

# Agents with emotional energy from social interactions

Dr Christopher Watts

CRESS Seminar, University of Surrey

28<sup>th</sup> October 2009

# Outline

- The concept of “energy”
- Simulation models of energisers
- Claims and scenarios
- Where next?

# About me

“I have, alas! Philosophy,  
Operations Research too,  
And to my cost Theology,  
With ardent labour, studied through.  
And here I stand, with all my lore,  
Poor fool, no wiser than before.”

(With apologies to Johann Wolfgang Von Goethe...)

# The PhD

- Warwick Business School (2004-9)
  - Operational Research / Management Science Group
- Supervisor: Stewart Robinson
  - Discrete-event simulation expert
- Title: “An agent-based model of agents with energy”

# The concept of “energy”

# How did I ever get started on this...?

- Proposal to look at “complexity” with an expert in (discrete-event) simulation
- Dynamic Social Networks
  - MSc thesis on Social Network Analysis (SNA)
  - Cutting edge in SNA: dynamic networks
- Why not do something on this...?
  - E.g. Organisation science
    - efficiency, effectiveness, robustness

# Energising & De-energising relations

- Rob Cross & Andrew Parker (2004) “The Hidden Power of Social Networks”
  - “How work *really* gets done in organisations”
  - 60 case studies using SNA
- See also:
  - Wayne Baker & Ryan Quinn
    - (Working paper on an agent-based model!)
  - “Positive Organization Studies”
    - E.g. Jane Dutton

# Cross & Parker's network data

- Collected using questionnaires:
  - “People can affect the energy and enthusiasm we have at work in various ways. Interactions with some people can leave you feeling drained while others can leave you feeling enthused about possibilities. When you interact with each person below, how does it typically affect your energy level?” (Cross et al, 2006, p.9)
- “1” means strongly de-energising, “5” means strongly energising.



# Following network analysis

- Identify the energisers and de-energisers
  - Highest in-degree centrality
- Investigate through interviews why some people (de-)energise during interactions
- Coach the de-energisers (often the managers!)
- Use energisers to promote initiatives

# What is “energising”?

- A social relation
- A motivation concept, a cause of activity, change (in rate)
- Related to social organisation:
  - work performance in groups
  - take up of others’ ideas
- Clarify and apply through simulation

# The view from Psychology

- Thayer: “Energetic Arousal”
  - Opposed to “Tense Arousal”
  - Compare also: “Positive Affect” vs. “Negative Affect” (PANA)
- Measured by self-report questionnaires
- Some association with body language, physiology, food and sleep
- Not much for simulation modelling here?

