Cognition vs time as constraints in the structuring of human social networks

Robin Dunbar
British Academy Centenary Project
Institute of Cognitive & Evolutionary Anthropology
University of Oxford

robin.dunbar@anthro.ox.ac.uk
Convergence of Three Projects

- **British Academy’s “Lucy Project”**
  
  http://www.liv.ac.uk/lucy2003/
  
  - Liverpool (Archaeology + Psychology), Kent (Social Psychology)
  - how social bonds work
  - cognition and brain evolution (Social Brain Hypothesis)

- **EPSRC/ESRC DTESS Project**
  
  http://www.informatics.man.ac.uk/research/groups/isd/projects/dtess
  
  - Manchester Business School + Sheffield Hallam
  - Integrating Small-Groups-as-Dynamic-Systems Theory with Social Brain Hypothesis

- **EU-FP7 SOCIALNETS Project**
  
  http://www.social-nets.eu/
  
  - Computer Sciences at Cambridge and Cardiff; + EU partners
  - How to design better networking technology
The Social Brain Hypothesis

Primates have big brains because they live in a complex social world

- Predicted group size for humans is ~150
- “Dunbar’s Number”
Human Social Networks

These all have mean sizes of 100-200

Neolithic villages 6500 BC 150-200
military units (company) (N=10) 180
* Hutterite communities (N=51) 107
Nebraska Amish parishes (N=8) 113
business organisation <200
ideal church congregations <200
Doomsday Book villages 150
C18th English villages 160
* GoreTex Inc’s structure 150
Research sub-disciplines (N=13) 100-200

Small world experiments (N=2) 134
Hunter-Gatherer communities 148
Xmas card networks 154

“Reverse” Small World Experiments

Hunter-Gatherer Societies
Dunbar (1993)

Xmas Card Networks
What Makes it Work?

- Personalised relationships
- Trust
- Expectations of reciprocity
- In traditional societies:
  - kinship
  - a shared history

The Atapuerca “family” [Homo heidelbergensis]
Hidden Structure of Social Networks

- Stable points in group size at:
  - 5-7
  - 12-15
  - ~35
  - ~80?
  - ~150

The Fractal Periodicity of Human Group Sizes

Peak at $\omega = 5.4$

Social Groupings Database [N=60]

Scaling ratio = $\exp(2\pi/\omega)$
= 3.2 and 3.3

Horton Order Analysis of Hunter-Gatherer Group Sizes

Peak at $\omega = 5.2$

Xmas Card Database


Hamilton et al (2007)
Intimacy, Frequency and Trust

- Relationship between frequency of contact and intimacy
- Trust and obligation seem to be important

The Circles of Acquaintanceship

- A hierarchically inclusive series of levels of acquaintanceship
- Levels reflect familiarity and emotional closeness
- There are at least TWO more layers at ~500 and ~1500
  [is this where weak “work” ties lie?]
**Friends ≠ Kin**

- Friends and Kin are not the same thing
- Friendship requires emotional closeness
- We have no choice about Kin
- Hence: Friendships are fragile….
  
  ….Kinship is robust
  
  [We put up with them even though we don’t particularly like them]
Structure of Networks

- For relationships indexed on a 1-10 scale:
  - Among UNRELATEDs:
    - medium strength links predominate
    - large networks exhibit more STRONG links
  - Among RELATEDs:
    - Weak and Medium links predominate
    - large networks exhibit more WEAK links

---

Unrelated Alters

- Medium
- Weak
- Strong

Median percentage of unrelated network

<55 55-82 >82

Related Alters

- Weak
- Medium
- Strong

Median percentage of related network

<55 55-82 >82

Total Network Size

Over 82
Blood is Thicker than water

- Kin are given priority over Friends
- Kinship may reduce the cognitive load?

![Graph showing related and unrelated networks](attachment:graph.png)
### Estimating the Limit on Network Size

<table>
<thead>
<tr>
<th>N</th>
<th>P</th>
<th>Maximum Network Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>0.011</td>
<td>150.0</td>
</tr>
<tr>
<td>8</td>
<td>0.002</td>
<td>146.1</td>
</tr>
<tr>
<td>10</td>
<td>0.001</td>
<td>144.5</td>
</tr>
<tr>
<td>12</td>
<td>0.004</td>
<td>145.3</td>
</tr>
<tr>
<td>14</td>
<td>0.004</td>
<td>141.8</td>
</tr>
<tr>
<td>16</td>
<td>0.001</td>
<td>136.3</td>
</tr>
</tbody>
</table>

The table shows the estimated limits on network size for different values of N, along with the corresponding probabilities (P) and maximum network sizes. The graph illustrates the relationship between related network size and unrelated network size, with a trend line indicating the estimated limit on network size as N increases.
Two Unresolved Questions

Are human groupings limited by:

⇒ frequency of interaction

⇒ capacity for emotional closeness [i.e. cognition]

Is the limit at:

• higher level, with the internal structure a consequence of fragmentation [top down]?

