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The limits and abilities of agent-based modelling to integrate systemic and actor viewpoints

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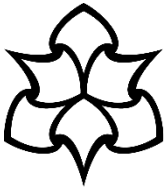
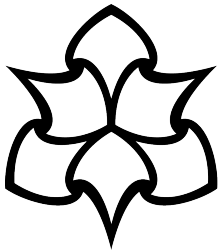
Some (selected) issues arising from the discussions about CSI



- Relating the micro-actor and macro-systemic viewpoints
- Dealing with qualitative & stakeholder input in conjunction with formal models/data
- What specific methods and projects could come under the CSI umbrella
- The difficulty of communication between very different viewpoints, languages and conceptual frameworks
- How to relate values to formal models



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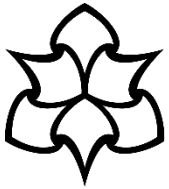
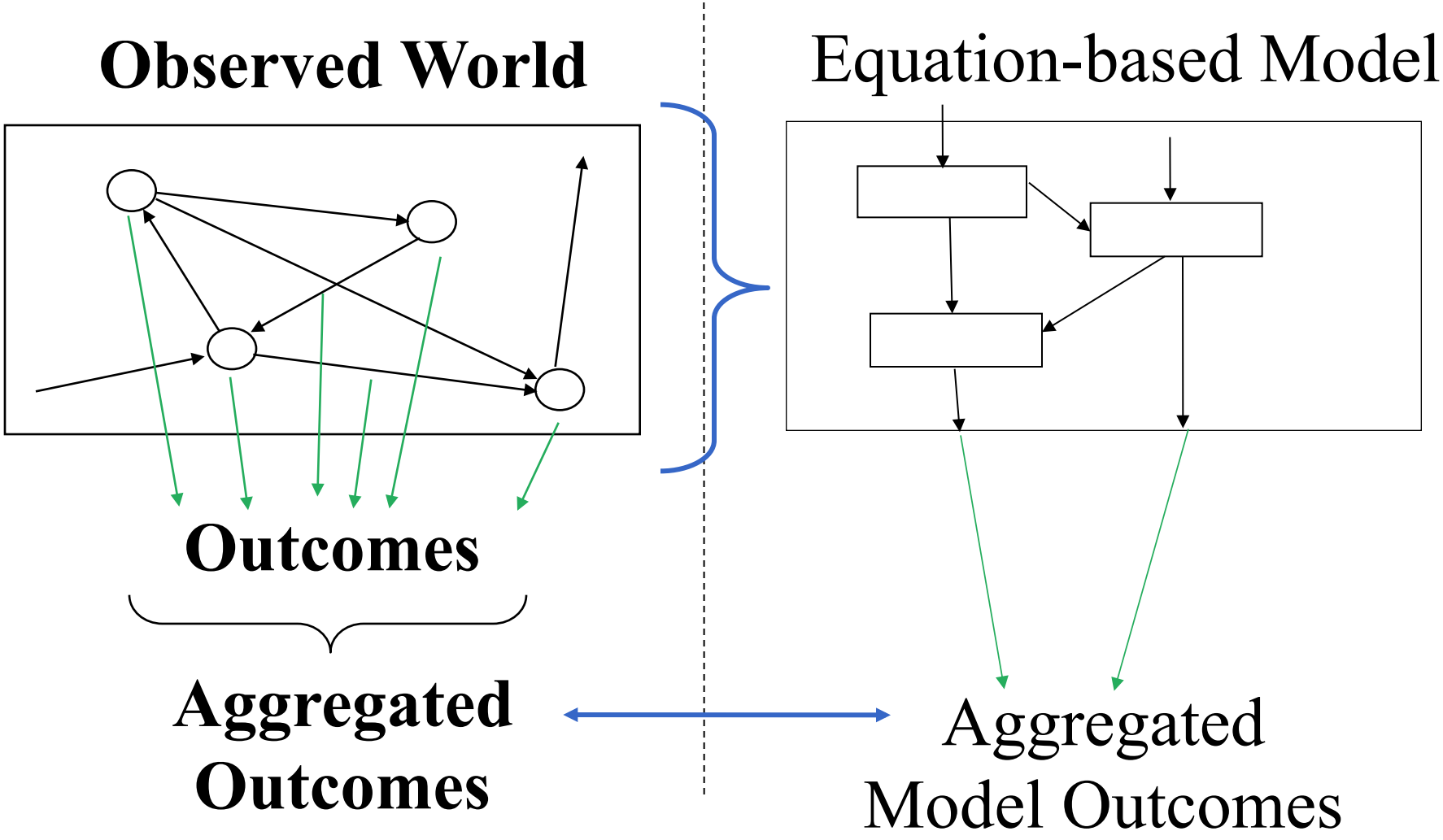
About Agent-Based Modelling