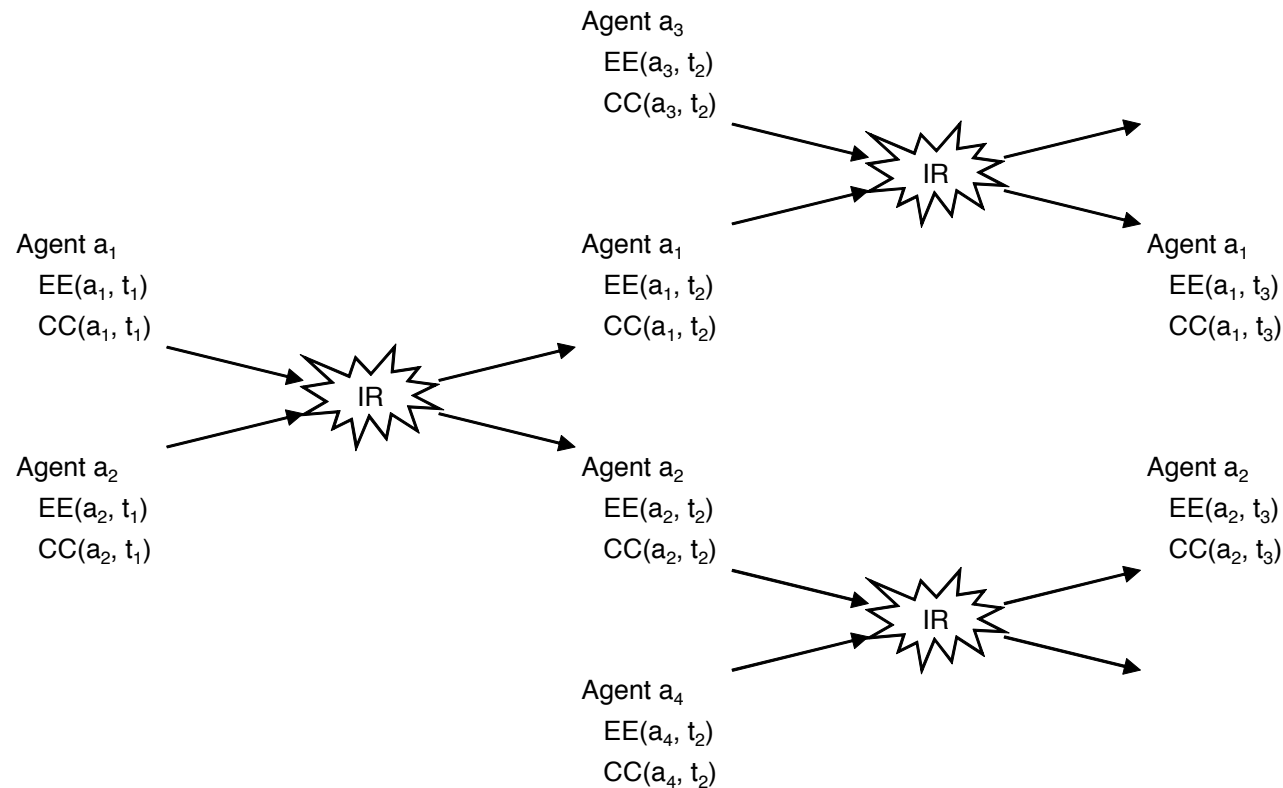
# Social psychology

- Ryan & Deci, Self-determination theory
  - Intrinsic vs Extrinsic motivation
    - Measured in lab experiments by duration of activity performance
  - Raised by behaviour perceived as enhancing one's sense of:
    - autonomy
    - belongingness / relatedness
    - competence
- Tricky: modelling “sense of autonomy”, perception of causal agency...

# Sociology

- Randall Collins (2004) “Interaction Ritual Chains”
  - Agents have “Emotional Energy” (EE) and “Cultural Capital” (CC)
  - Agents perform interaction rituals (IR)
    - Mutual awareness of focusing on common objects generates a “charge” of EE
    - Charge decays over time
    - Objects charged up as symbols of group membership
    - Energy as feelings of group solidarity
    - New symbols added to agent’s cultural capital
  - EE & CC determine expectations for future IR opportunities – hence IR chains

# Interaction Ritual Chains



After Collins, R (2004) "Interaction Ritual Chains", p.152, fig. 4.3

# IR Theory applied



Cultural Capital:  
Symbols of group membership



Group focuses on its Sacred Objects



Interaction Ritual event to recharge symbols



Successful IR:  
Symbols charged up for years



Material resources needed for IR



Unsuccessful IR?  
Symbols not recharged well

# Emotional energy

- Derived from Durkheim and Goffman
- Applied to
  - Intellectual production (social networks of philosophers)
  - Violence
  - Smoking
  - Sex
  - The family
- A sociological theory of everything...?

