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

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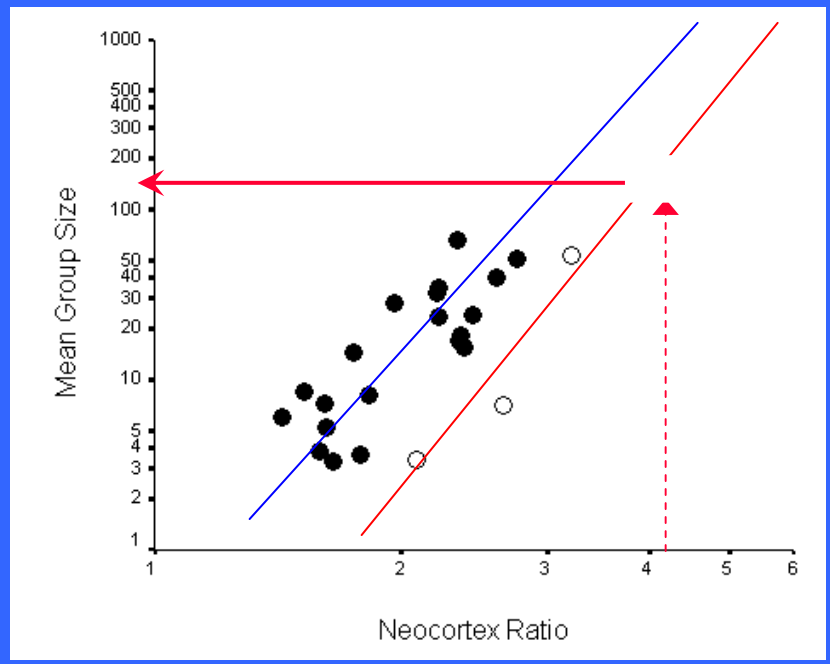
Convergence of Three Projects

- 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"

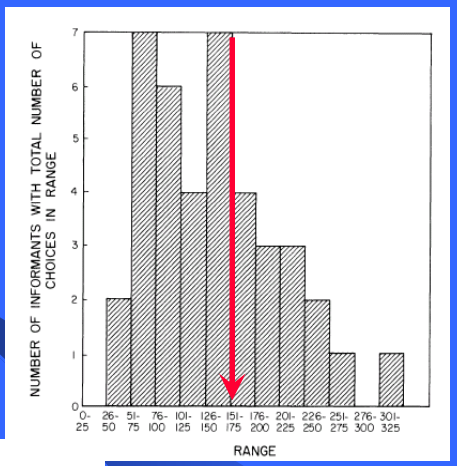
Human Social Networks

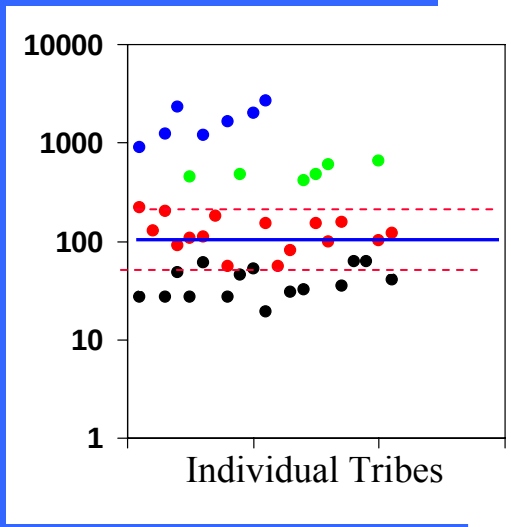
These all have mean sizes of 100-200

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

Killworth et al (1984)



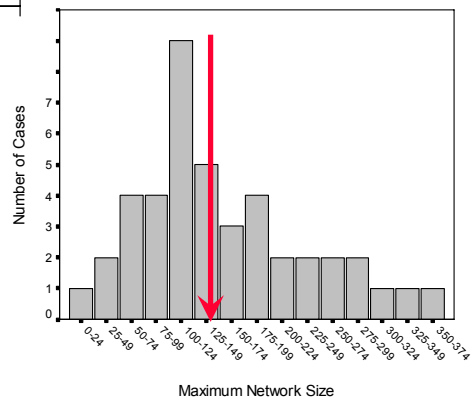


Hunter-Gatherer Societies

Dunbar (1993)

Xmas Card Networks

Hill & Dunbar (2003)



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:

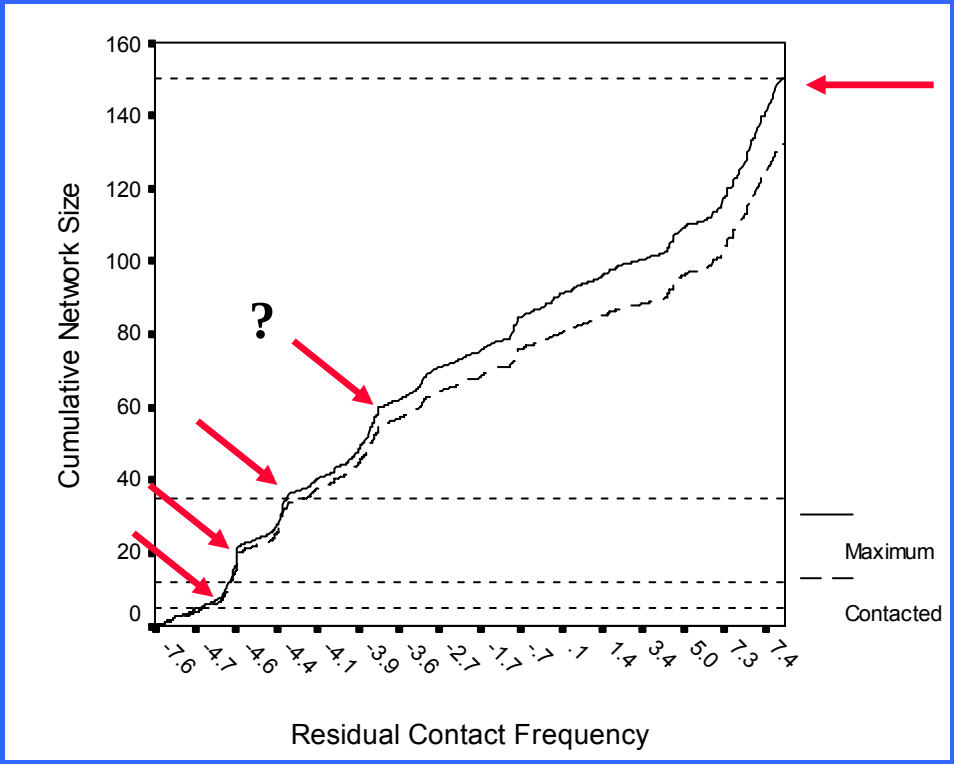
5-7

12-15

~35

~80?