Characteristics of agent-based modelling

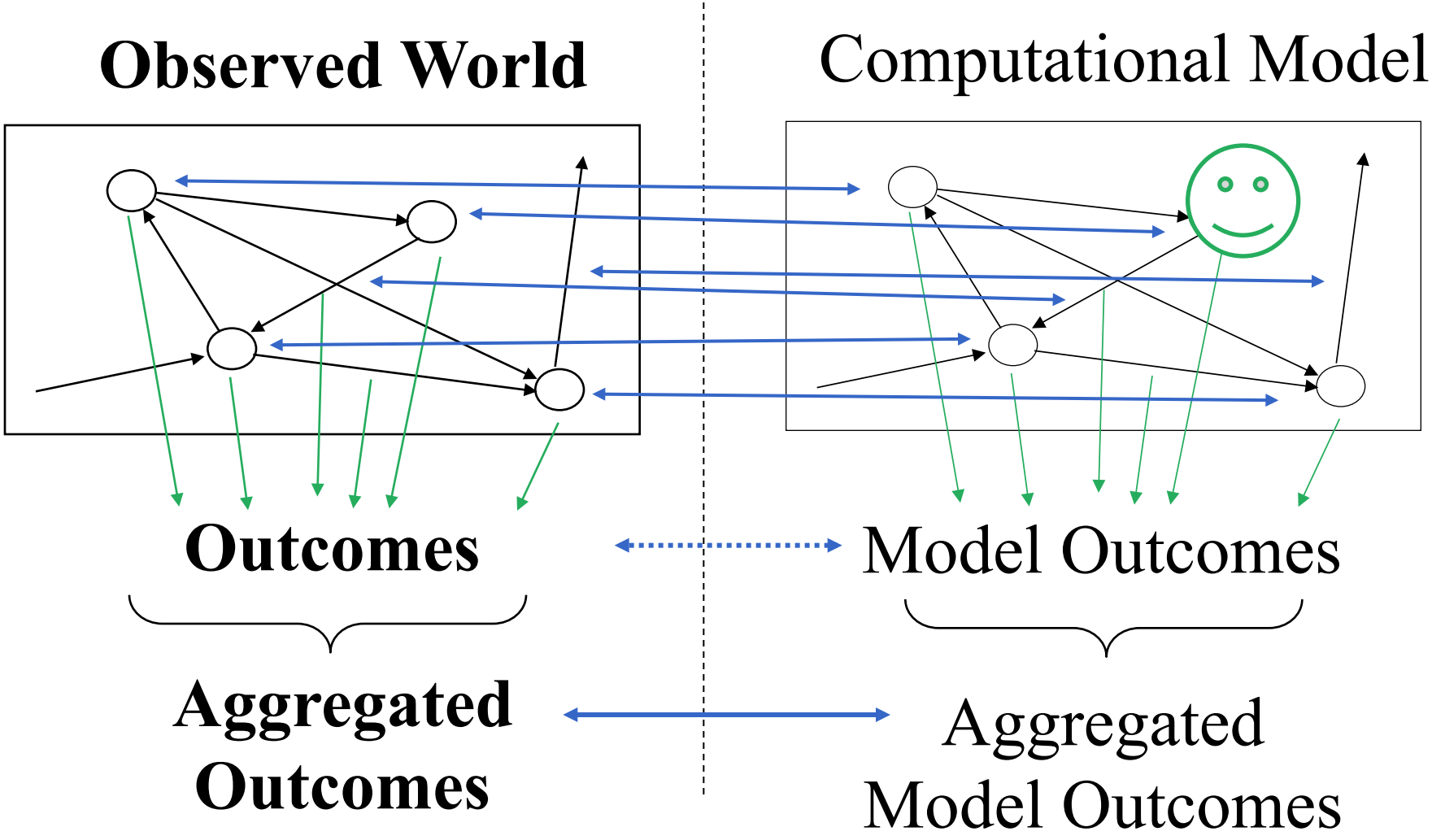


- Computational description of process
- Not usually analytically tractable
- More context-dependent…
- … but assumptions are much less drastic
- Detail of unfolding processes accessible
  - more criticisable (including by non-experts)
- Used to explore inherent possibilities
- Validatable by data, opinion, narrative ...
- Often very complicated themselves

Equation-based/statistical/system dynamics modelling



Agent-based simulation

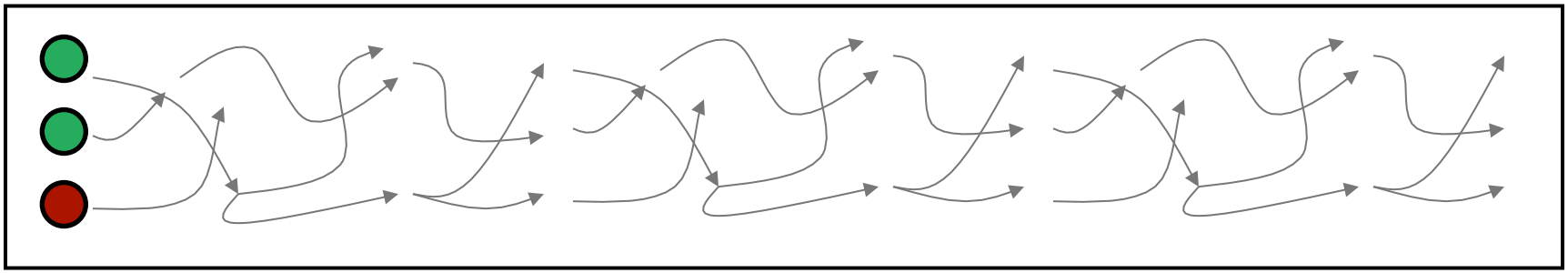


What happens in ABSS

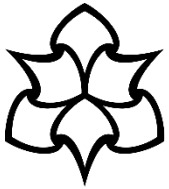
- Kinds of entity in simulation are decided upon
- Behavioural Rules for each kind specified (e.g. sets of rules like: if *this has happened* then *do this*)
- Repeatedly evaluated in parallel to see what happens: agents have their own characteristics which can change
- Outcomes are inspected, graphed, pictured, measured and interpreted in different ways

Specification (incl. rules)