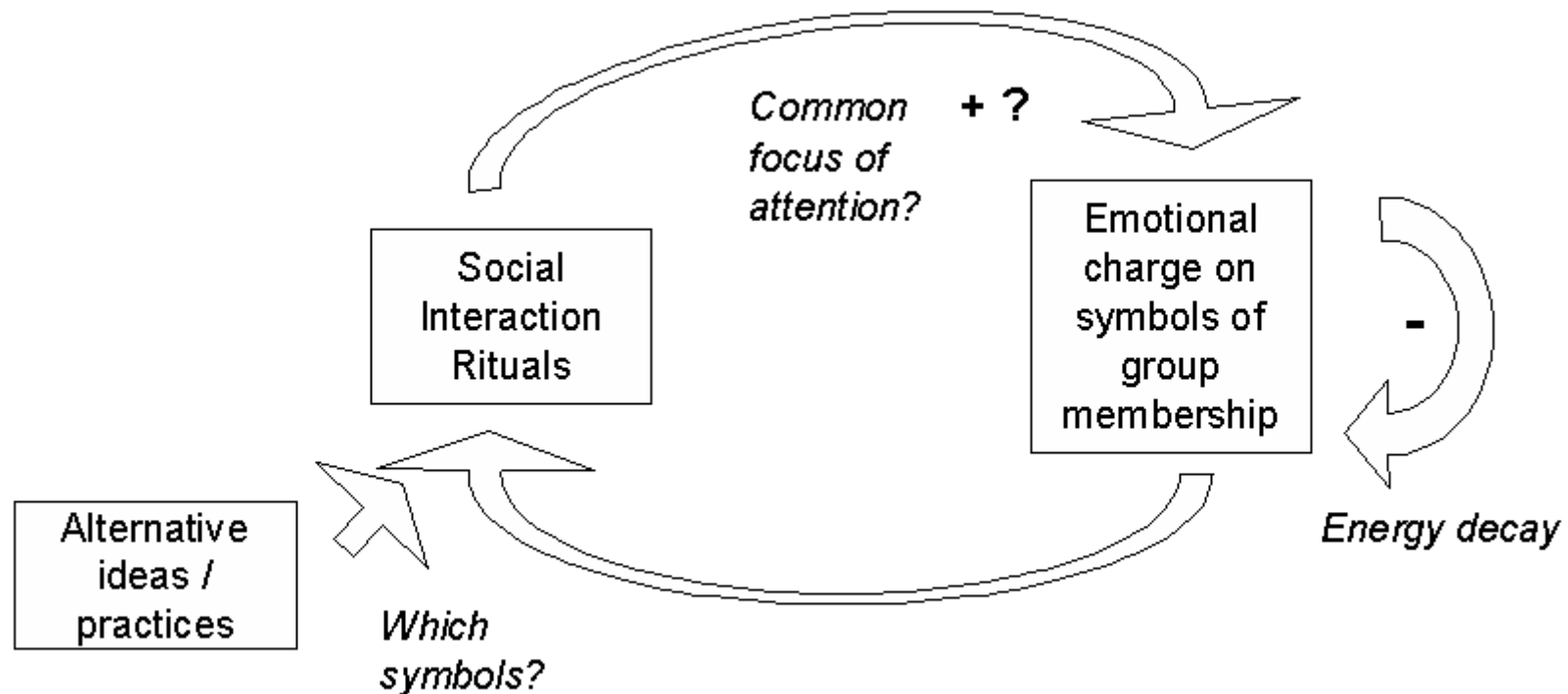


# Contrast with

- Economic exchange between rational optimisers of (financial) utility
  - Instead: agents as ritual performers; bounded-rational seekers after EE
- Competition, prisoner's dilemma etc.
  - Instead: payoff generated by social agreement, solidarity

# Group solidarity and Diffusion of Innovations

Randall Collins (2004) *Interaction Ritual Chains*



# Conclusions about the concept

- Cross & Parker (2004) and Baker & Quinn (2007) write as if the same concept is being named in this psychology, social psychology and sociology
- Should we draw distinctions?
  - Collins's concept is integrated with culture and groups
  - Ryan & Deci seem more concerned with particular forms of behaviour (e.g. “controlling language”) that may not be widely shared in a group (though some evidence exists of contagion)
- Who are the key people?
  - Collins: High-EE people (who *have* energy)
  - Cross & Parker: Hubs in the networks of energising and de-energising relations (who *affect others'* energy)

# Empirical Sources

	Main researchers		
	Cross & Parker	Ryan & Deci	Randall Collins
Background	Social Network Analysis; Business consultancy	Social Psychology	Sociology
Venue	Work organisations	Laboratory, Classroom, Workplace	Wherever relevant for studying education, intellectual production, violence, property etc.
Phenomena	Social interactions	Activity performance before and after social interactions	Interaction ritual performances
Data collection	Questionnaires giving social network data; Interviews	Quantifying of activity performance - e.g. timing; Observation of language & gestures used - e.g. transcripts; Extrinsic motivations applied Y/N?	"Micro-situational" data: ethnography; photographs; video; first-hand accounts; frequency counts of ritual performances
Concept names	Energising & De-energising relations; Energisers & De-energisers	Intrinsic motivation; Subjective vitality; senses of autonomy, belongingness, & competence	Emotional energy; Group solidarity
Example outcomes affecting the phenomena	De-energisers identified and coached; Energisers selected for teams	Controlling language and tasks avoided - e.g. through training; Motivation tactics revised - e.g. compensation schemes	Predictions made re. patterns in future data; No interventions documented, but casts doubt on interventions implied by other theories - e.g. class-based explanations of violent crime
Key references	Cross & Parker (2004b)	Ryan & Deci (2000); Deci & Ryan (2002)	Collins (1979; 1981; 1998; 2004; 2008)

# Simulation models of “energisers”

# Modelling Aims

- Link emotional energy, culture and groups
  - (from Collins)
- Introduce agents with special ability to seem more energising / de-energising
  - (closer to Ryan & Deci, Cross & Parker)
- Uncover ambiguities and incoherence in the theories
  - Coding simulation models forces you to be specific
- Look for qualitative, macro-level behaviour
  - Could we use empirical studies to rule some suggested models?

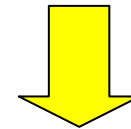
# Programs

- *VBA in Excel*
  - With random number generation from *C DLL* file (Mersenne Twister)
  - Very rapid development (for me)
    - Useful when you have so little idea of what you should be doing!
  - Very flexible (providing I can program it)
- Later produced:
  - System dynamics model
  - *NetLogo*
    - 1/10<sup>th</sup> of the speed of *VBA* version
    - Useful for model verification though
  - Simpler *VBA* versions
    - Retrace design steps
    - Try variations

# Consider the Axelrod Cultural Model (ACM)

- Agents have cultural traits (CC)
- Agents compare traits during social interaction (IR)
- Successful interaction depends on cultural agreement (EE)
- Initial agreement leads to imitation of traits (EE change on new symbols)
- Homogeneous cultural regions emerge from initial diversity (group formation)