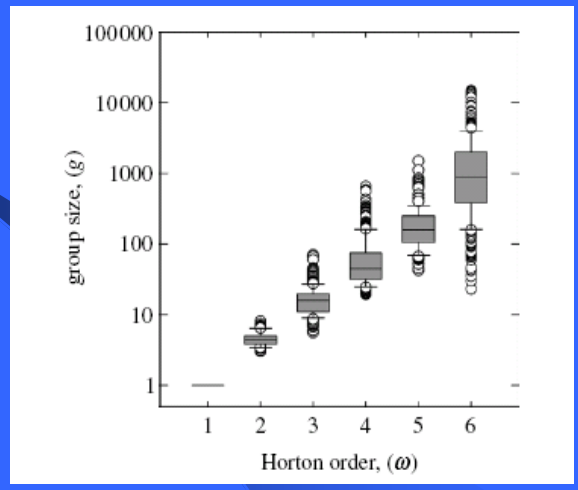
~150



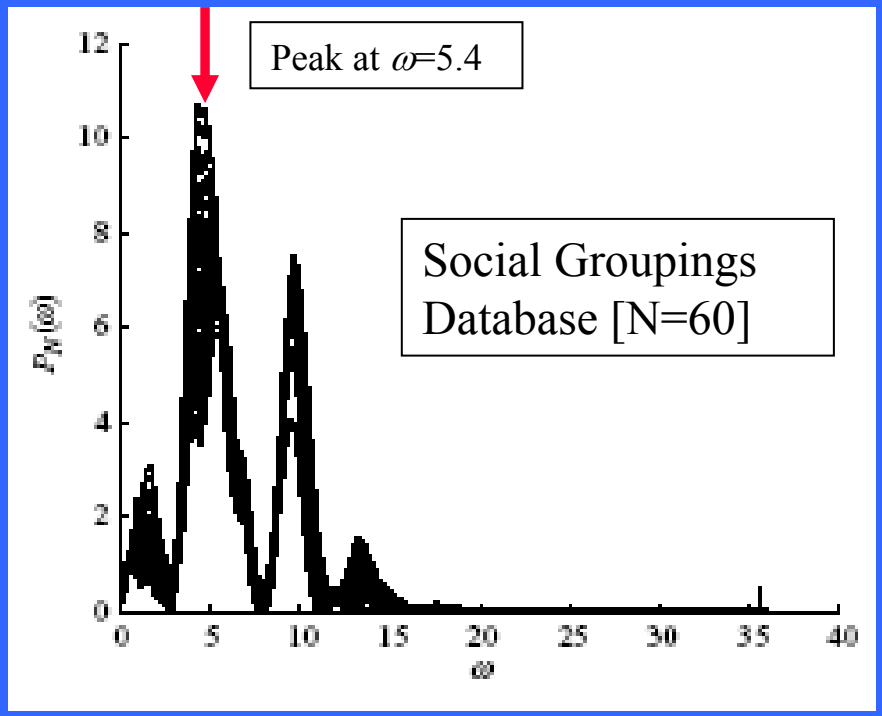
Hill & Dunbar (2003)

The Fractal Periodicity of Human Group Sizes

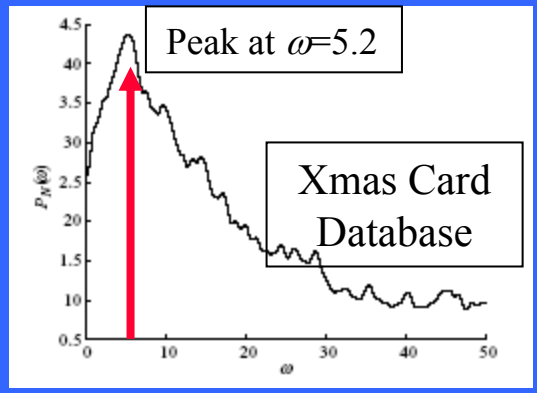
Horton Order Analysis of Hunter-Gatherer Group Sizes



Hamilton et al (2007)



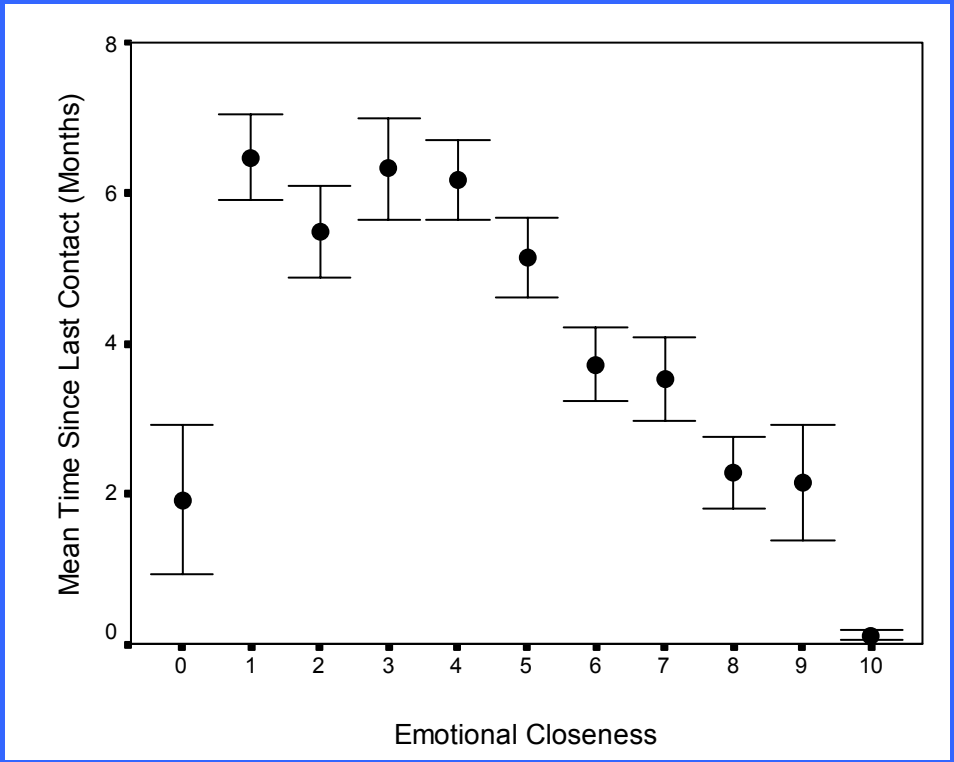
Scaling ratio = $\exp(2\pi/\omega)$
= 3.2 and 3.3



Zhou, Sornette, Hill & Dunbar (2005)

Intimacy, Frequency and Trust

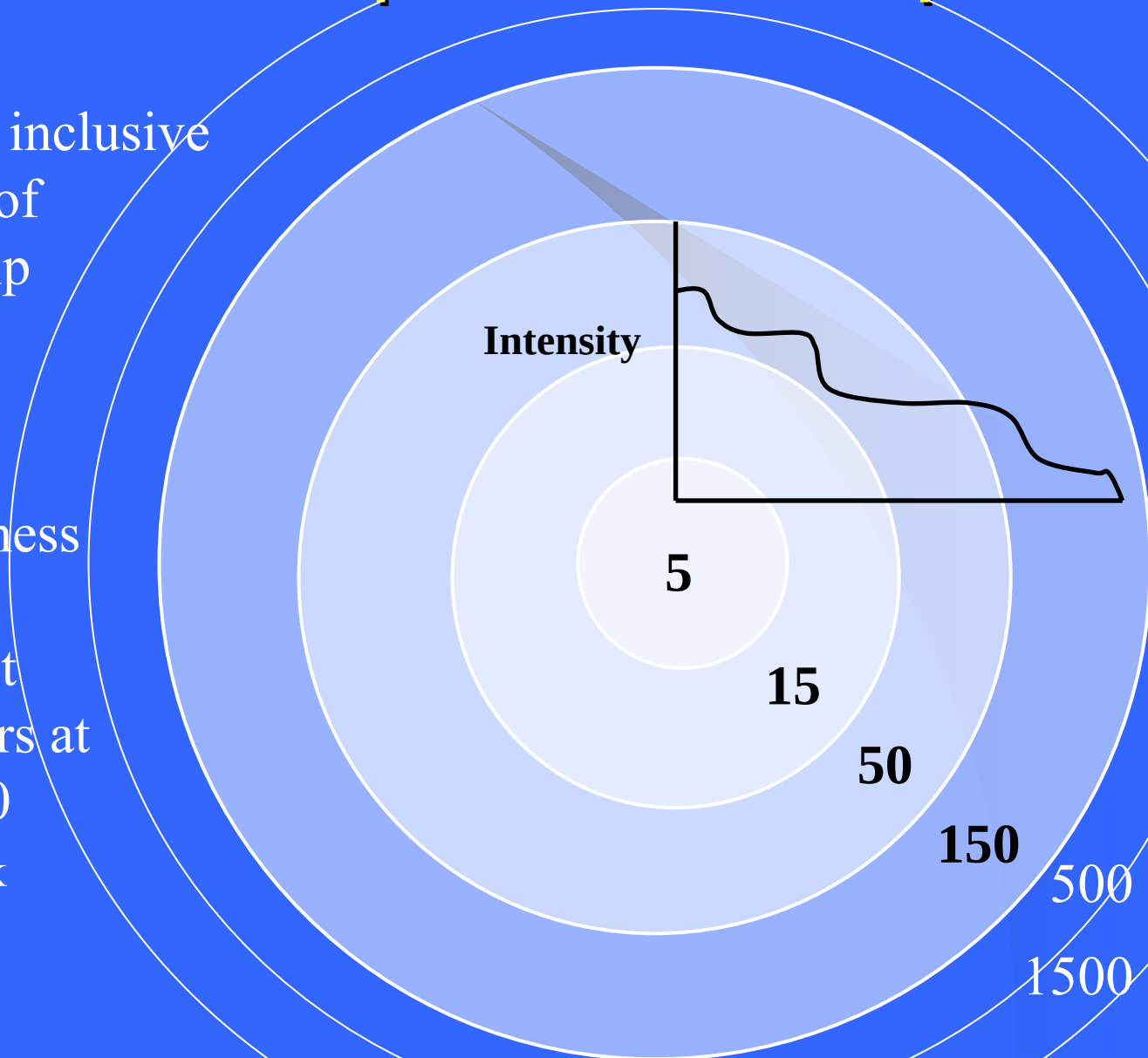
- Relationship between frequency of contact and intimacy
- Trust and obligation seem to be important