Representations of Outcomes

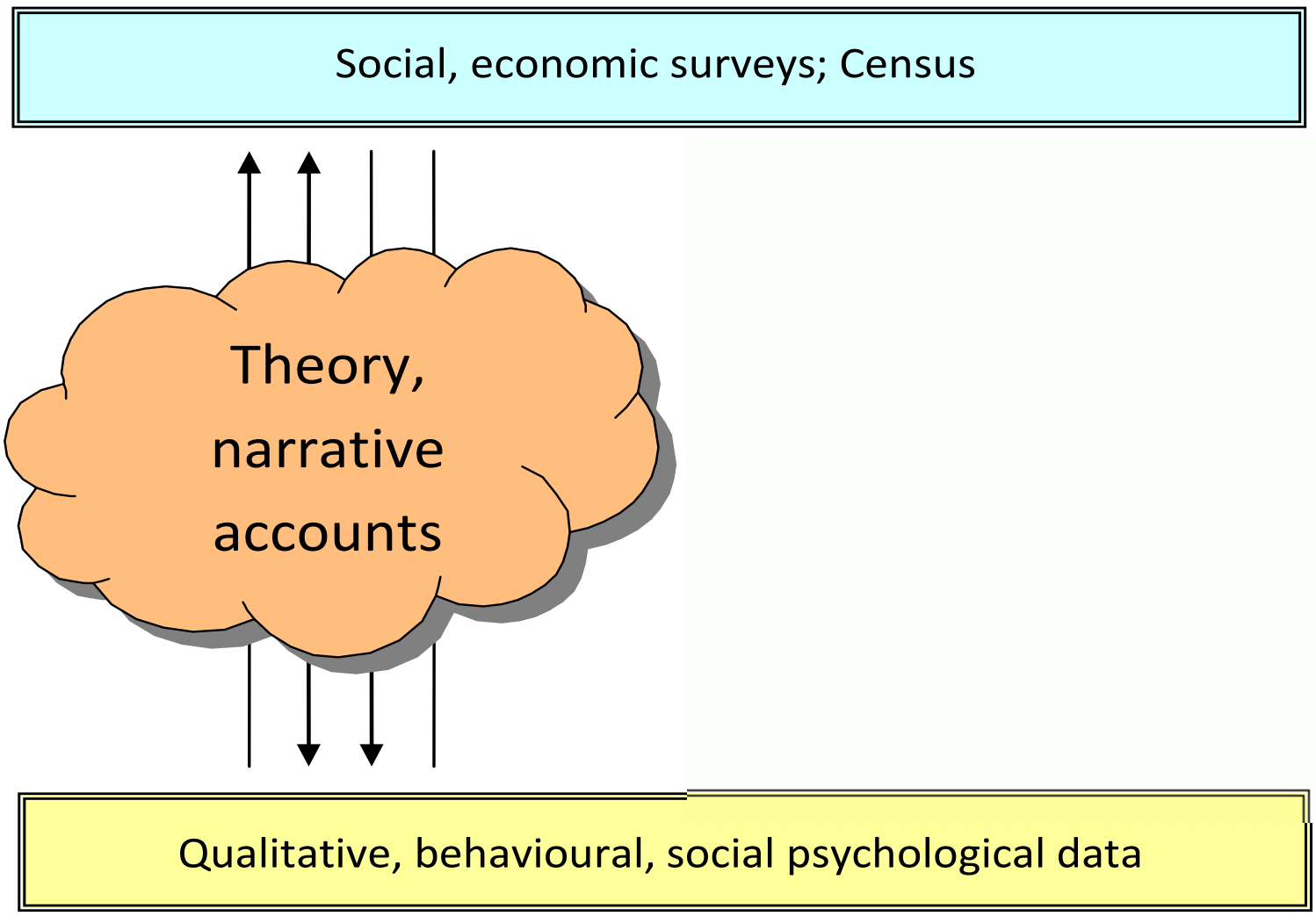


An Example: Social Norms

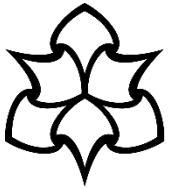


- A social norm emerges partly as a result of the beliefs, self-identity, actions, etc. of individuals
- But, *simultaneously*, the same norm constrains/ influences the perceptions, beliefs, self-identity, actions, etc. of those individuals
- What we identify and label as a "social norm" is a dynamic *complex* of upwards "*emergence*" and downwards "*immergence*"
- Like many social phenomena, it has a complex micro-macro relationship/interaction at its core
- *Agent-based simulation allows the representation and exploration of such micro-macro complexes*

Micro-Macro Relationships



Different Modelling Purposes



Including….

- Prediction
- Explanation
- Illustration
- Theoretical Exploration
- Description
- Analogy
- Mediation

Edmonds et al. (2019) http://jasss.soc.surrey.ac.uk/22/3/6.html

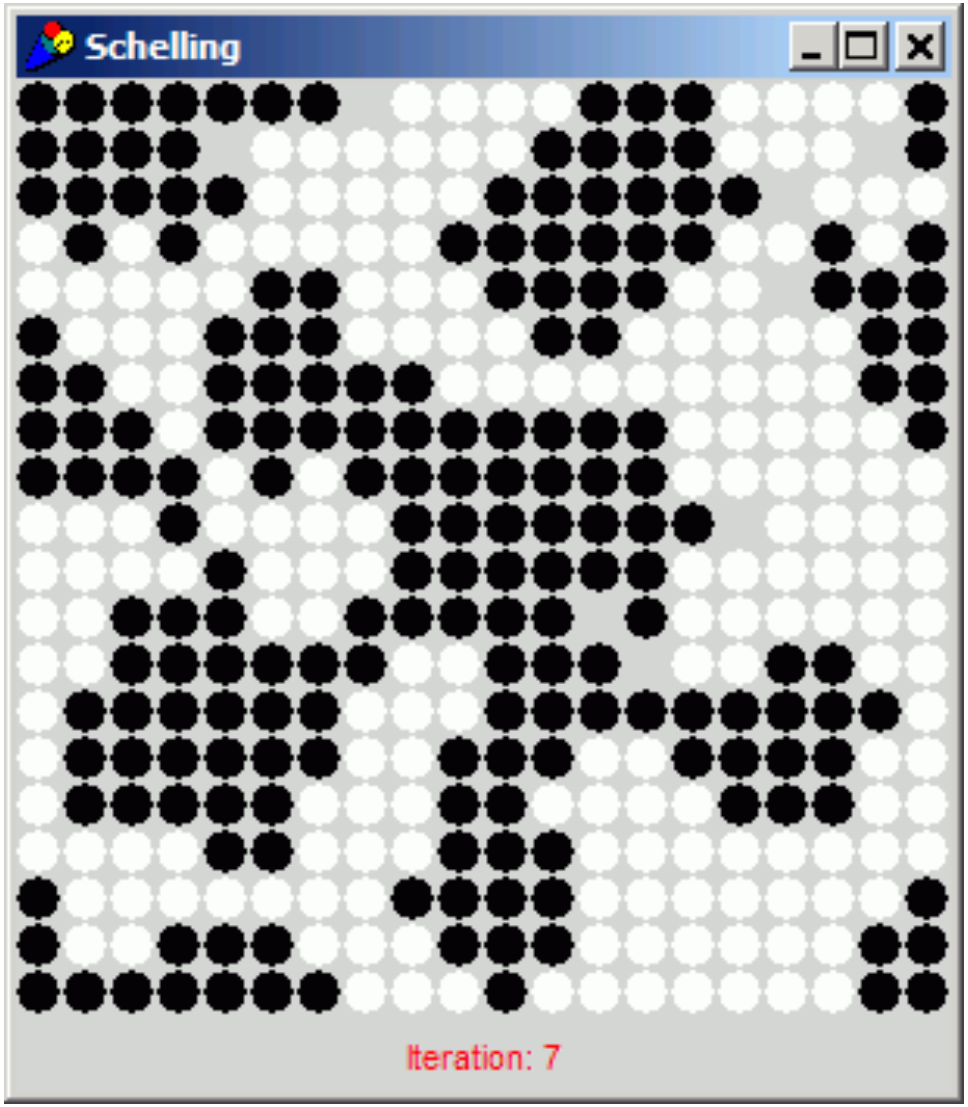
An Illustrative Simulation: *Schelling's Segregation Model*

Schelling, Thomas C. 1971. Dynamic Models of Segregation. *Journal of Mathematical Sociology* **1**:143-186.

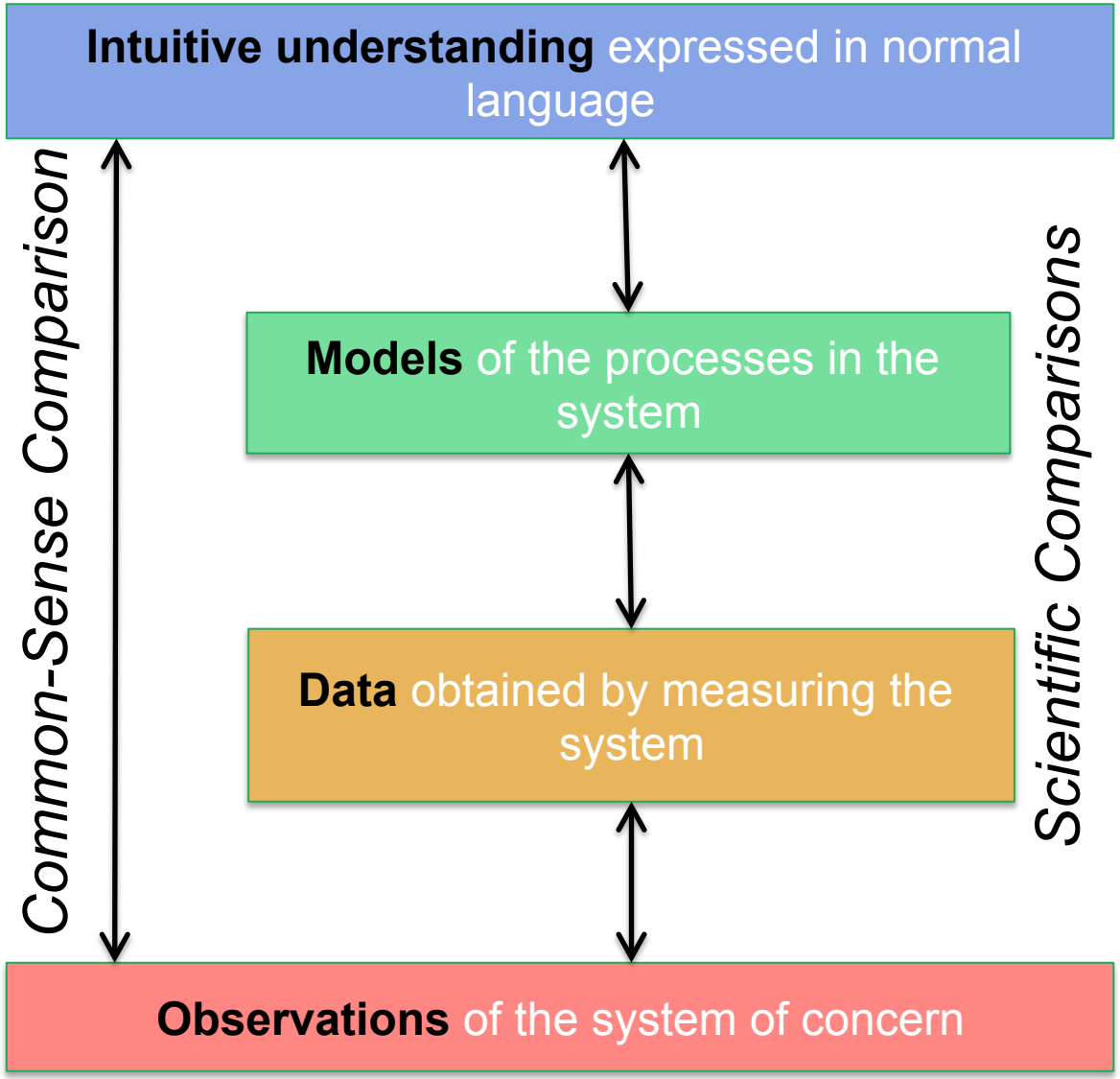
Rule: each iteration, each dot looks at its neighbours and if less than 30% are the same colour as itself, it moves to a random empty square

