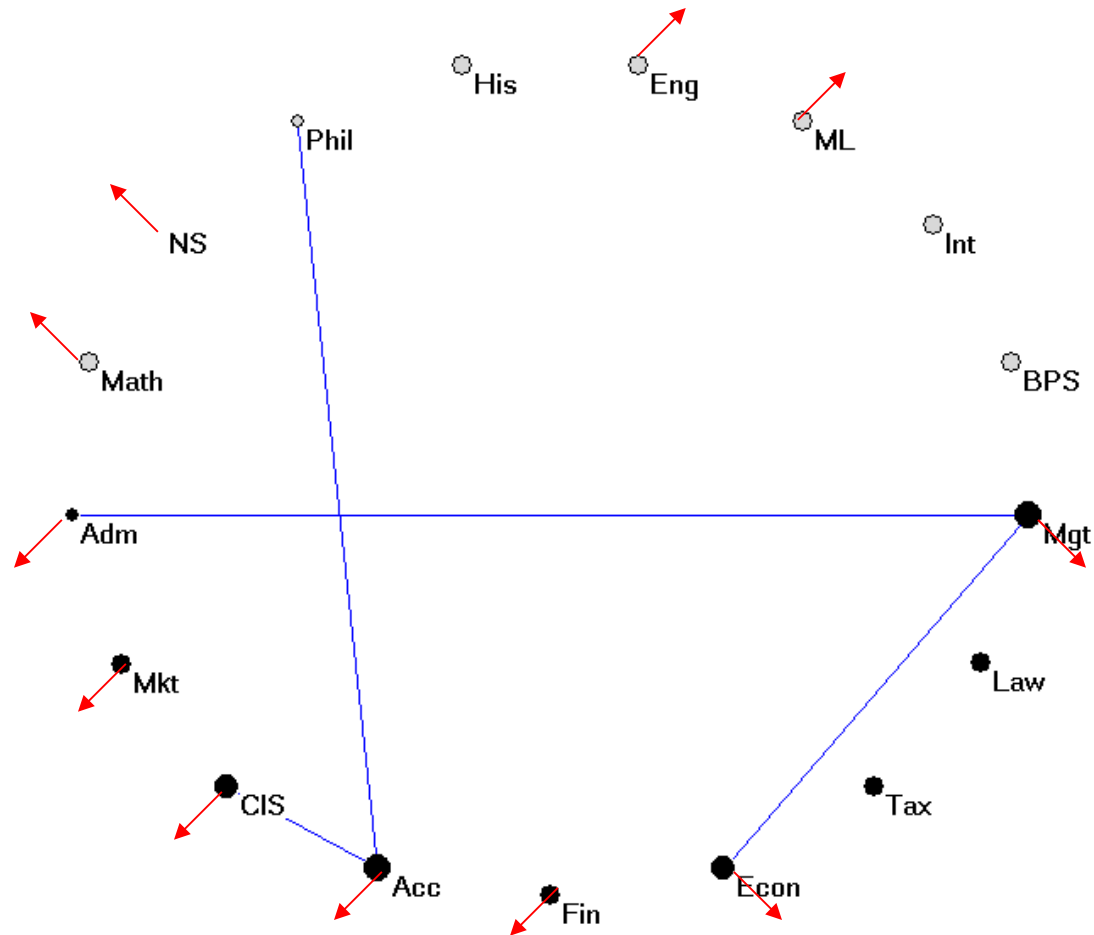


A Time Effect in a Social Network from a Bayesian Perspective

**Susan Adams, Nathan Carter, Charles Hadlock,
Dominique Haughton, George Sirbu**

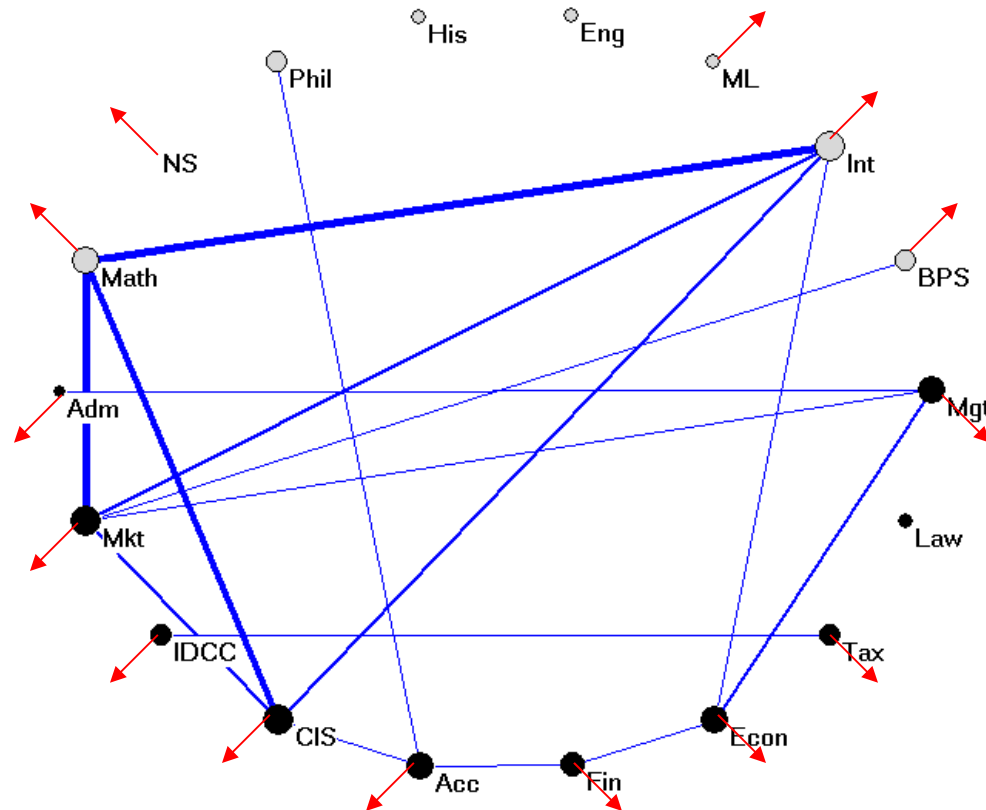
Bentley

Co-publication Network Considering Only Journal Articles in



Notes: Gray vertices are Arts and Sciences departments, black vertices are Business departments (or Administration). The thickness of the lines is proportional to the strength of the connection; the size of the vertices is proportional to the degree. Arrows indicate that outside collaborators have also been involved. Note that Math, NS, Phil, His, Eng, ML, Int and BPS are Arts and Sciences departments.

Co-publication Network Considering Only Journal Articles in 2003-04



Notes: Gray vertices are Arts and Sciences departments, black vertices are Business departments (or Administration). The thickness of the lines is proportional to the strength of the connection; the size of the vertices is proportional to the degree. Arrows indicate that outside collaborators have also been involved.

The Model

Since in our case the ties are non-directional, the $p1$ -model reduces to the following (where we adopt the Wasserman and Faust (1994) formulation)

$$Y^k_{ij11} = \begin{cases} 1 & \text{if } i, j \text{ are connected} \\ 0 & \text{otherwise} \end{cases}$$

$$Y^k_{ij00} = \begin{cases} 1 & \text{if } i, j \text{ are not connected} \\ 0 & \text{otherwise} \end{cases}$$

$$\log(P(Y^k_{ij11} = 1)) = \lambda^k_{ij} + \theta^k + \alpha^k_i + \alpha^k_j$$

$$\log(P(Y^k_{ij00} = 0)) = \lambda^k_{ij}$$

The Model

k denotes times periods:

- k=A for 2003-2004
- k=B for 2000-2001
- Note that λ_{ij}^k is a constant subject to:

$$P(Y_{ij11}^k = 1) + P(Y_{ij00}^k = 0) = 1$$

The model

$\forall \theta^k$: choice parameter

$\forall \alpha_i^k$: expansiveness/attractiveness
parameter corresponding to node i for
period k