Hill & Dunbar (2003)

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?]

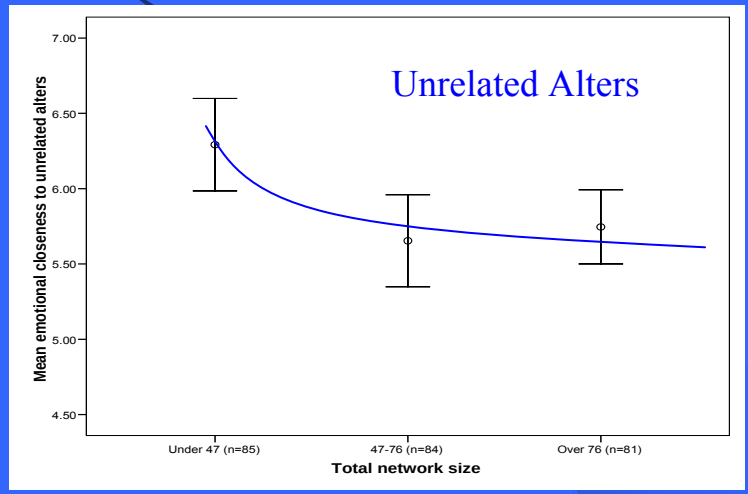


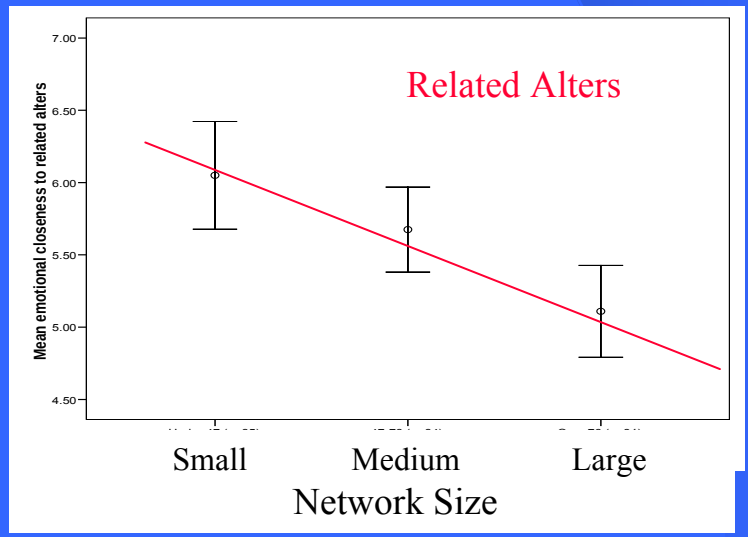
Friends ≠ Kin

- 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

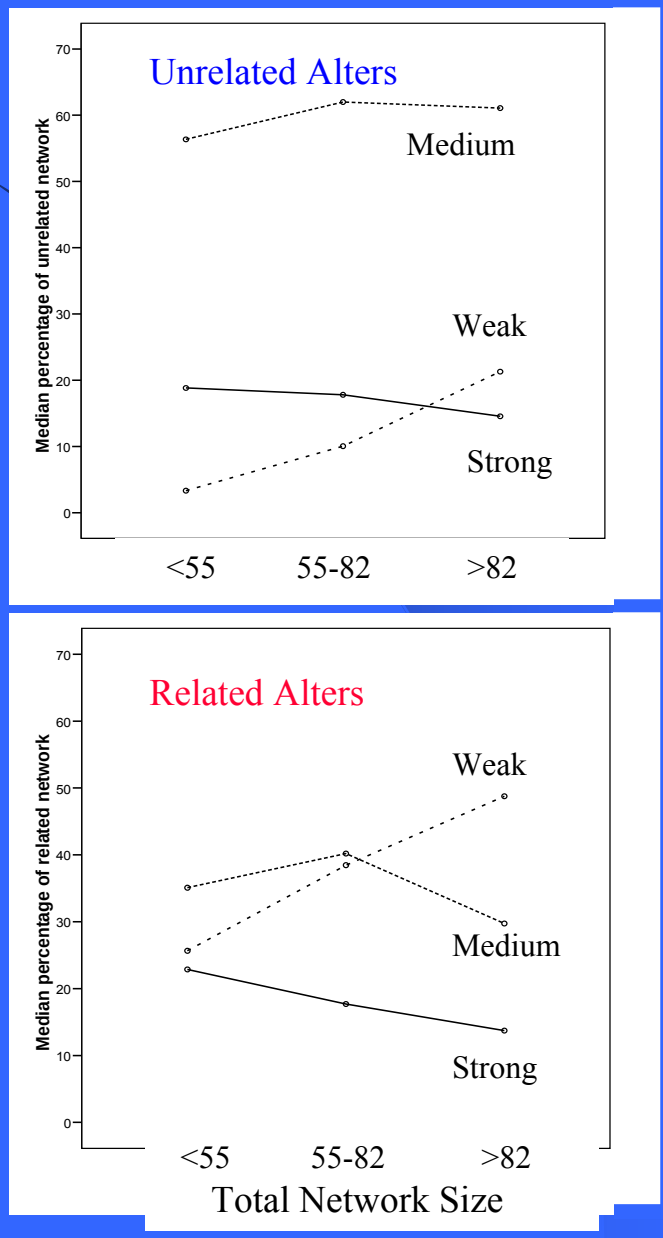
  [We put up with them even though we don't particularly like them]