Conclusion:

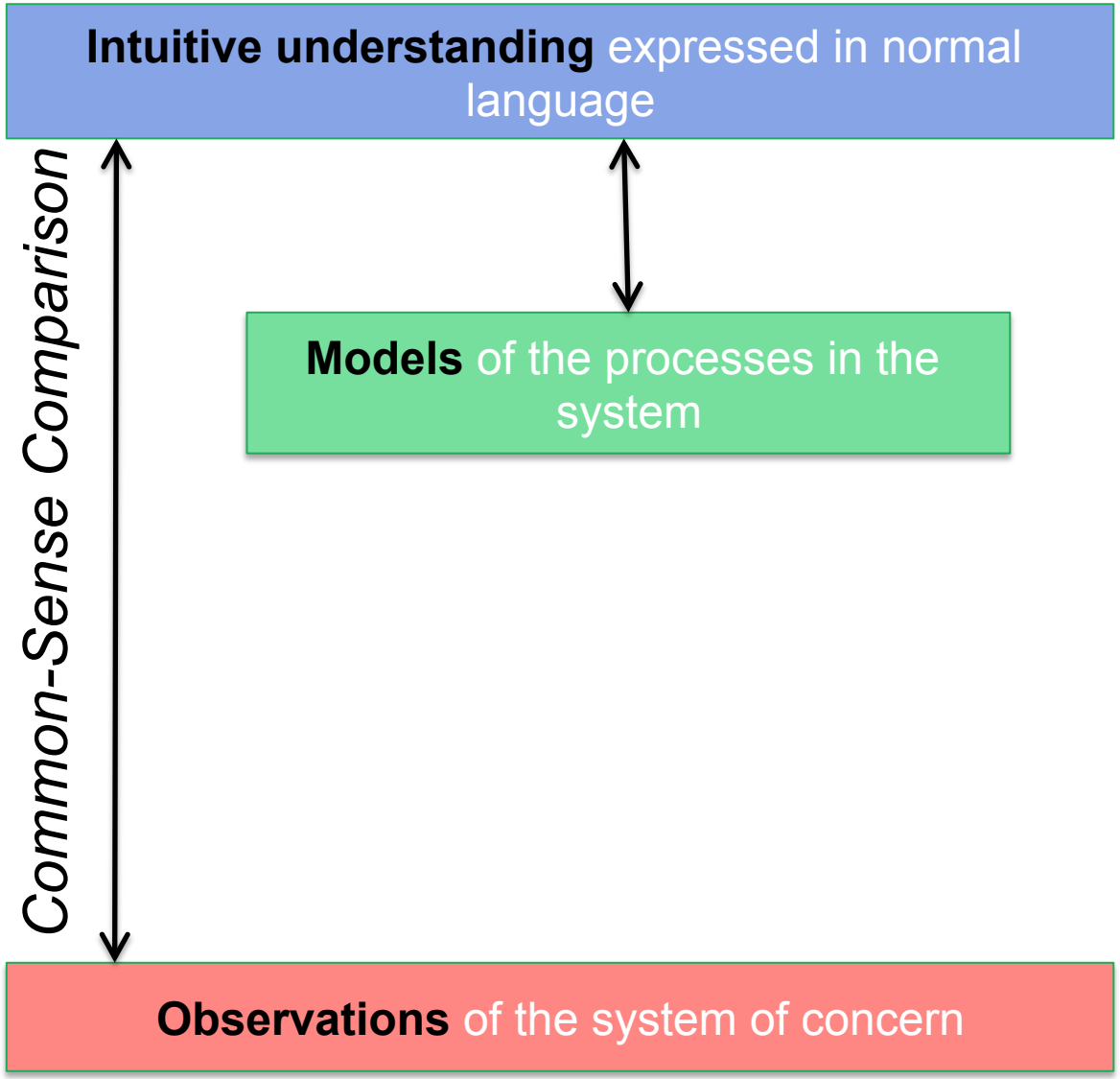
Segregation can result from wanting only a few neighbours of a like colour



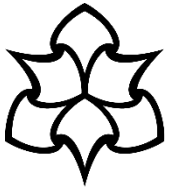
Models stage understanding



Models as Analogies



What ABM Can Do



- ABM can allow the production and examination of sets of possible complicated processes both emergent and immergent
- Using a precise (well-defined and replicable) language (a computer program)
- But one which allows the tracing of very complicated interactions
- And thus does not need the strong assumptions that other approaches require to obtain their outcomes
- It allows the indefinite experimentation and examination of outcomes (*in vitro*)
- Which is related to what we observe (*in vivo*) either analogically or empirically (dependent on the strength of the map between model and data)

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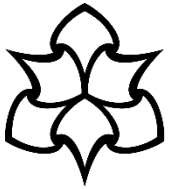
A model of social influence and water demand

CC:DeW Climate Change: the Demand for Water



Project commissioned by UK Gov EA/DEFRA to look at domestic water demand under different societal and climate scenarios

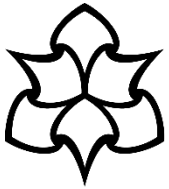
Other Partners were:

- Stockholm Environment Institute (oxford)
- Canfield University
- Atkins

The main part of the project were statistical projections under different scenarios. Our part was to test social assumptions and outcomes