Priors

$$\begin{pmatrix} \alpha^A_i \\ \alpha^B_i \end{pmatrix} \sim N\left(\begin{pmatrix} \mathbf{0} \\ \mathbf{0} \end{pmatrix}, \Sigma\right), \Sigma = \begin{pmatrix} \sigma_A^2 & \rho \sigma_A \sigma_B \\ \rho \sigma_A \sigma_B & \sigma_B^2 \end{pmatrix}$$

$$\Sigma^{-1} \sim \text{Wishart}\left(\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}, 2\right)$$

$$\theta^k \sim N(0, \tau_\theta)$$

$$\tau_\theta \sim \text{Gamma}(0.0001, 0.0001)$$

Parameters of interest

- Difference in choice parameters:

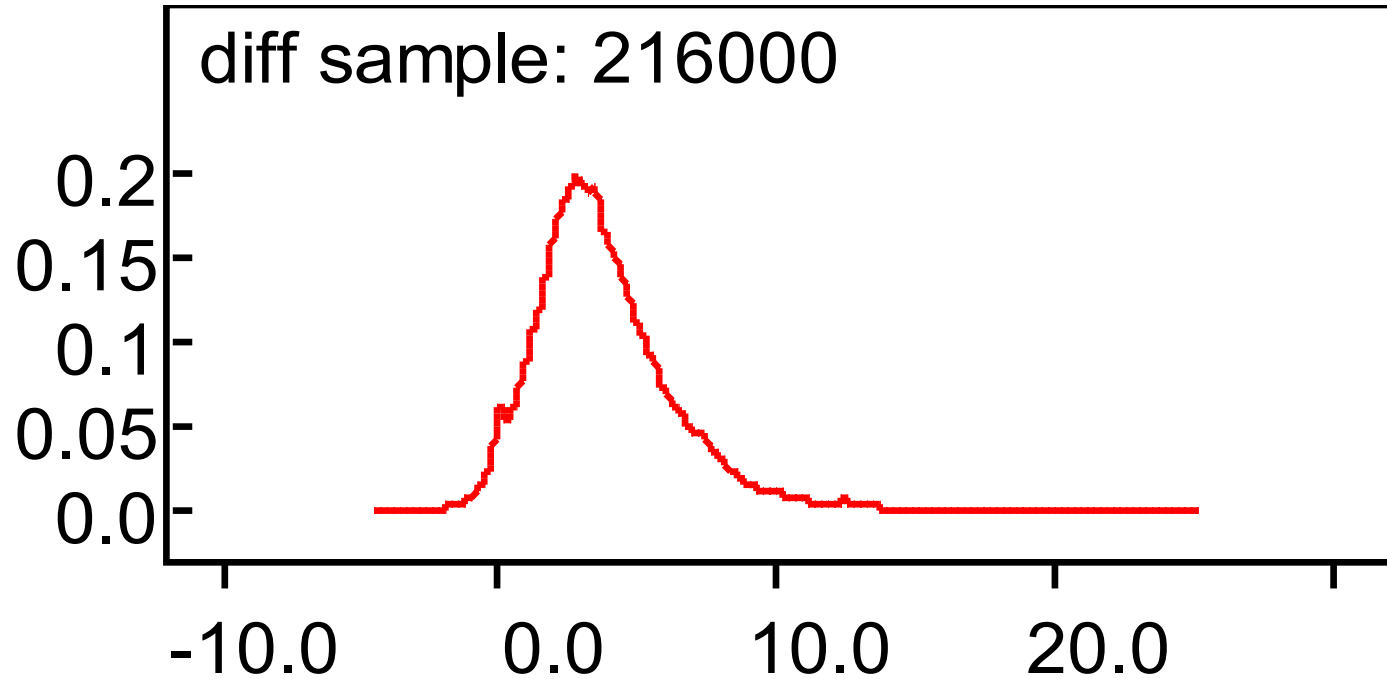