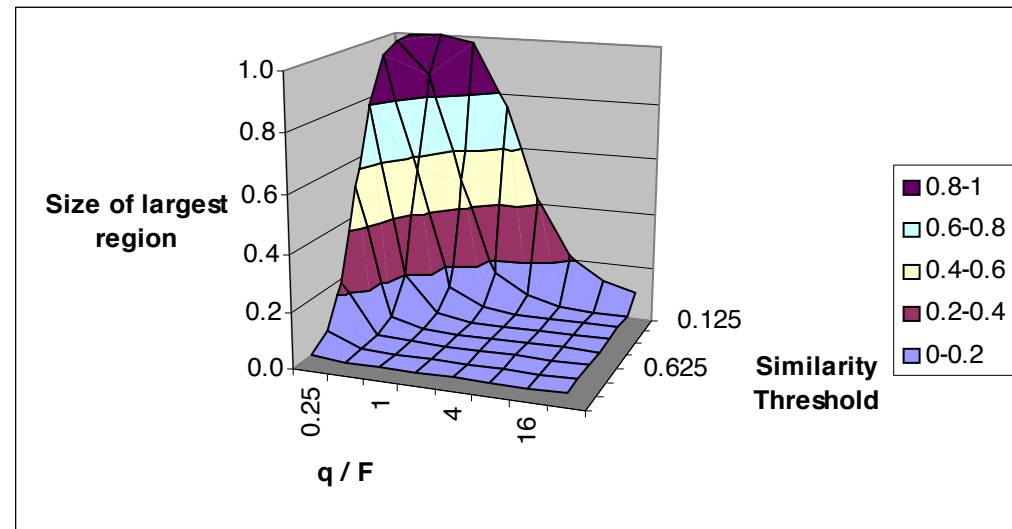
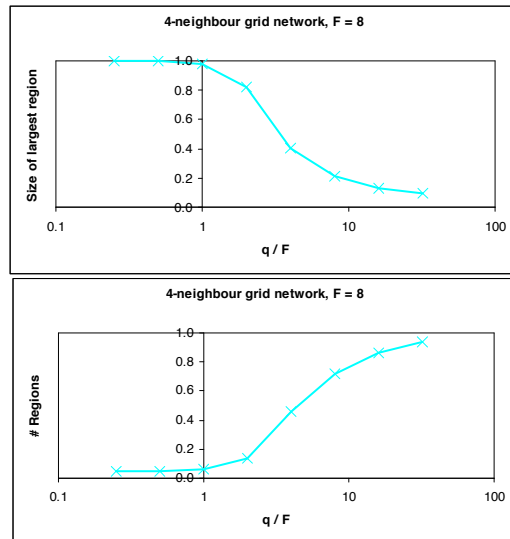
1_FDA	2_CDF	3_DEA	4_BBB
5_DDE	6_AFA	7_BCA	8_ECC
9_ECB	10_AEE	11_CCE	12_BFD
13_BBF	14_CBF	15_FAA	16_BCE
17_AED	18_DAB	19_CEB	20_BAB



1_FDE	2_FDE	3_BEA	4_FDE
5_FDE	6_BEA	7_BEA	8_BEA
9_BEA	10_BEA	11_BEA	12_BEA
13_BEA	14_BEA	15_BEA	16_BEA
17_BEA	18_FDE	19_CAB	20_CAB



# S-curves from varying “cultural complexity”



- System converges on stable state
  - Cultural homogeneity measured as # “regions”
    - Agents in same region are identical in culture (so no more imitation)
    - Agents in different regions have no common traits (so no basis for interaction)
  - # cultural features (F) is # agent attributes
  - # cultural traits (q) is # attribute values
  - “Similarity threshold” is # feature comparisons needing to match for imitation to occur

# Why start from ACM?

- Easy to reproduce (Axelrod posted code)
- Easy model verification
  - reproduce others' results
- Easy to extend
  - Network structures, mutations, fitness, similarity threshold...
  - Energy?
- Easy to understand (well, not bad...)