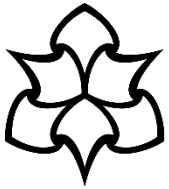
Work here was joint with *Olivier Bartelemy*

Aims and Constraints



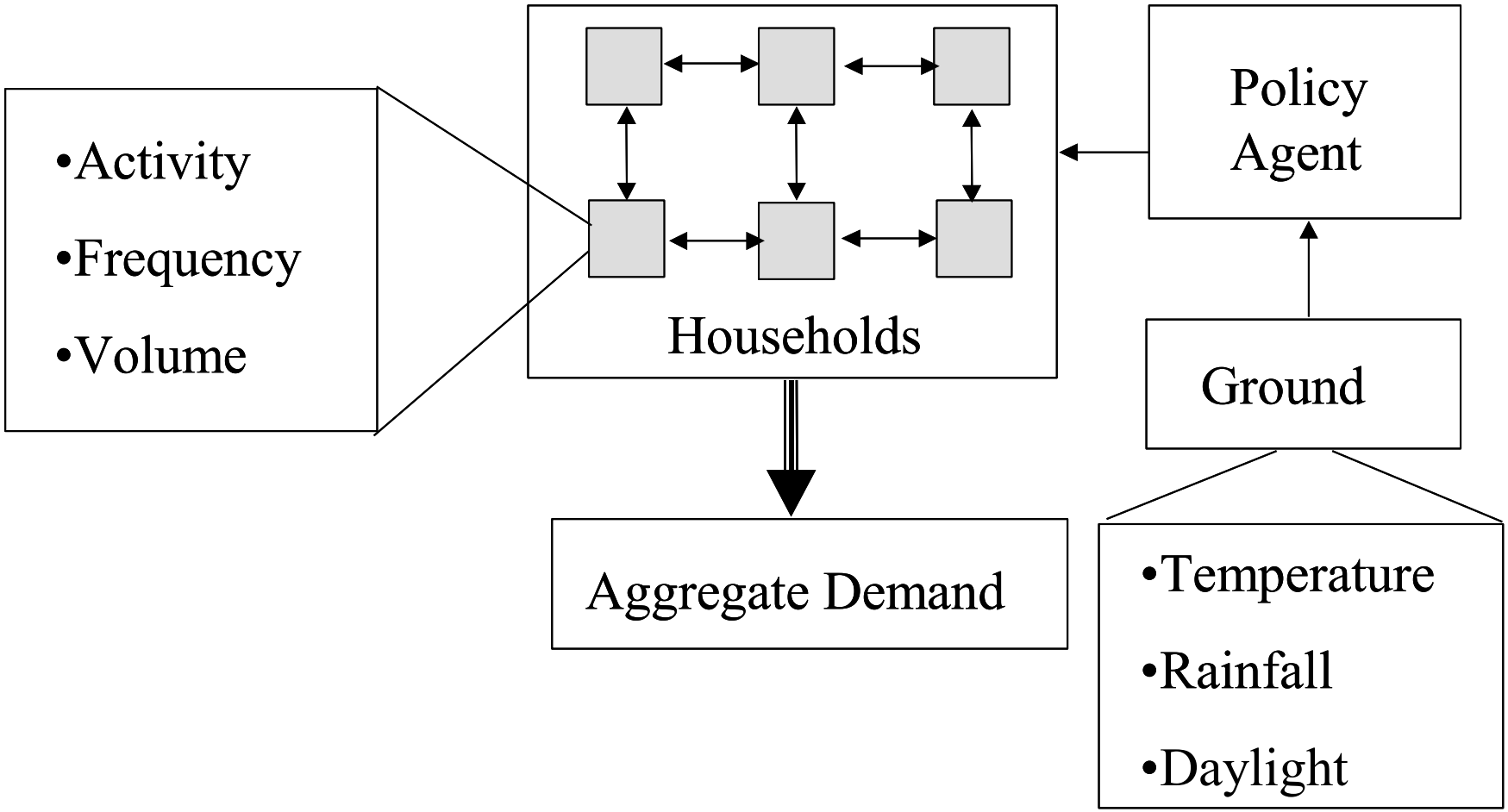
- Investigate the possible impact of social influence between households on patterns of water consumption
- Design and detailed behavioural outcomes from simulation validated against expert and stakeholder opinion at each stage
- Some of the inputs are real data
- Characteristics of resulting aggregate time series validated against similar real data

Type, context, purpose

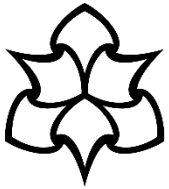


- Type: A complex agent-based descriptive simulation integrating a variety of streams of evidence
- Context: statistical and other models of domestic water demand under different climate change scenarios
- Purposes:
  - to critique the assumptions that may be implicit in the other models
  - to demonstrate an alternative

Simulation structure

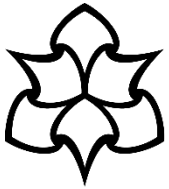


Household Behaviour – Endorsement on Actions



- Each action an agent might take is a particular frequency and use of water
- Action Endorsements (source of influence):
  recentAction neighbourhoodSourced selfSourced globallySourced newAppliance bestEndorsedNeighbourSourced
- 3 Weights moderate effective strengths of
  neighbourhoodSourced selfSourced globallySourced
  endorsements and hence the bias of households
- Can be simplified as 3 types of households influenced in different ways: *global*-; *neighbourhood*-; and *self*-sourced depending on the dominant weight

History of a particular action from one agent's point of view with respect to one action



Month 1: **X** used, endorsed as **self sourced**

Month 2: **X** endorsed as **recent** (from personal use) and **neighbour sourced** (used by agent 27) and **self sourced** (remembered)

Month 3: **X** endorsed as **recent** (from personal use) and **neighbour sourced** (agent 27 in month 2).