$$\Delta = \theta^A - \theta^B$$

- We are interested in the posterior distribution of Δ

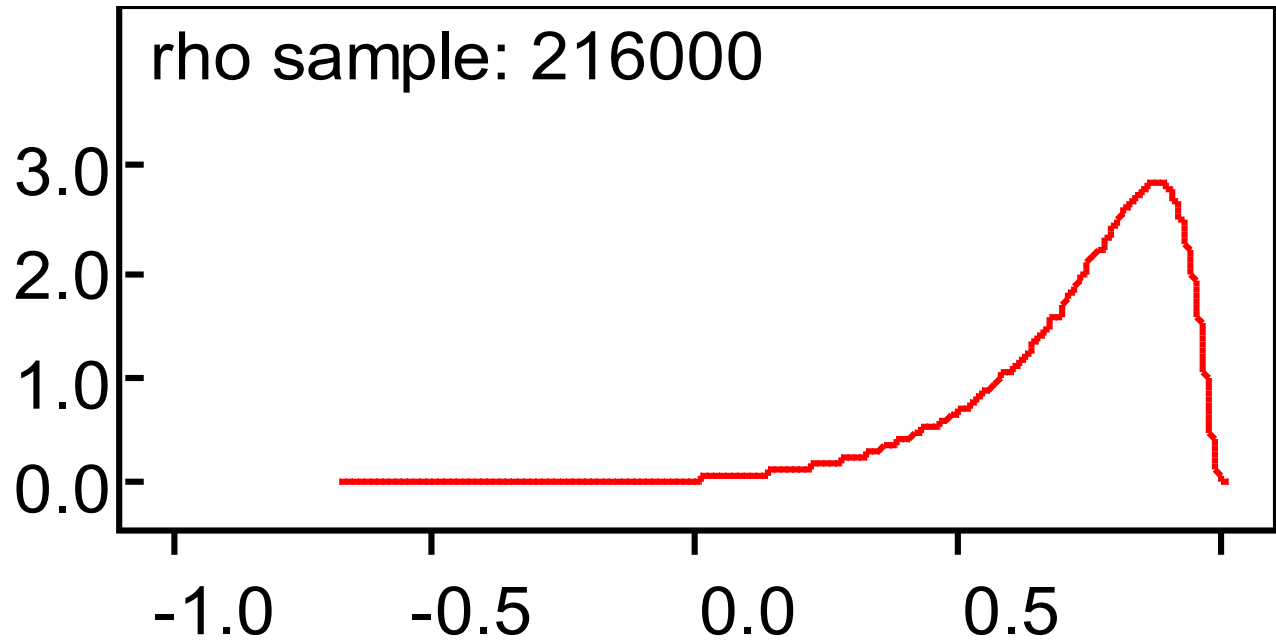
Results

param	mean	sd	MC error	2.50%	5.00%	median	95.00%	97.50%
Δ	3.896	2.878	0.1112	-0.202	0.2239	3.407	8.975	11.29
θ^A	-3.564	1.907	0.07833	-7.318	-6.535	-3.681	-0.0061	0.0645
θ^B	-7.459	3.554	0.1488	-15.93	-13.71	-7.166	-2.168	-0.3507
ρ	0.7232	0.21	0.003121	0.2017	.3206	0.7744	0.9476	0.9621
σ_A	2.689	0.89	0.02019	1.482	1.605	2.515	4.367	4.9
σ_B	3.932	2.2	0.06824	1.598	1.791	3.392	7.847	9.604