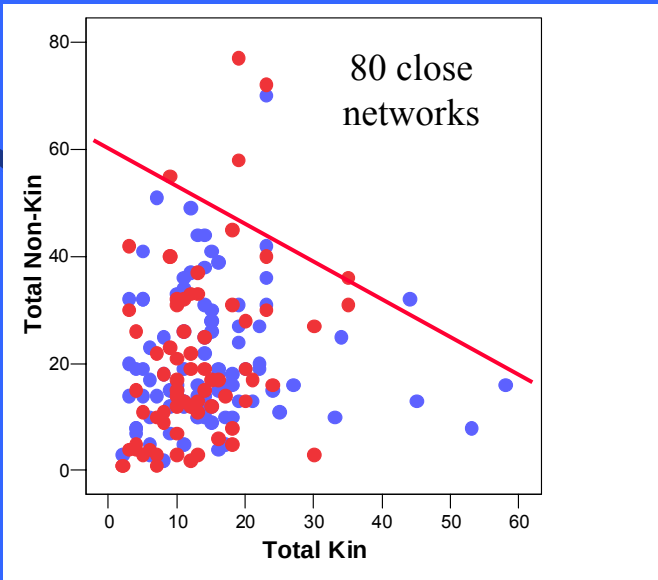
Structure of Networks

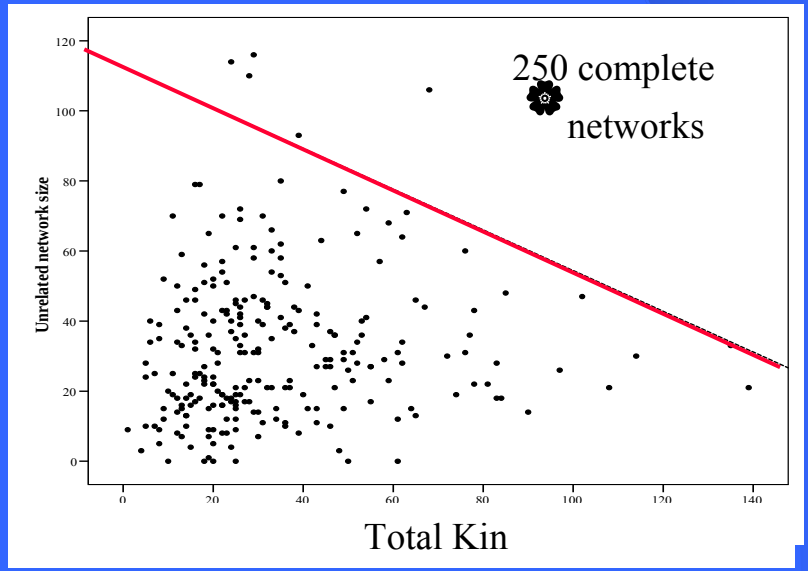
- For relationships indexed on a 1-10 scale:
- Among UNRELATEDs:
  - medium strength links predominate
  - large networks exhibit more STRONG links
- Among RELATEDs:
  - Weak and Medium links predominate
  - large networks exhibit more WEAK links



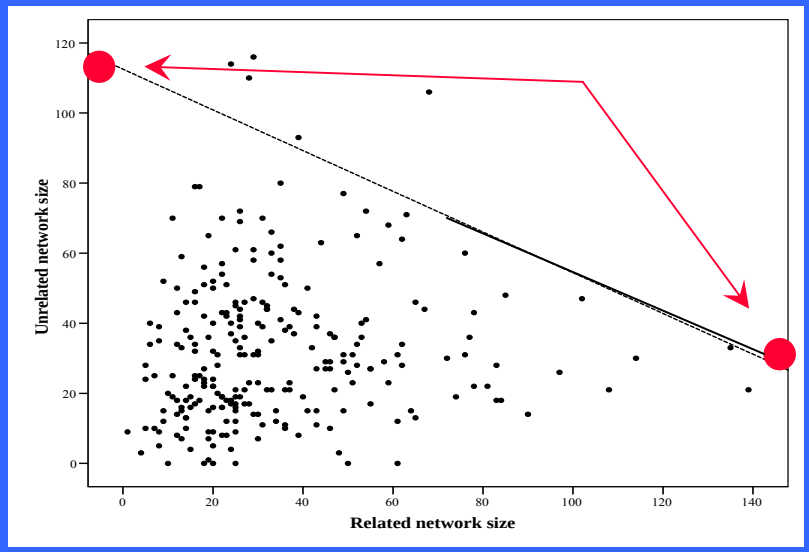
Blood is Thicker than water

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





Estimating the Limit on Network Size



N	P	Maximum Network Size
6	0.011	150.0
8	0.002	146.1
10	0.001	144.5
12	0.004	145.3
14	0.004	141.8
16	0.001	136.3

Two Unresolved Questions

Are human groupings limited by:

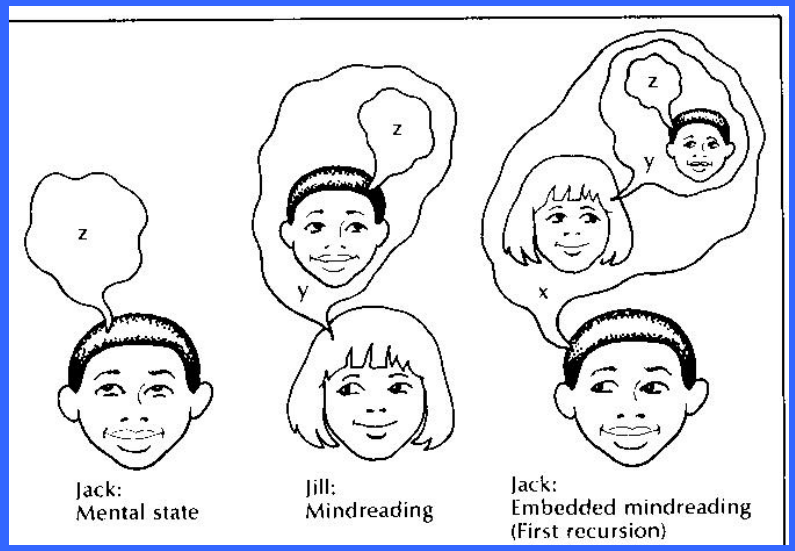
⇒ frequency of interaction

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

Is the limit at:

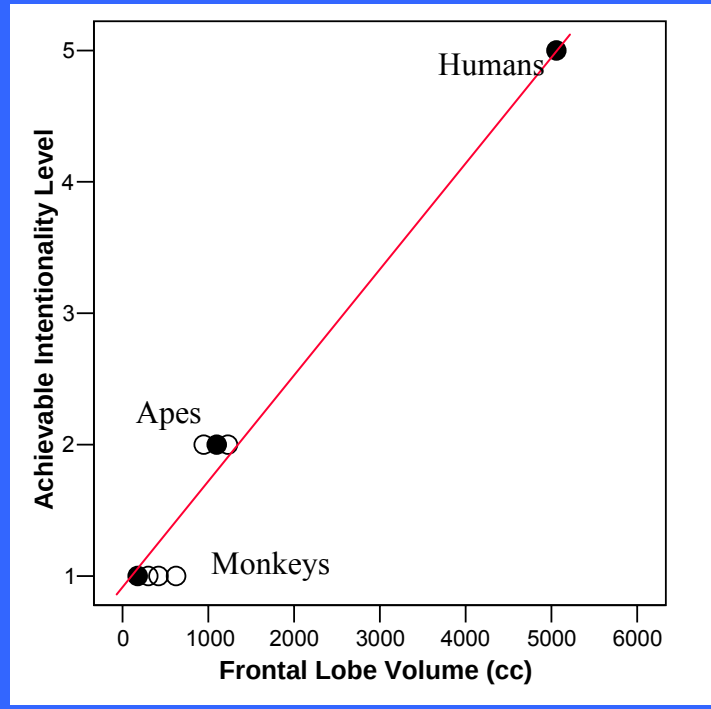
- higher level, with the internal structure a consequence of fragmentation [top down]?
- lower level, with higher levels simply being small-world emergent properties [bottom-up]?