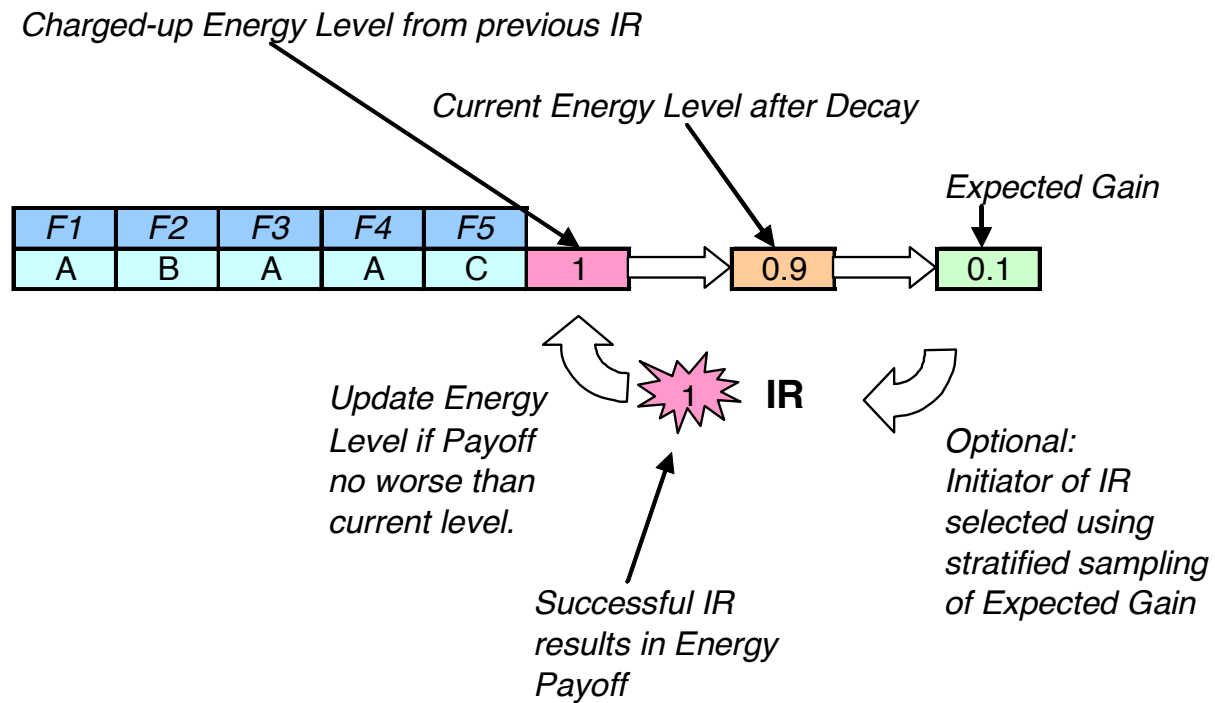
# Problems with ACM

- ACM was not designed to be a model of IR theory
- System converges to static state
- Cultural boundaries (between regions) are unrealistically strong
- No energy decay

# 3-4 energy models

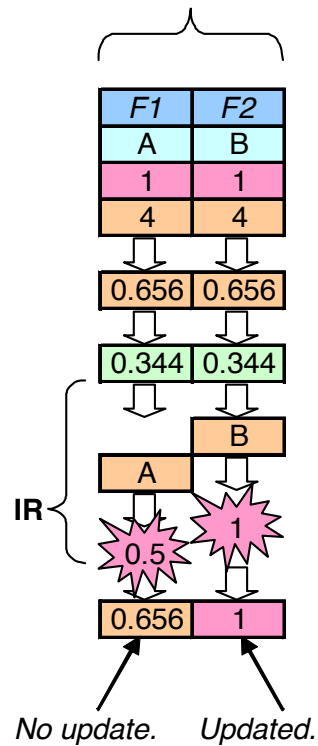
- Record energy charges for:
  - Agents (Agent-Energy Model)
  - Agents' attributes (Feature-Energy Model)
  - Memories of IR events (IR Memory)
  - What objects / traits focused on
  - Include IR participants in memories (Interaction Ritual Agents Model: IRAM)

# Agent-Energy Model



# Feature-Energy Model

**Cultural Capital** (Here there are slots for  $F = 2$  symbols)



**Charged-up Level**  
Time elapsed since recharge

**Current Level**

**Expected Gain**  
Stratified sampling  
to select  
features.  
Create Payoffs

Update charge if Payoff  $\geq$  Current Level  
New Current Level

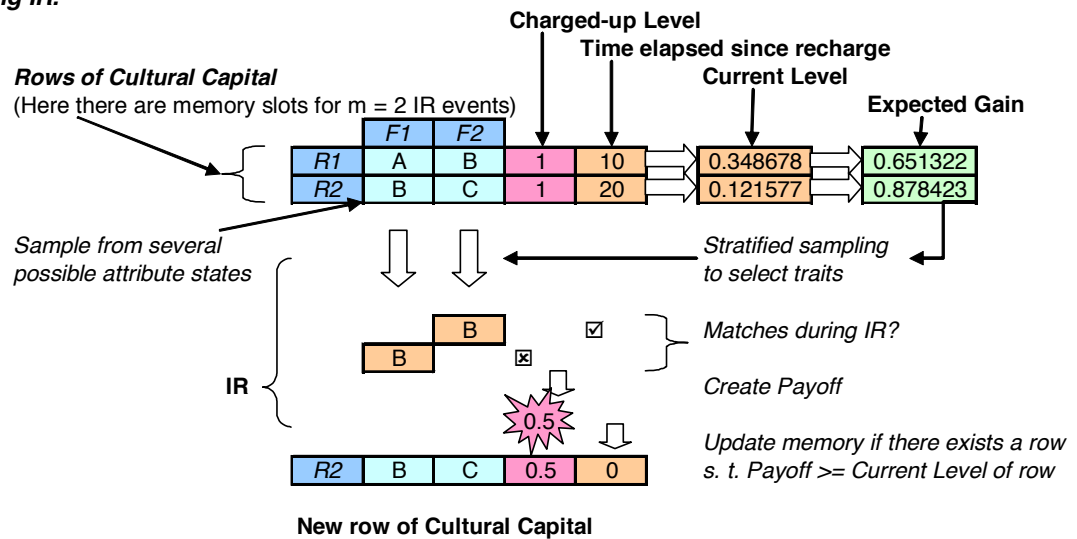
No update. Updated.

# IR Memory

IR Memory has both rows and columns

	F1	F2	F3	
R1	A	B	B	0.651
R2	B	B	B	0.878
R3	A	C	A	0.958
R4	A	A	A	0.985
R5	C	C	A	0.995

Sample from several possible traits for each feature compared during IR.



# IRAM

*Memory* includes who initiated and who received the IR based on this culture.