• lower level, with higher levels simply being small-world emergent properties [bottom-up]?
A Role for the Social Brain

Intentionality as a reflexively hierarchical sequence of belief states

The Levels of Intentionality

...that may be very costly in computational terms
The Limits to Intentionality...

A natural limit at 5th order intentionality:

“I intend that you believe that Fred understands that we want him to be willing to [do something]…” [level 5]

The Story-Teller’s Art

- BUT…
  Shakespeare had to do SIX

- The audience has to do FIVE orders of intentionality

Stories (especially “origins” stories) are an integral part of community-bonding
Is Mentalising Costly? 
Two Experiments

Reaction Time Experiment
N = 8
Mentalising vs Memory (controlling for order)
accuracy: p = 0.919
RT: p < 0.05

Functional Imaging Experiment
fMRI [BOLD]
5 stories
with 20 mentalising and memory questions @ levels 2, 3 and 4
N=17
Areas with significant parametric effects on the contrast [intentionality > memory] at p=0.001 uncorrected

After FWE correction [p=0.05]:
right TPJ, bilateral TP, right inferior FG, cerebellum

Significant effects for parametric contrast [ToM>memory] masked by nonparametric contrast [ToM>memory] (p<0.005 uncorrected)

Lewis, Birch & Dunbar (in prep)
Cognitive Limits to Sociality?

- Achievable intentionality level indexed from stories
- 5th order seems to be the limit

- Intentionality correlates with clique size

- We now have two neuroimaging studies to support this

[Stiller & Dunbar 2006]
A Volumetric Perspective

Optimised VBM
with modulation
[N=29 subjects, aged 18-50]

Grey matter volume correlates of network size for ToM > memory contrast [corrected p<0.005]:

- Middle frontal gyrus
- Orbitofrontal area
- Dorsolateral PFC
- ACC
- Hippocampus
- Amygdalla

among others, most bilaterally

Masked analysis for both ToM and network size
Social Bonding
Primate-Style

- Primate social bonds seem to involve two distinct components:
  - An emotionally intense component [=grooming]
  - A cognitive component [=brain size + cognition]
Why Does Grooming Work?

- Endorphins are relaxing.
- They create a psychopharmacological environment for building trust.

An experimental study with monkeys:

Opiates block social drive;

Opiate-blockers enhance social drive.

[Keeverne et al 1979]
How Much Time Should Humans Spend Grooming?

- If humans bonded their groups as primates do….
- Grooming time would be about \(~45\%\) of total day time
Physical Interaction may be Critical…

- A touch is worth a thousand words….

We underestimate the importance of physical contact

Touch may be critical in establishing “honesty”
Three Ways to Bridge the Gap?

- Modern humans
- Archaic humans
- Australopiths

Graph showing Predicted Grooming Time (%) over Millions Years BP:

- 50
- 40
- 30
- 20
- 10

- Religion and its rituals
- Music and dance
- Laughter, a cross-cultural trait shared with chimpanzees
An Opium for the Masses?

Religious practices are often well suited to stimulate endorphins

Endorphins:
⇒ make you relaxed
⇒ may trigger the release of oxytocins (creating sense of “euphoric love”)
⇒ enhance sense of communality
⇒ positively influence immune system

Ellen Goodman

[Image of Medieval flagellants]
[Image of Bernini’s "Ecstasy of St Theresa of Avila"]

Modern whirling dervishes [an Islamic Sufi sect]
Laughter
The Best Medicine?

In a Public Goods Game (Prisoner’s Dilemma)
Ss were more generous to strangers (but not friends) after watching a comedy video

van Vugt et al (submitted)
Lessons for Networking

Technology?

- Constraint may be internal rather than technical
- Why do people want to contact each other?
- Are all contacts really equal?
- Can technology ever replace face-to-face?

Texting:
- Averaging 120 texts per day to just 2 people

Technology:
- May slow relationship decay rate, but be poor for creating new ones
Conclusions

- There are cognitive constraints on sociality
- Human social groupings are structured in discrete layers
- Does Cognition or Time (or both) limit network size and structure?
- So….
  - Will cognition limit electronic networks?
  - Can technology help us to overcome this?