A Role for the Social Brain



The Levels of Intentionality

Intentionality as a reflexively hierarchical sequence of belief states

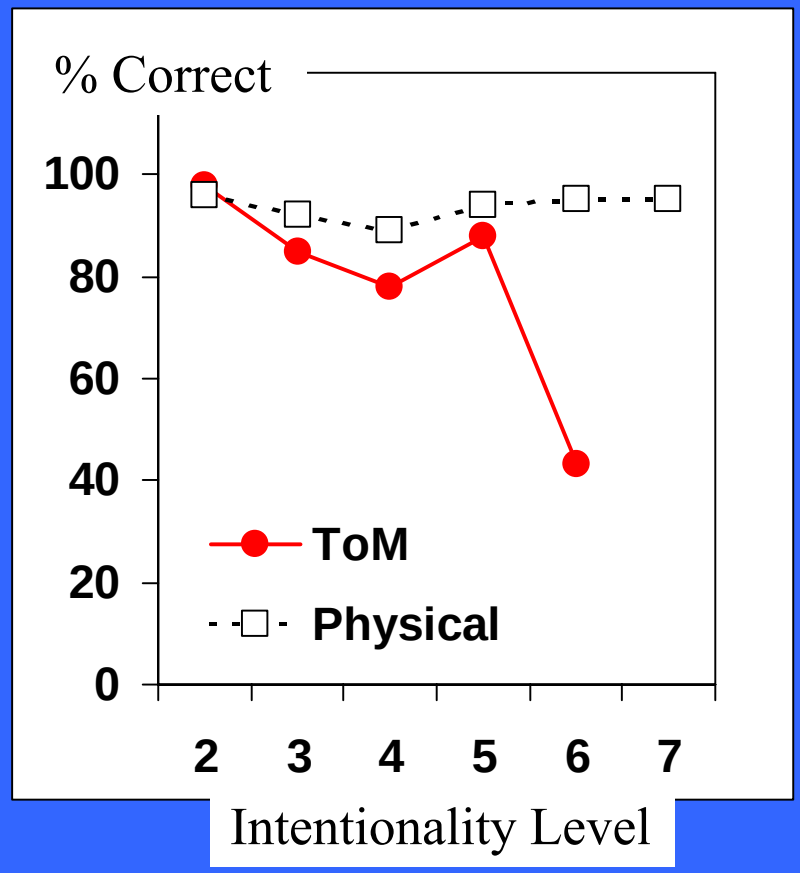


…that may be very costly in computational terms

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]

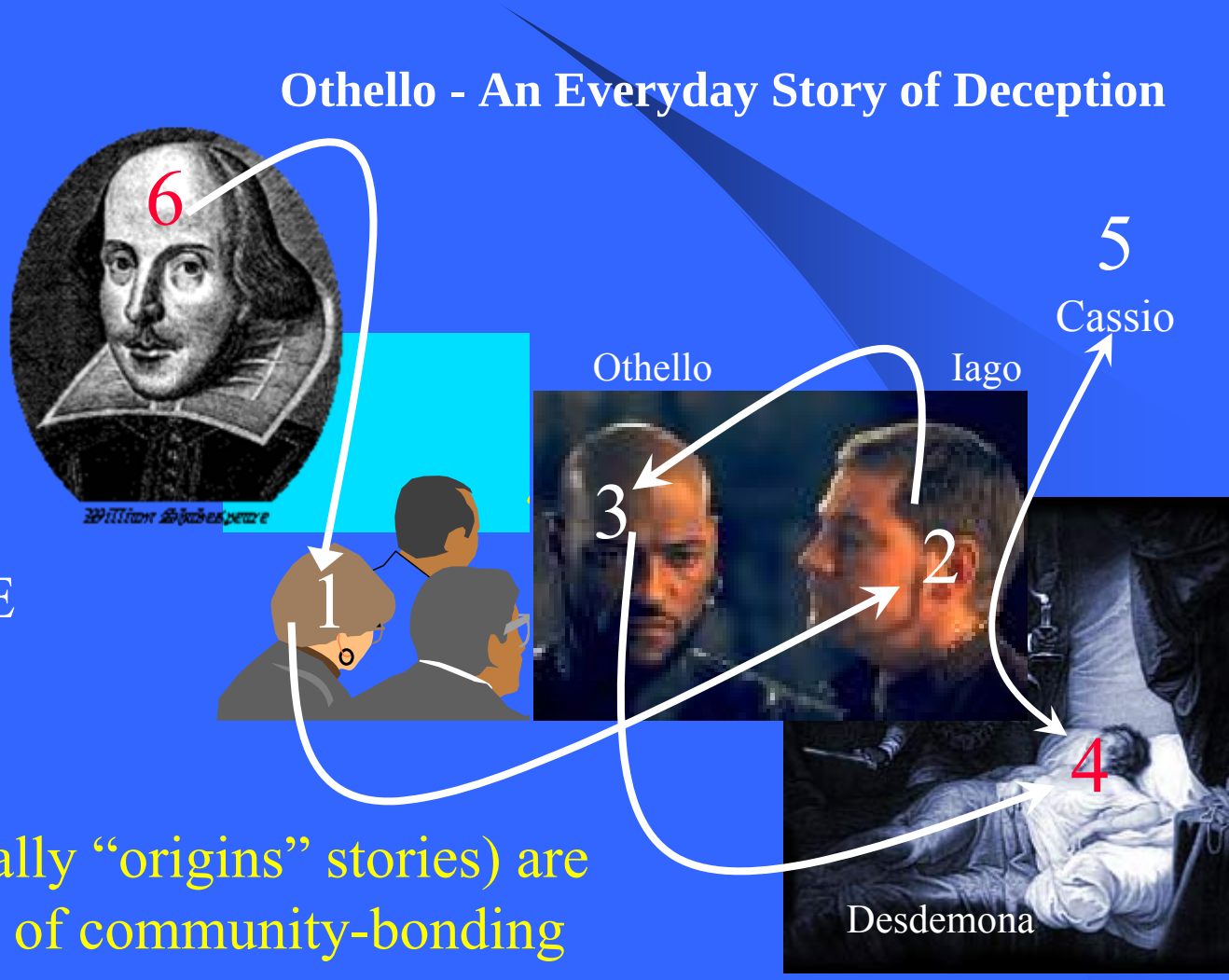


Kinderman, Dunbar & Bentall (1998).

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

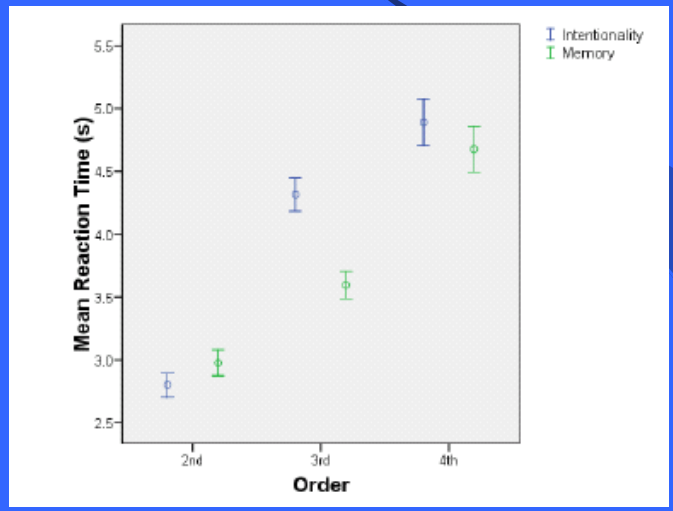
Reaction Time Experiment

N = 8

Mentalising vs Memory
(controlling for order)

accuracy: $p = 0.919$

RT: $p < 0.05$

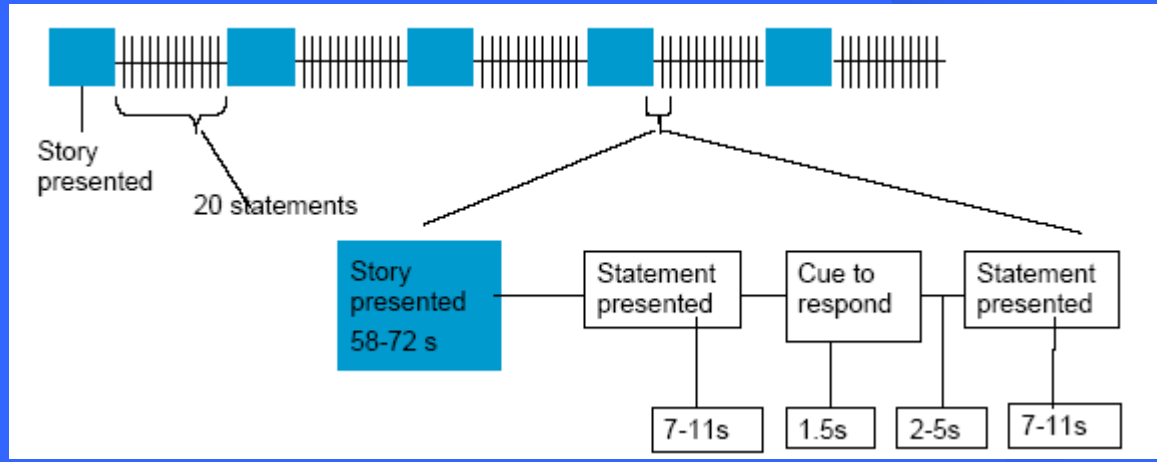


Functional Imaging Experiment

fMRI [BOLD]