	Ego	Alter	F1	F2	F3	
R1	1	2	A	B	B	0.651
R2	4	1	B	B	B	0.878
R3	2	1	A	C	A	0.958
R4	1	4	A	A	A	0.985
R5	1	2	C	C	A	0.995

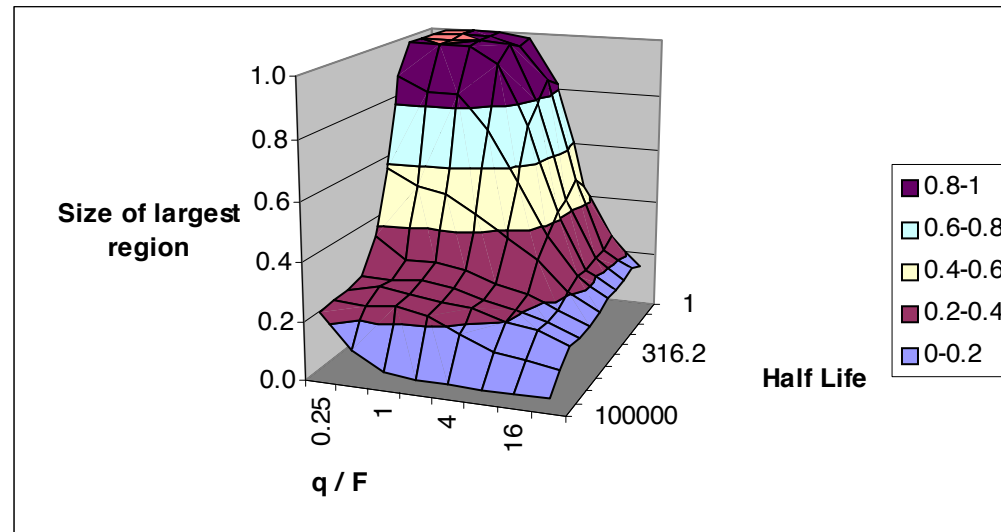
← Agent 1 initiated  
← Agent 1 received

↓ ↓  
**Sample initiators from rows where Ego = this agent**

**Sample recipients of this agent's approaches from rows where Alter <math>\neq</math> this agent**



# Factors



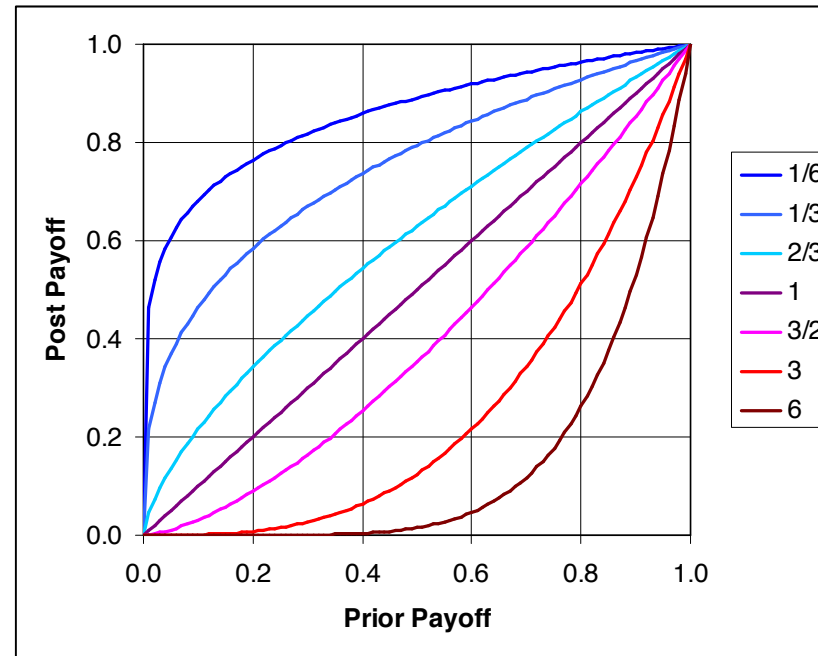
- Energy Decay (Half Life)
  - Also think of Frequency of Interaction
- # Traits ( $q$ ) / # Features ( $F$ )
- Payoff functions (Autonomy, Belongingness, Competence, Combinations of these)
- Energising Characteristics (One agent in population is especially (de-)energising)

# Payoffs from IR event

Concept	Definition
Failed IR event	A failure to match traits in the first feature compared results in a failed IR event. All participants exit with payoffs of 0 and neither cultural capital nor energy levels can be updated.
Otherwise, payoffs are based on:	
A. Autonomy	Proportion of cultural features for which agent was first to supply the trait.
B. Belongingness	Proportion of cultural features for which participating agents matched trait.
C. Competence	Mean for all features of trait-based fitness values. In the simplest case, trait fitness is scaled linearly, with trait “A” scoring 1 and the qth trait scoring 0.