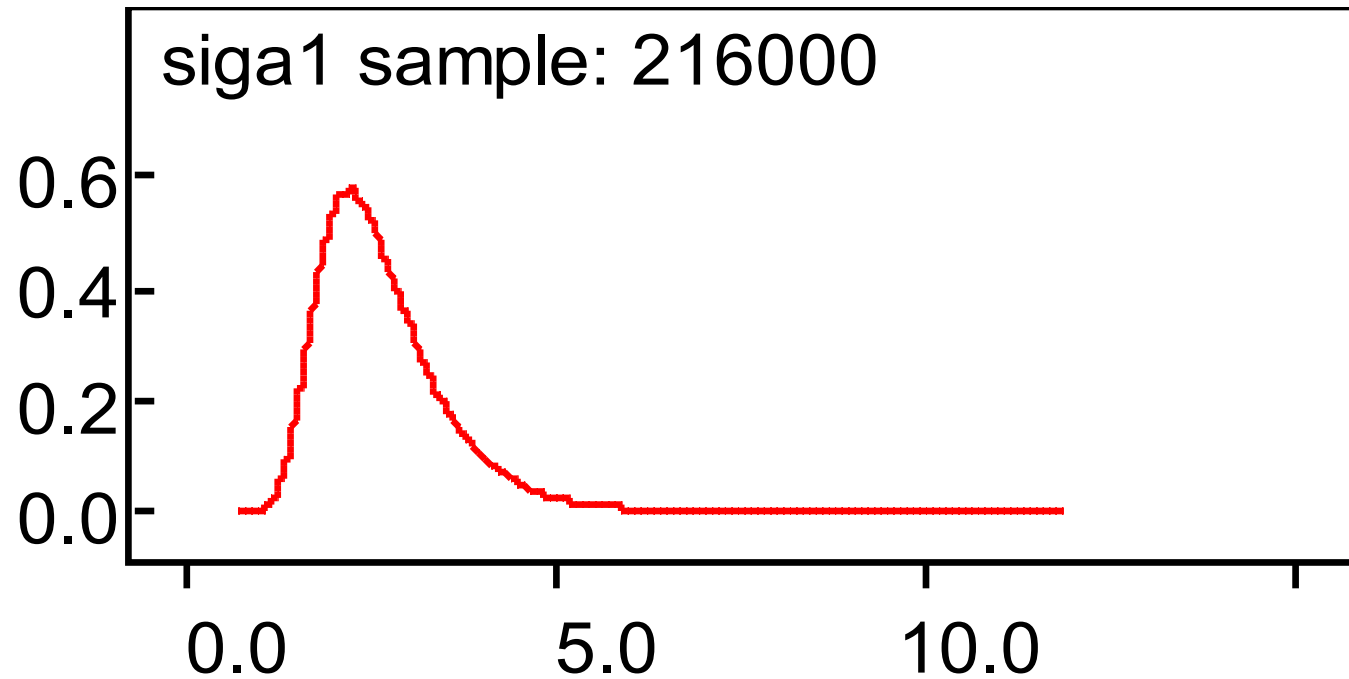
Results



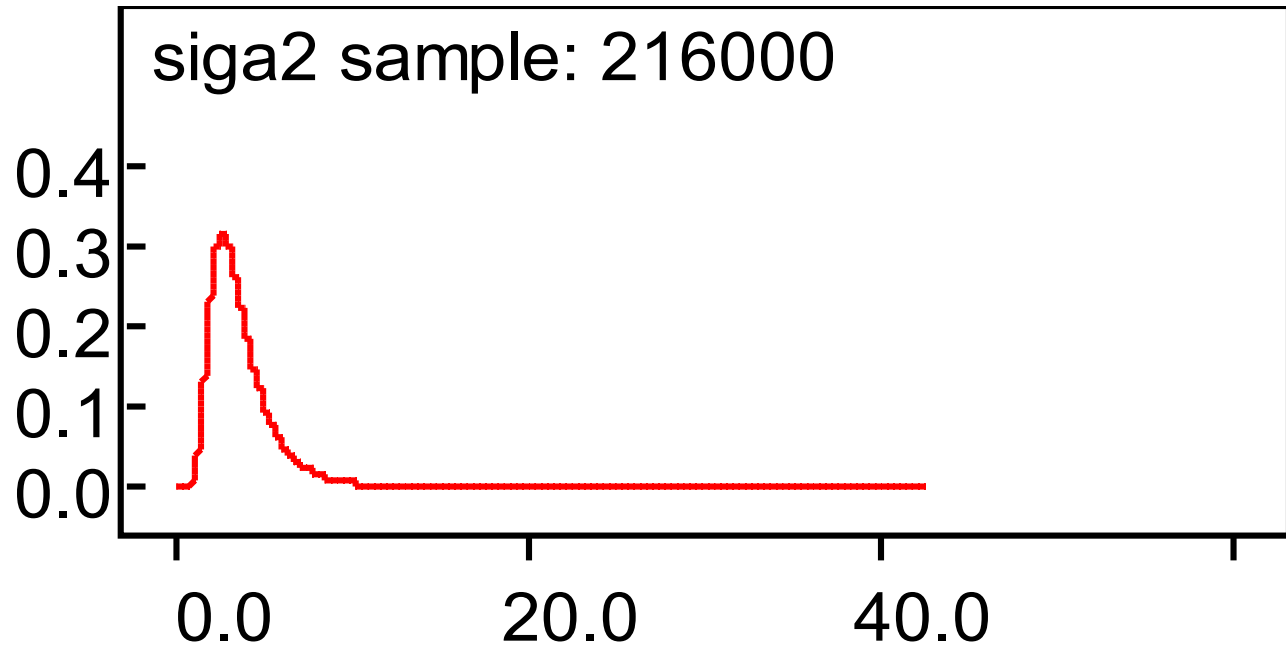
Results



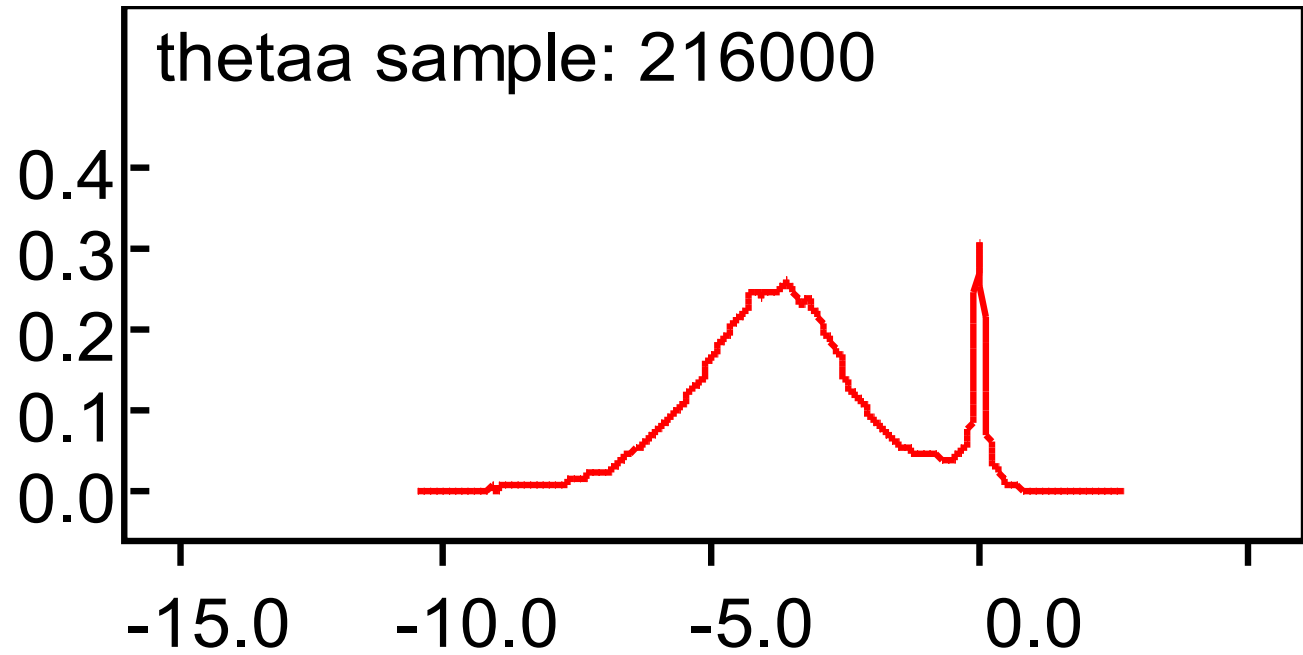
Results



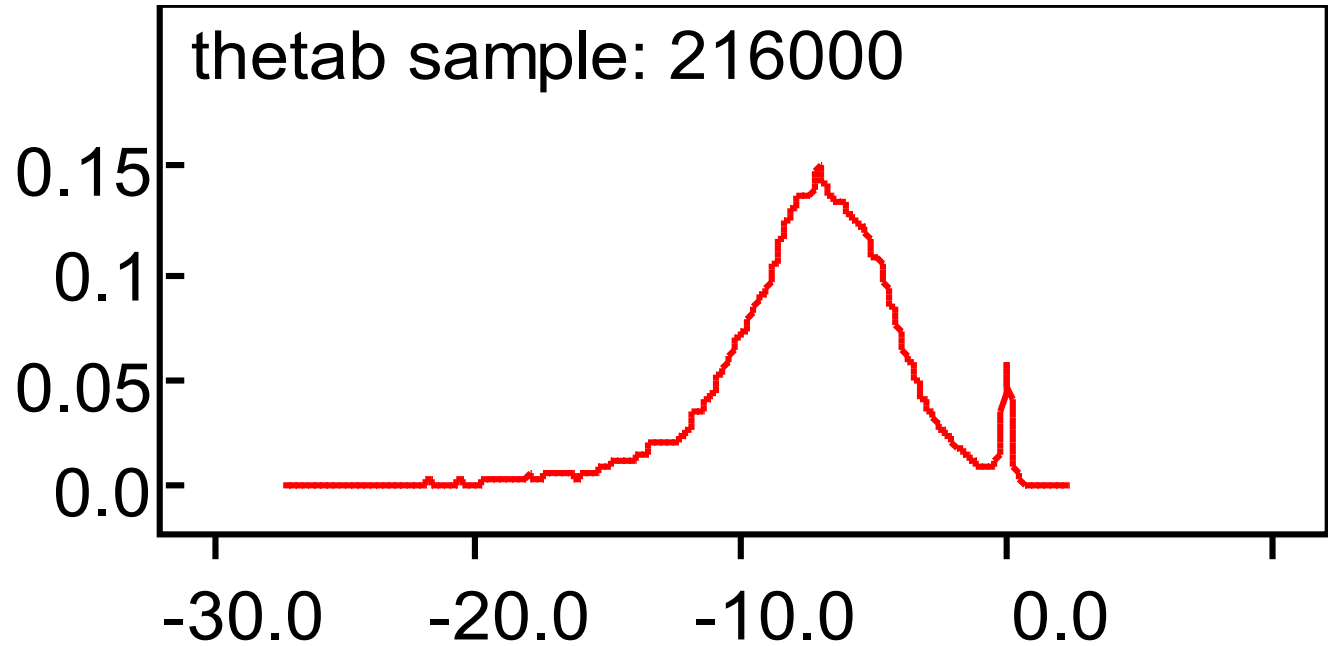
Results



Results



Results



Winbugs code

```
model {  
  
  for (i in 1:g1-1) { for (j in i+1:g1)  
    { y00a[i,j] ~ dbern(p00a[i,j])  
  
      log(p00a[i,j]) <- lambdaa[i,j]  
      y11a[i,j] ~ dbern(p11a[i,j])  
  
log(p11a[i,j]) <- lambdaa[i,j] + thetaa + a[i,1] + a[j,1]  
  
lambdaa[i,j] <- -log(1 + exp(thetaa + a[i,1] + a[j,1]))  
  y00b[i,j] ~ dbern(p00b[i,j])  
  
      log(p00b[i,j]) <- lambdab[i,j]  
      y11b[i,j] ~ dbern(p11b[i,j])  
  
log(p11b[i,j]) <- lambdab[i,j] + thetab + a[i,2] + a[j,2]  
  
lambdab[i,j] <- -log(1 + exp(thetab + a[i,2] + a[j,2] ))  
  
  }  
}
```