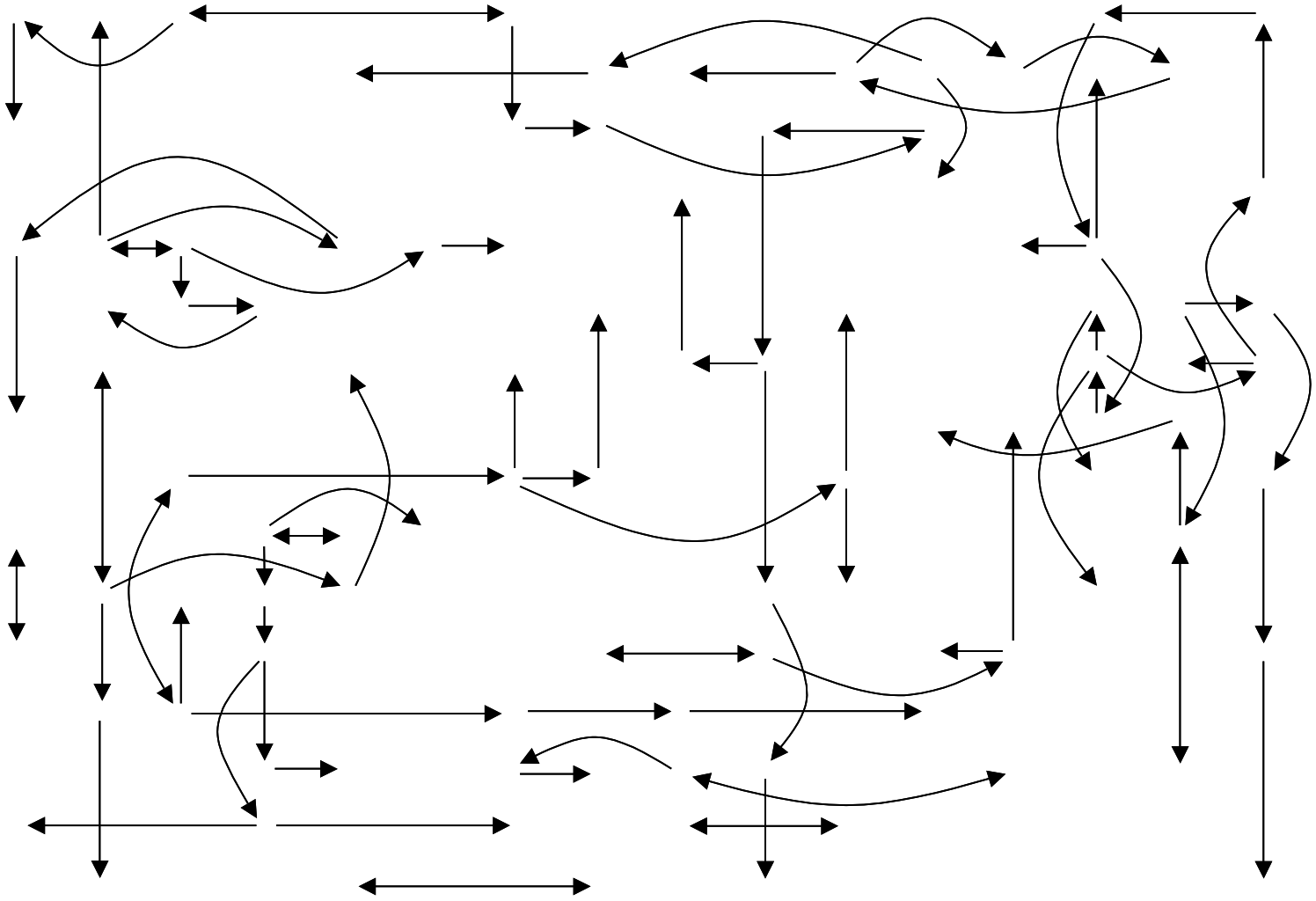
Month 4: **X** endorsed as **neighbour sourced** twice, used by agents 26 and 27 in month 3, also **recent**

Month 5: **X** endorsed as **neighbour sourced** (agent 26 in month 4), also **recent**

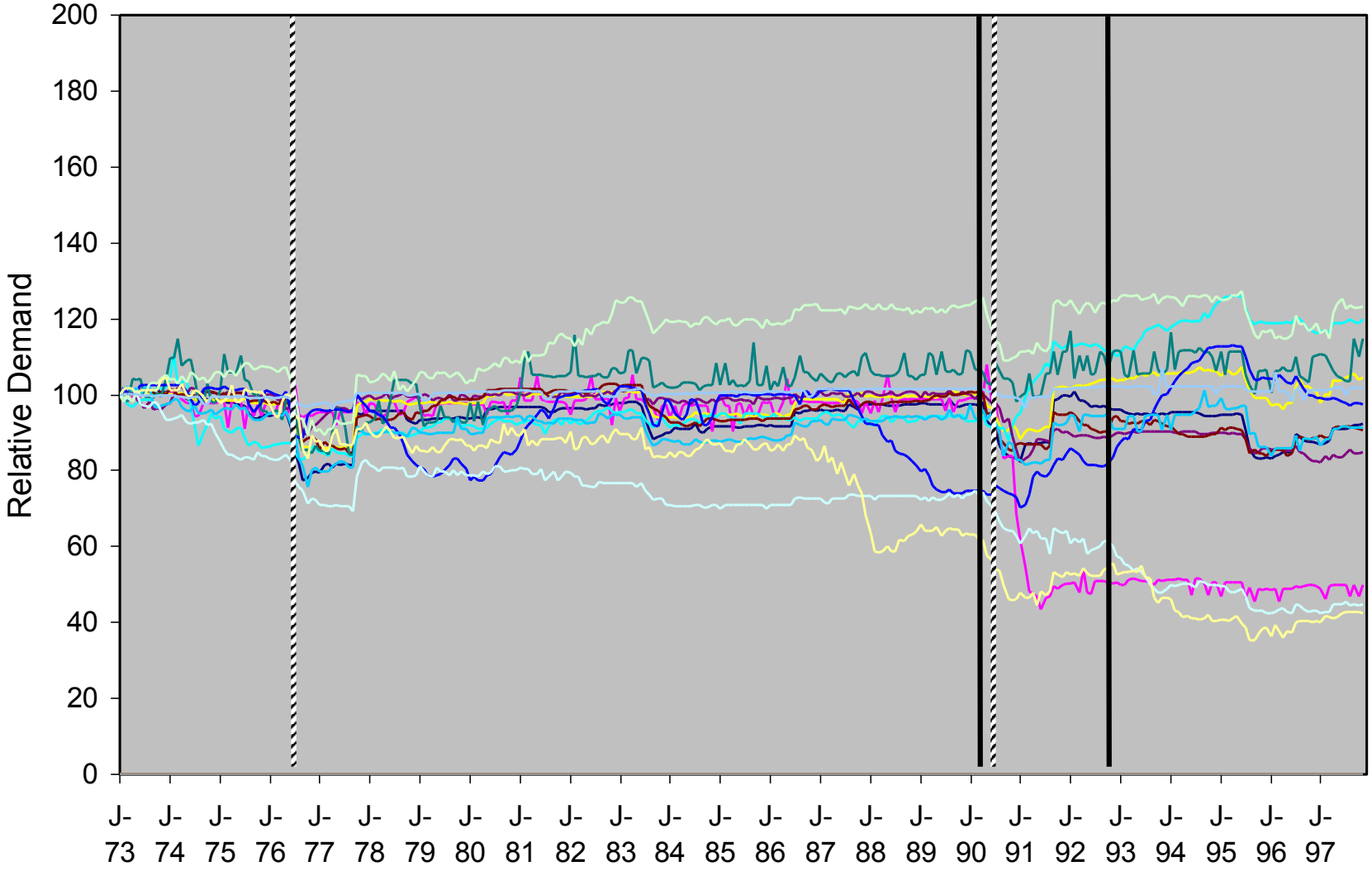
Month 6: **X** endorsed as **neighbour sourced** (agent 26 in month 5)

Month 7: replaced by **Y** (appeared in month 5 as **neighbour sourced**, now endorsed 4 times, including by the **most alike neighbour** – agent 50)

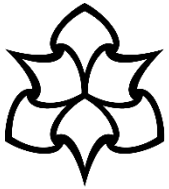
Some of the household influence structure