- Lots of options to try (B; C; B\*C; B\*A; etc.)
  - Focused on B (compare ACM) and C (for claim 3)
  - A did not help

# The effects of “energising characteristics”



- Each agent has extra “(de-)energising capabilities”
- Fixed at start and do not change (unlike cultural traits)
- These are exponents applied to their partners’ payoffs

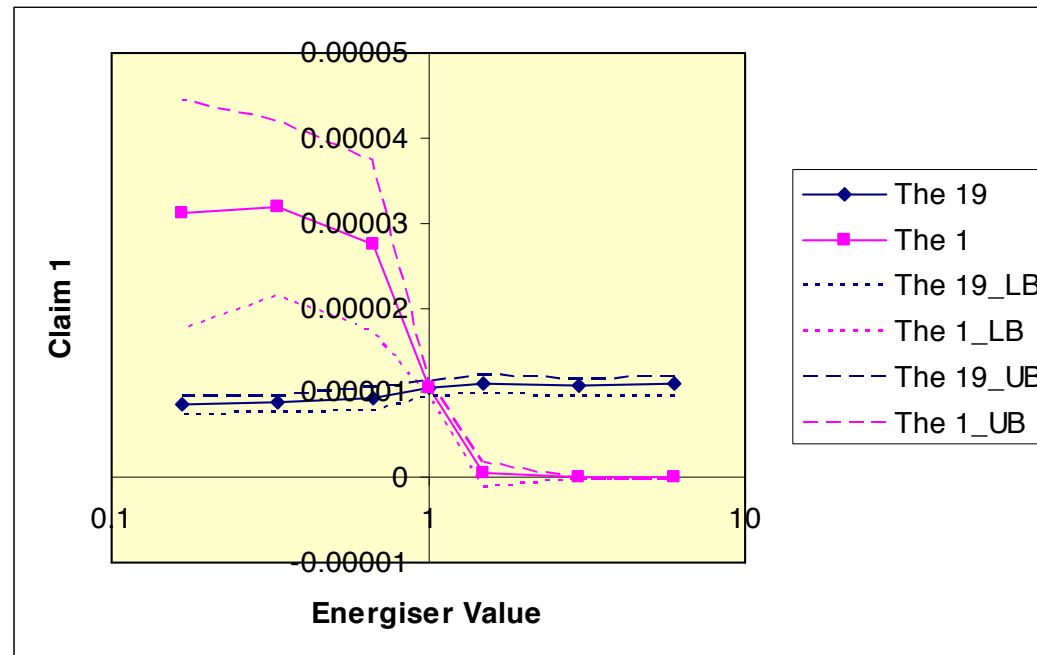
# Claims and Scenarios

Exploring the energy models

# 3 claims

- Energisers have greater take up of their ideas than (non-energisers and de-energisers)
  - Count # imitations for each agent
- Energisers have larger groups form around them
  - Count size of cultural region for each agent
- Organisations with energisers perform work better than those without or with de-energisers
  - Perform simple optimisation task using population

# 6 t tests



- Population of 20 agents contains 1 (de-)energiser
- Run multiple simulation replications for each parameter combination
- For each value of that 1 agent's energising characteristics, perform t-test comparison:
  - “Energiser vs Rest” or “De-energiser vs Rest”
  - Use 5% level of significance for combined set of 6 t tests

# Test of Claim 1 (AgentE, B=E)

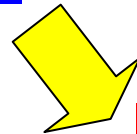
		3.1	34.3	346.2	3465.4	34657
1	0	1	3	0	0	
2	0	1	3	3	3	
4	0	1	3	3	3	
8	0	0	1	3	3	
16	0	0	1	3	3	
32	0	0	0	1	1	
64	0	0	0	1	1	

- “3” means Energisers beat Neutrals beat De-energisers
- Varying factors:
  - Rows: # traits / # features (q/F)
  - Columns: Energy charge half life
- Claims 2 and 3 mostly failed for all parameter values and all models

# The “Maverick” and “Boundary Spanner” scenarios

- One maverick has a novel idea
  - Can they spread it to homogeneous groups?
  - Can they use it to span cultural boundaries?

1_AB	2_AB	3_AB	4_AB
5_AB	6_AB	7_AB	8_AB
9_AB	10_AA	11_BA	12_BA
13_BA	14_BA	15_BA	16_BA
17_BA	18_BA	19_BA	20_BA



1_AB	2_AA	3_AB	4_AB
5_AB	6_AA	7_AA	8_AB
9_AA	10_AA	11_AA	12_BA
13_AA	14_BA	15_BA	16_BA
17_BA	18_BA	19_BA	20_BA



# Boundary Spanning (Agent-Energy Model)

	Half Life						
Energising	3.1	34.3	346.2	3465.4	34657	346573.2	
1/6	1.8	12.8	20	20	20	20	20
1/3	1.6	10	20	20	20	20	20
2/3	1.8	8.4	6.3	1	1	1	1
1	2.2	3.2	0.04	1	1	1	1
3/2	1.2	1	0.03	1	1	1	1
3	1.4	0	0.04	1	1	1	1
6	0.8	0	0.01	1	1	1	1