Winbugs code

```
for (j in 1:g1-1) { for (i in j+1:g1)
  { y00a[i,j] ~ dbern(p00a[i,j])

    log(p00a[i,j]) <- lambdaa[i,j]
    y11a[i,j] ~ dbern(p11a[i,j])

log(p11a[i,j]) <- lambdaa[i,j] + thetaa + a[i,1] + a[j,1]

lambdaa[i,j] <- -log(1 + exp(thetaa + a[i,1] + a[j,1]))
  y00b[i,j] ~ dbern(p00b[i,j])

    log(p00b[i,j]) <- lambdab[i,j]
    y11b[i,j] ~ dbern(p11b[i,j])

log(p11b[i,j]) <- lambdab[i,j] + thetab + a[i,2]+ a[j,2]

lambdab[i,j] <- -log(1 + exp(thetab + a[i,2] + a[j,2] ))
```

Winbugs code

```
diff <- thetaa-thetab
```

```
for (i in 1:g1) { a[i,1:2] ~ dnorm(zero[],prec.a[,]) }  
for (k in 1:2) {zero[k] <- 0}  
prec.a[1:2,1:2] ~ dwish(b[,],nu)  
nu<-2  
for (k in 1:2) {b[k,k] <- 1}  
b[1,2]<-0  
b[2,1]<-0  
thetaa ~ dnorm(0,tau.thetaa)  
tau.thetaa ~ dgamma(0.0001,0.0001)  
thetab ~ dnorm(0,tau.thetab)  
tau.thetab ~ dgamma(0.0001,0.0001)  
sigmaa[1:2,1:2] <- inverse(prec.a[,])  
rho <- sigmaa[1,2]/sqrt(sigmaa[1,1]*sigmaa[2,2])  
siga1 <- sqrt(sigmaa[1,1])  
siga2 <- sqrt(sigmaa[2,2])  
}
```

```
# Initial values
```

```
list(thetaa=0,tau.thetaa=1,  
thetab=0,tau.thetab=1
```

```
)
```

Winbugs code

```
#Data file  
list(g1=17,
```

```
y00a = structure(.Data = c(  
0,1,1,1,1,1,1,1,0,1,1,1,1,1,1,1,  
1,0,0,1,1,1,1,0,0,0,1,1,1,1,0,  
1,0,0,0,1,1,1,1,1,0,1,1,1,1,0,  
1,1,0,0,0,1,1,1,1,1,1,1,1,0,1,1,  
1,1,1,0,0,0,1,1,1,1,1,1,1,1,1,1,  
1,1,1,1,0,0,1,1,0,1,0,1,1,1,1,1,  
1,1,1,1,1,0,1,1,1,1,1,1,1,1,1,1,  
1,1,1,1,1,1,0,1,1,1,1,1,1,1,1,1,  
0,0,1,1,1,0,1,1,0,1,1,1,1,1,1,1,  
1,0,1,1,1,1,1,1,0,1,1,1,1,1,1,1,  
1,0,0,1,1,0,1,1,1,0,1,1,1,1,1,0,  
1,1,1,1,1,1,1,1,1,1,0,1,1,1,1,1,  
1,1,1,1,1,1,1,1,1,1,1,0,1,1,1,1,  
1,1,1,1,1,1,1,1,1,1,1,1,1,0,1,1,1,  
1,1,1,0,1,1,1,1,1,1,1,1,1,0,1,1,  
1,1,1,1,1,1,1,1,1,1,1,1,1,1,0,1,  
1,0,0,1,1,1,1,1,1,0,1,1,1,1,1,0),..Dim=c(17,17)),
```

```
y11a = structure(.Data = c(  
0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,  
0,0,1,0,0,0,0,0,1,1,1,0,0,0,0,1,  
0,1,0,1,0,0,0,0,0,1,0,0,0,0,1,  
0,0,1,0,1,0,0,0,0,0,0,0,0,1,0,0,  
0,0,0,1,0,1,0,0,0,0,0,0,0,0,0,0,  
0,0,0,0,1,0,0,0,1,0,1,0,0,0,0,0,  
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,  
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,  
1,1,0,0,0,1,0,0,0,0,0,0,0,0,0,0,  
0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,  
0,1,1,0,0,1,0,0,0,0,0,0,0,0,0,1,  
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,  
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,  
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,  
0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,  
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,  
0,1,1,0,0,0,0,0,1,0,0,0,0,0,0,0),..Dim=c(17,17)),
```