5 stories
with 20 mentalising and memory questions @ levels 2, 3 and 4

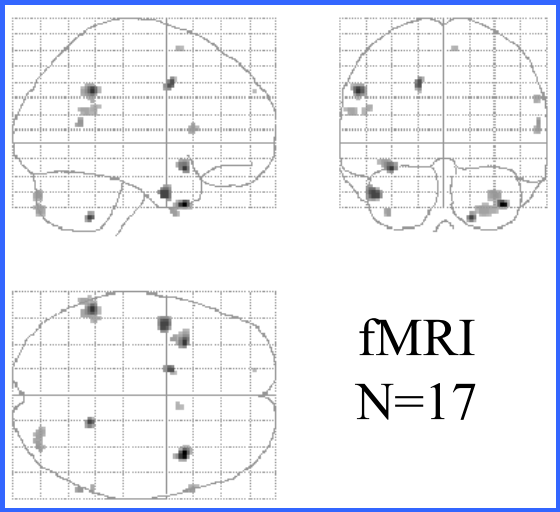
N=17



The Cognitive Demands of Mentalising?

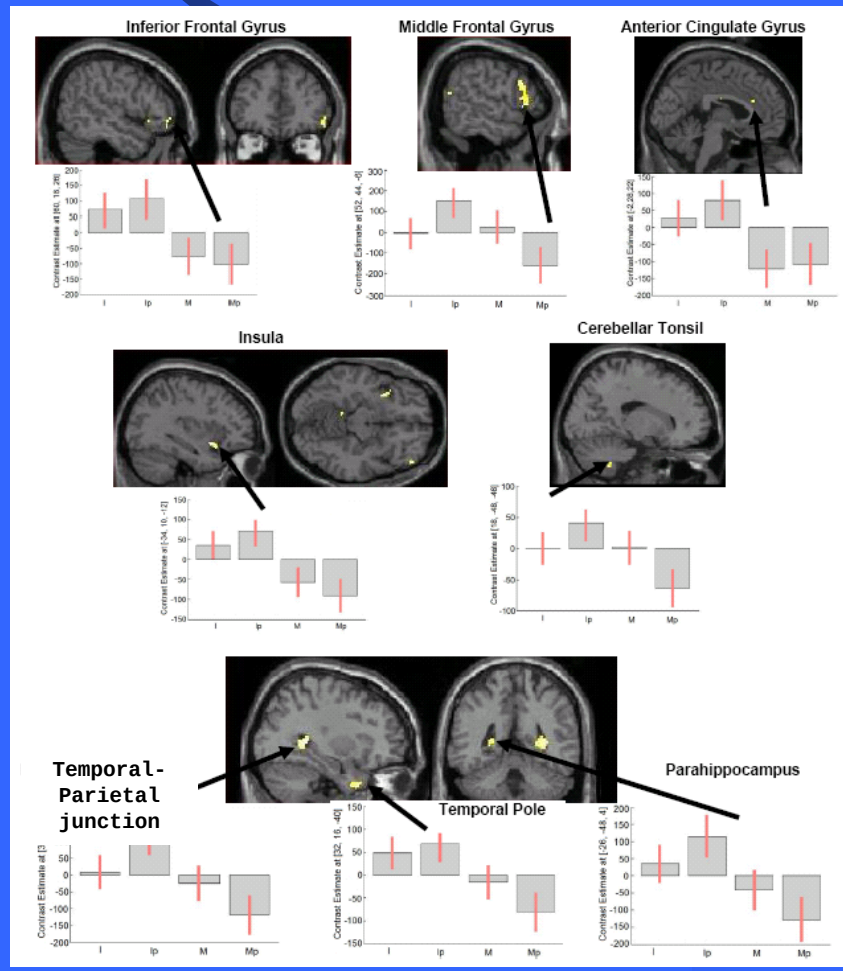
Areas with significant parametric effects on the contrast [intentionality > memory] at p=0.001 uncorrected

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



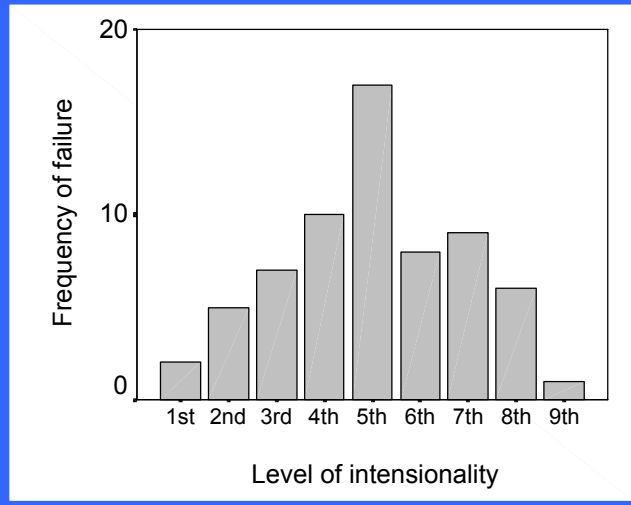
Lewis, Birch & Dunbar (in prep)

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

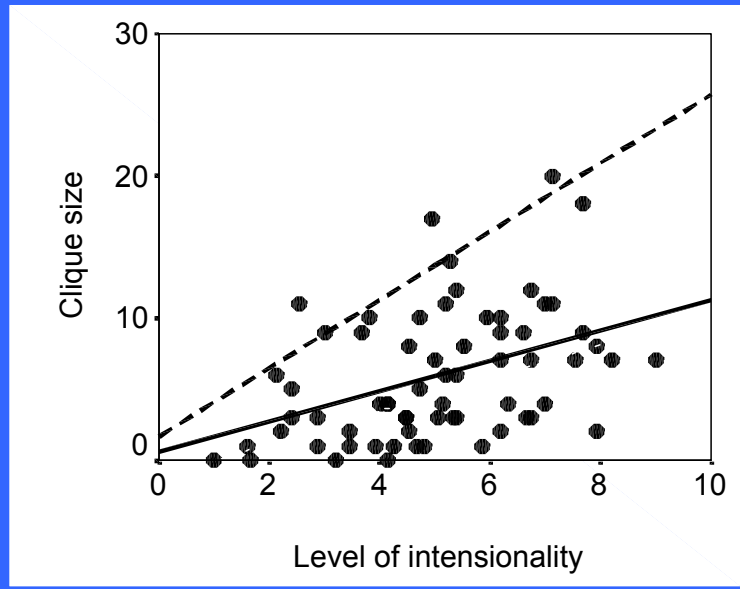


Cognitive Limits to Sociality?