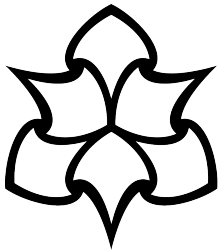
Example results



Conclusions from Water Demand Example



- The use of a concrete descriptive simulation model allowed the detailed criticism and, hence, improvement of the model
- The inclusion of social influence resulted in aggregate water demand patterns with many of the characteristics of observed demand patterns (local lock in, contrariness, shocks)
- The model established how it *was possible that* processes of mutual social influence could result in widely differing patterns of consumption that were self-reinforcing
- Then used as a basis for scenario development (ensuring process consistency)



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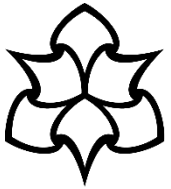
A model of diversity, immigration and political participation

Social Complexity of Immigration and Diversity

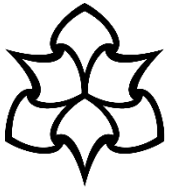
- A 5 year EPSRC-funded project between:
- ***University of Manchester***
  - Institute for Social Change
    - Ed Fieldhouse, Nick Shryane, Nick Crossely, Yaojun Li, Laurence Lessard-Phillips, Huw Vasey
  - Theoretical Physics Group
    - Alan McKane, Tim Rogers
- ***Manchester Metropolitan University***
  - Centre for Policy Modelling
    - Bruce Edmonds, Ruth Meyer, Stefano Picassa
- Aim was to apply complexity methods to social issues with policy relevance

Aims and Objectives of Descriptive Model



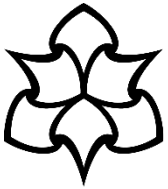
- To develop a simulation that integrates as much as possible of the relevant available evidence, both qualitative and statistical (a Data-Integration Model – a ***DIM***)
- Regardless of how complex this makes it
- A *description* of a specified kind of situation (not a general theory) that *represents* the evidence in a *single, consistent and dynamic simulation*
- This simulation is then a fixed and formal target for later analysis and abstraction

The DIM



- A relatively tight interactive “loop” between the social scientists who are experts in the subject matter and their data and the simulation developers...
- ...trying to give as much ownership and control to social scientists as possible.
- First target: *What makes people vote (within the context of a diverse community)?*
- Started with developing a fairly complete list of “causal stories” concerning the various processes that might contribute from (including from qual. research)
- Then initial model iteratively developed to enable maximum responsiveness and transparency
- A complicated simulation: guiding principle is what is there evidence for – if there is evidence it is included!
- *Later* there is simplification

An overview of model structure



Underlying Data from Surveys about Population Composition etc.

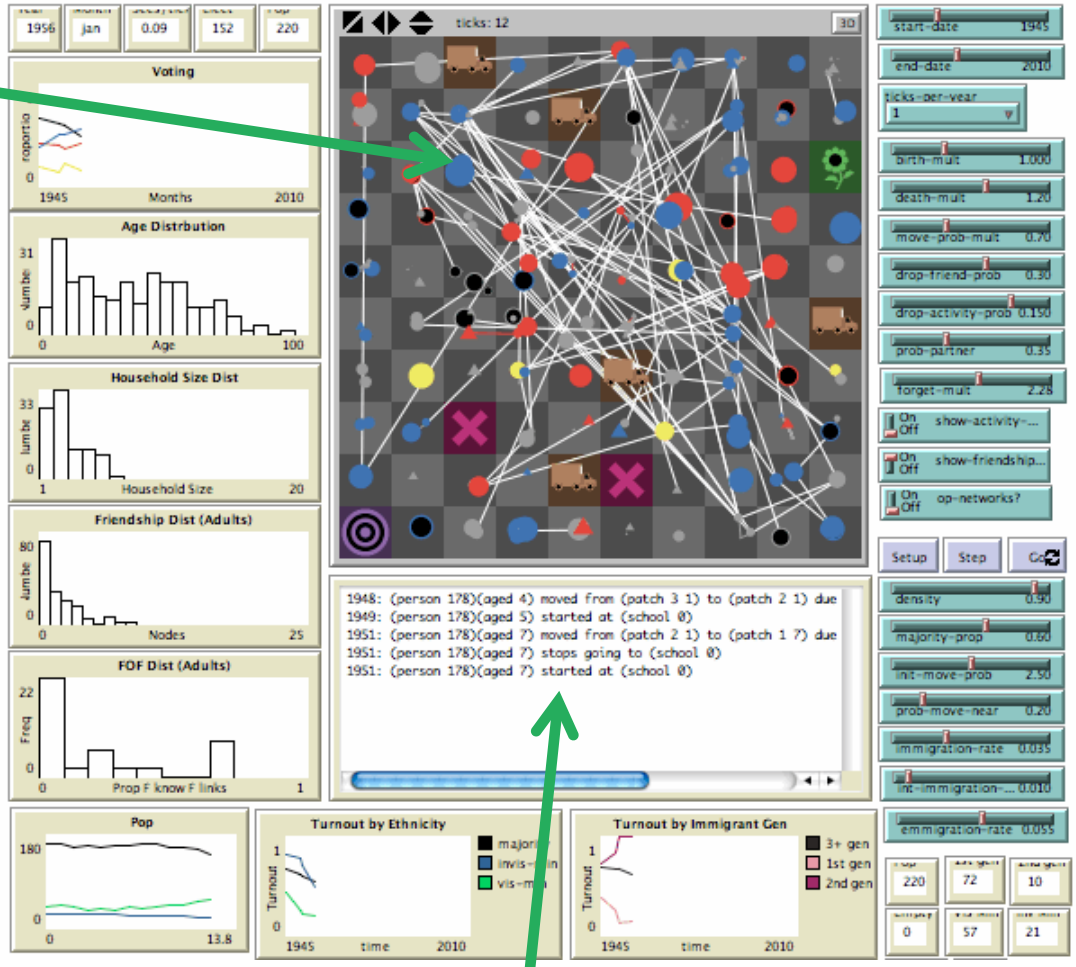
Demographics of people in households (both native and immigrant)

Homophily effects the social network and membership of organisations etc.

Social network effects how individuals influence each other, reinforcing and/or changing existing norms/opinions

This effect the behaviours of individuals, which can then be extracted from the simulation as model results and compared with evidence etc.