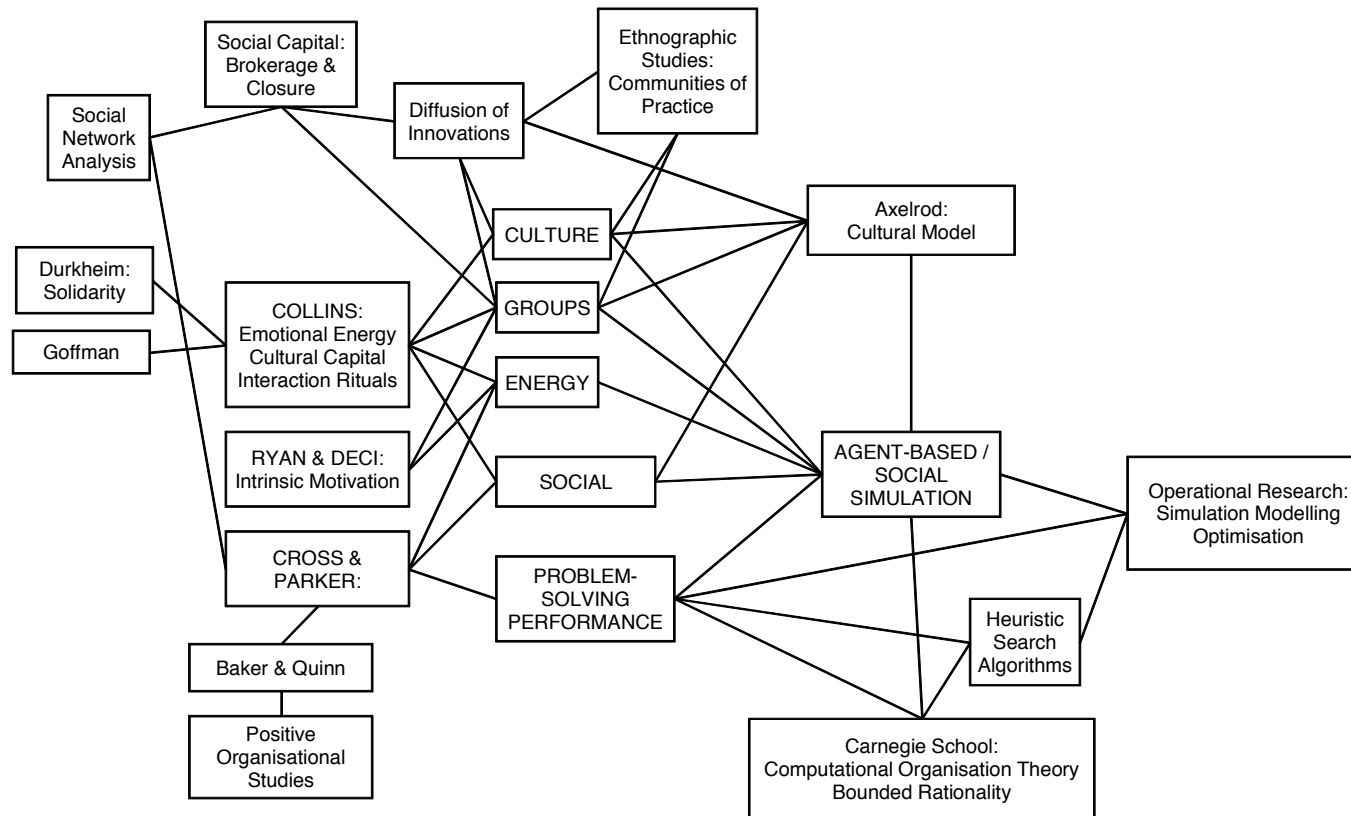
- Top-right: When Spanner is energiser and decay is slow (or interactions frequent), all 20 agents adopt
- Bottom-right: At slow decay, de-energisers convert no one but do not lose their ideas
- Bottom-left: With faster decay (or less frequent interactions), de-energisers lose out to more popular ideas

# Conclusions for diffusion of innovations

- Start with a superior idea (obviously)
- Use an energiser (as expected)
- Try to convert a smaller group first
  - Pilot group, temporarily isolated from rest
- Frequent interactions (be persistent)
  - So don't wait for others' energy charge to decay if they still interact with each other

Where next?

# The “coalition of concepts” (An actor-network)



- We have tried to bring together a very diverse collection of literature, using the discipline of simulation modelling
- Some tensions and lack of clarity identified

# Current modelling problems

- Too much cultural convergence!
  - Esp. the IR Memories
- No innovation
  - “cultural drift” is exogenous
  - Mutations are unrealistic
  - Real groups split (e.g. rival leaders)
- No motivation from conflict, only agreement
  - We agree to differ, to oppose “them”,...

# Current problems with the research

- Easy to generate ideas for more models and functions
- Not so easy to filter some out!
  - No empirical application; no problem to solve or decision to advise on...

# How to publish this?

- The supervisor wants *Management Science* (4\*)
- What's the OR application? What problem is solved by modelling energy?
  - Then *Journal of the OR Society*
- It's "Social Simulation"
  - Therefore *JASSS* ?
  - What have all those Opinion Dynamics models achieved?

# Any Questions?

Dr Christopher J Watts

Research Fellow

Centre for Research in Social Simulation (CRESS)

Department of Sociology, University of Surrey

Room: 24 AD 04

<http://www.soc.surrey.ac.uk/staff/cwatts/index.html>

[c.watts@surrey.ac.uk](mailto:c.watts@surrey.ac.uk)