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



- Intentionality correlates with clique size



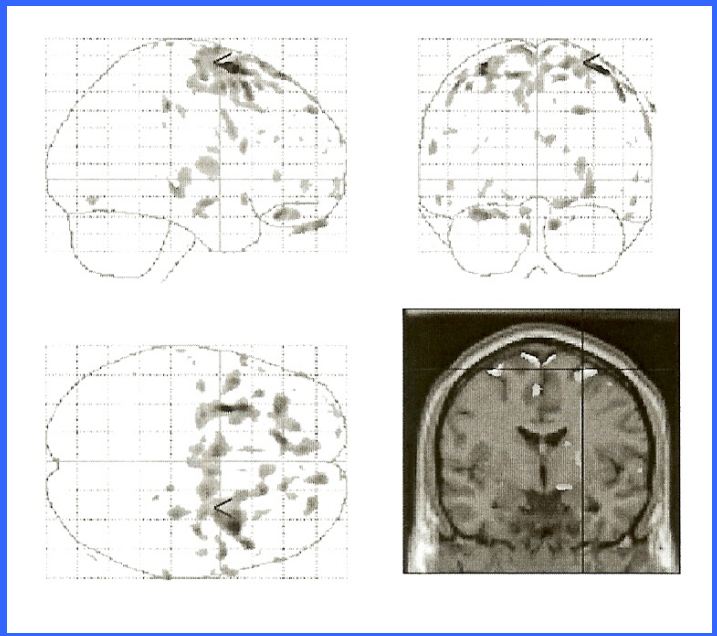
- We now have two neuroimaging studies to support this

[Stiller & Dunbar 2006]

A Volumetric Perspective

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

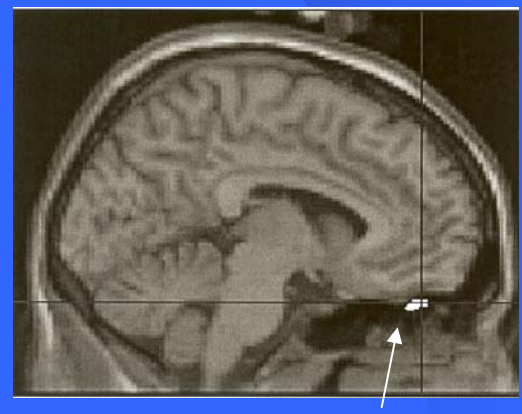
Grey matter volume correlates of network size for ToM > memory contrast [corrected p<0.005]:



Middle frontal gyrus
Orbitofrontal area
Dorsolateral PFC
ACC
Hippocampus
Amygdalla

among others, most bilaterally

Masked analysis for both ToM and network size



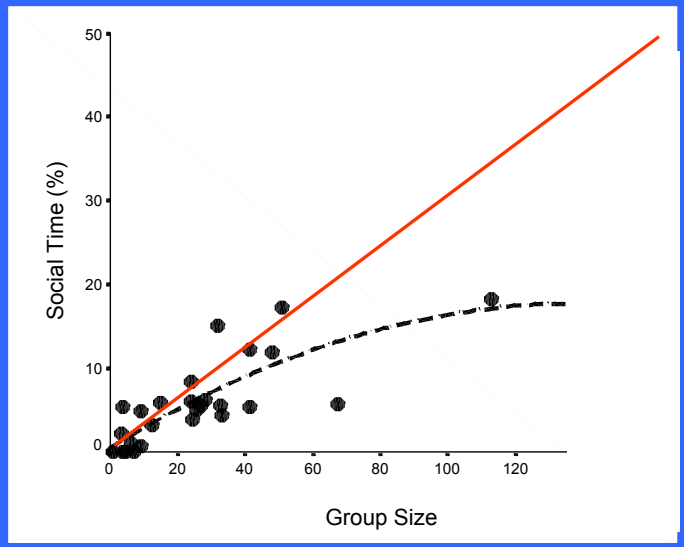
Orbitofrontal

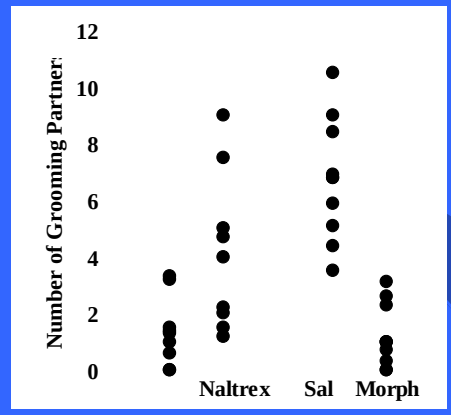
Lewis, Browne & Dunbar (in prep)

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?





[Keverne et al 1979]

An experimental study with monkeys

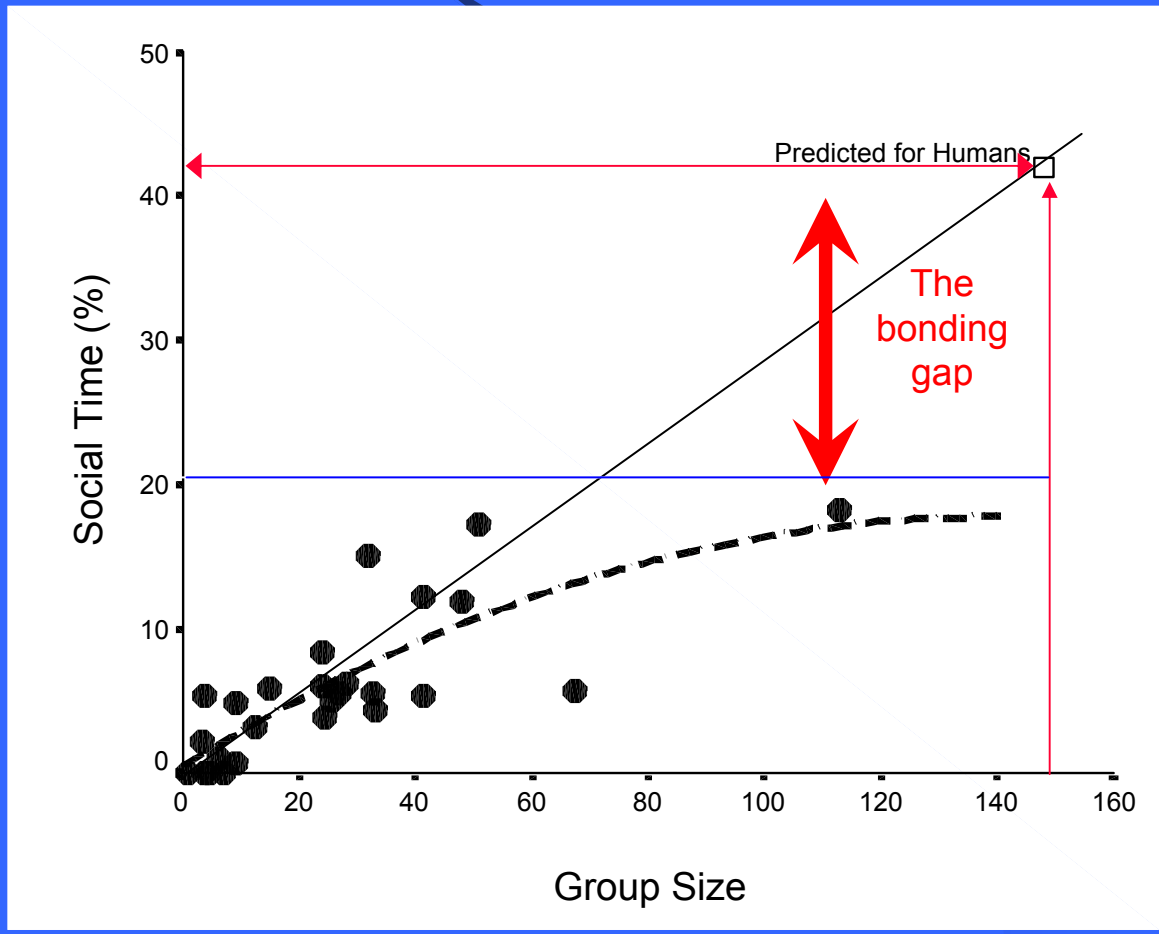
Opiates block social drive;

Opiate-blockers enhance social drive

- endorphins are relaxing
- They create a psycho-pharamological environment for building trust?

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



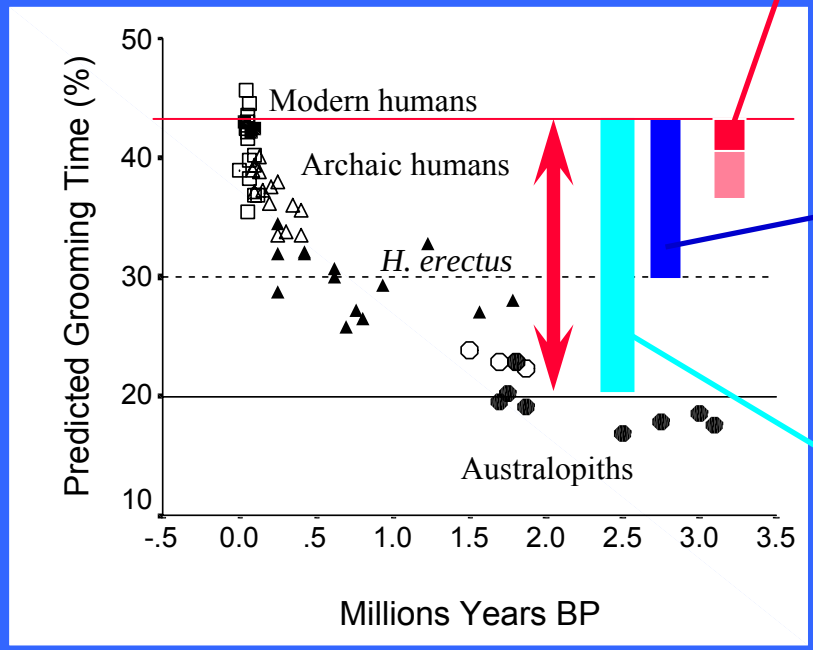
Physical Interaction may be Critical….

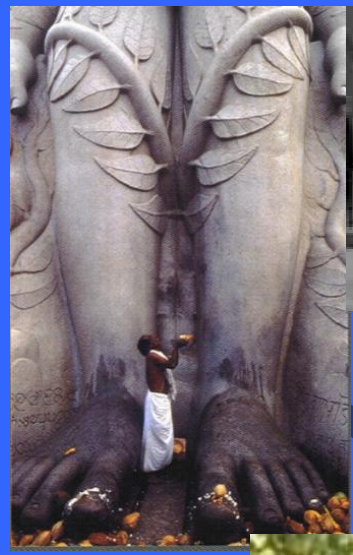
- A touch is worth a thousand words….

We underestimate the importance of physical contact

Touch may be critical in establishing "honesty"

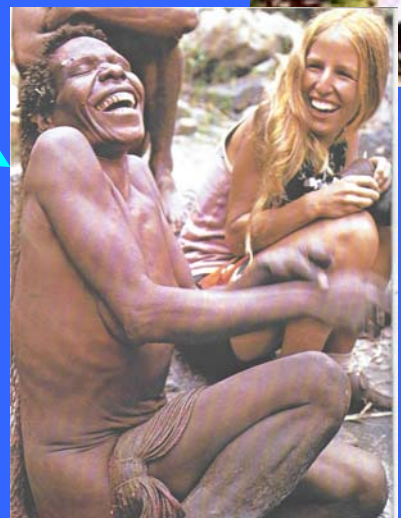
Three Ways to Bridge the Gap?





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

Whirling dervishes [an Islamic Sufi sect]

Medieval flagellants

Bernini's *Ecstacy of St Theresa of Avila*

Endorphins:

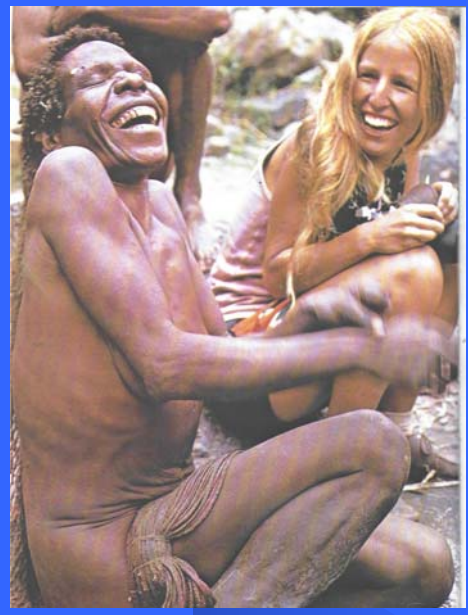
⇒ make you relaxed

⇒ may trigger the release of oxytocins (creating sense of "euphoric love")

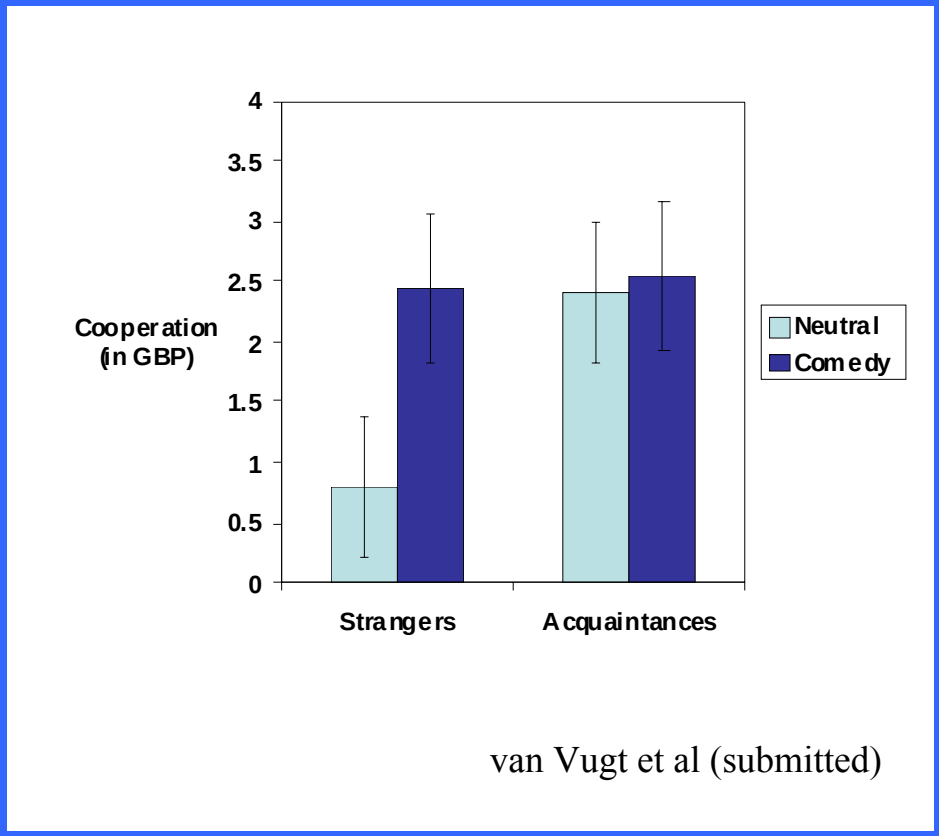
⇒ enhance sense of communality

⇒ positively influence immune system

Laughter
The Best Medicine?



A human universal



van Vugt et al (submitted)

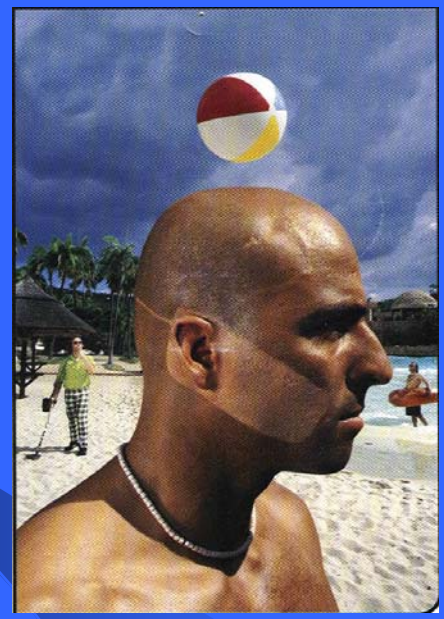
In a Public Goods Game (Prisoner's Dilemma)

Ss were more generous to strangers (but not friends) after watching a comedy video

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?