Demonstration Run



Picture of World

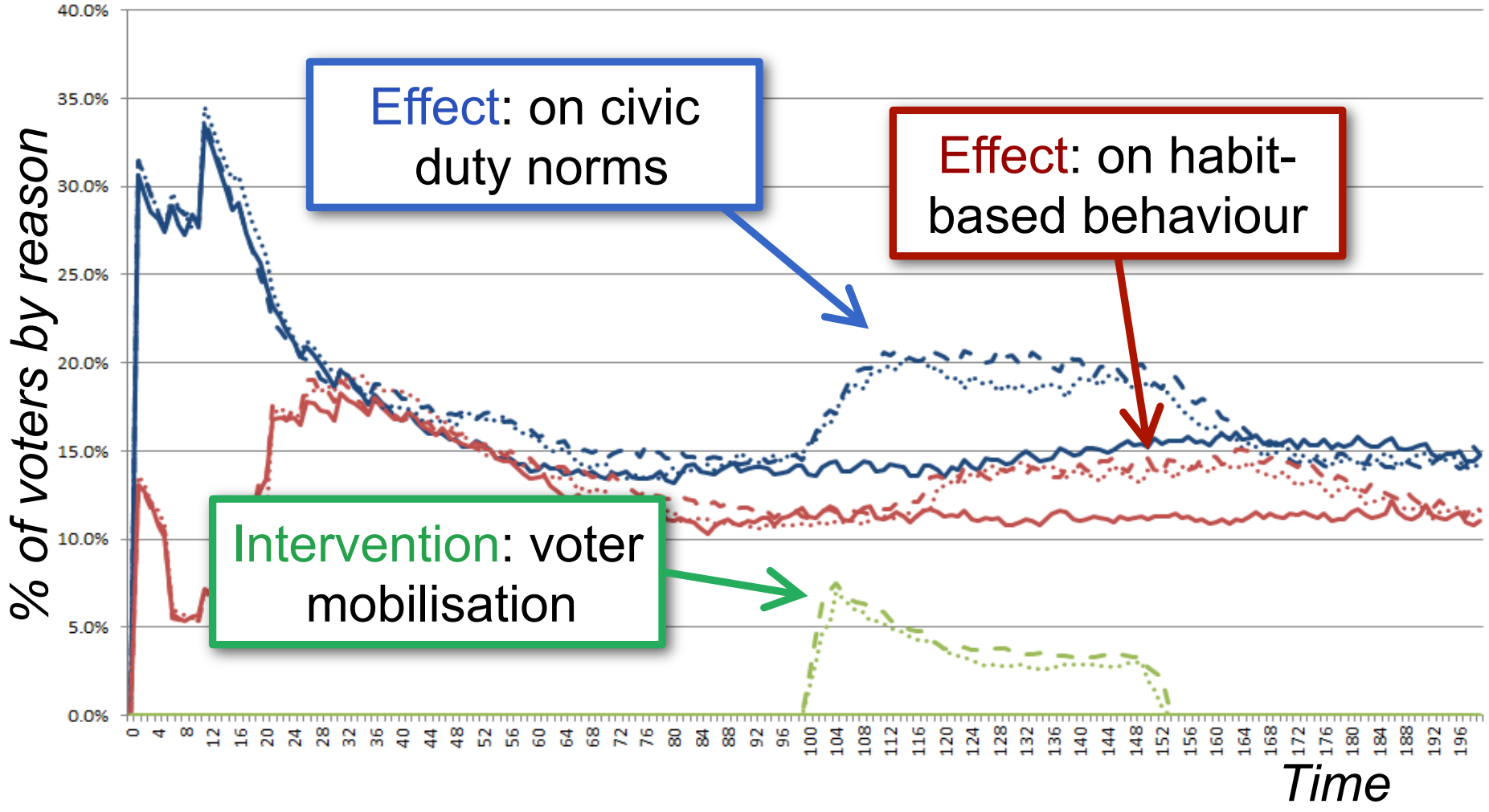
Indicative Graphs and Histograms

Parameters and Controls

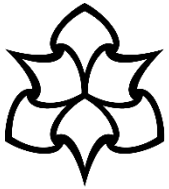
Simple Statistics concerning Outcomes

Pseudo-narrative log of events happening to a single agent

Example Output: why do people vote (if they do)

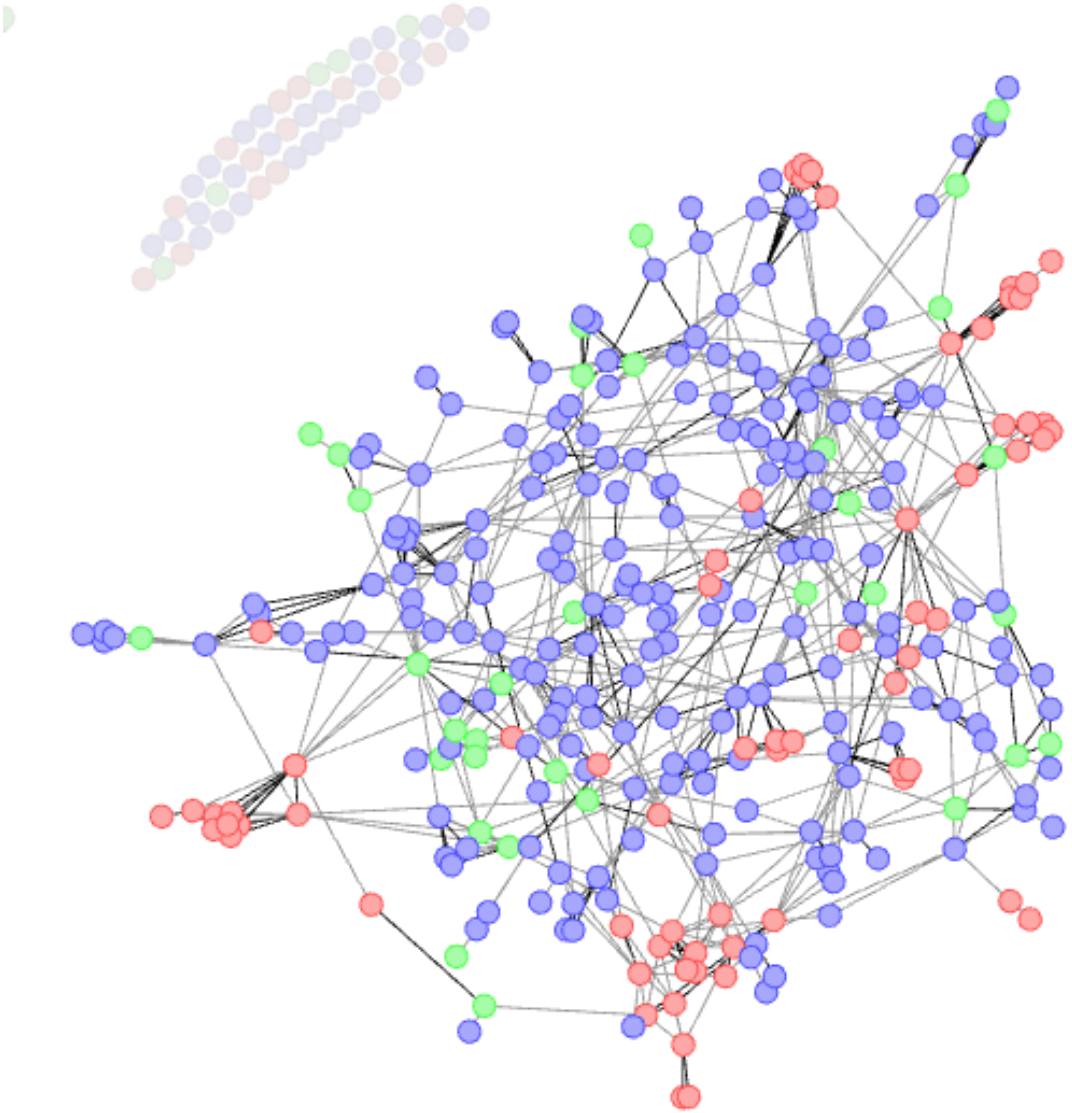


Example Output – one agent

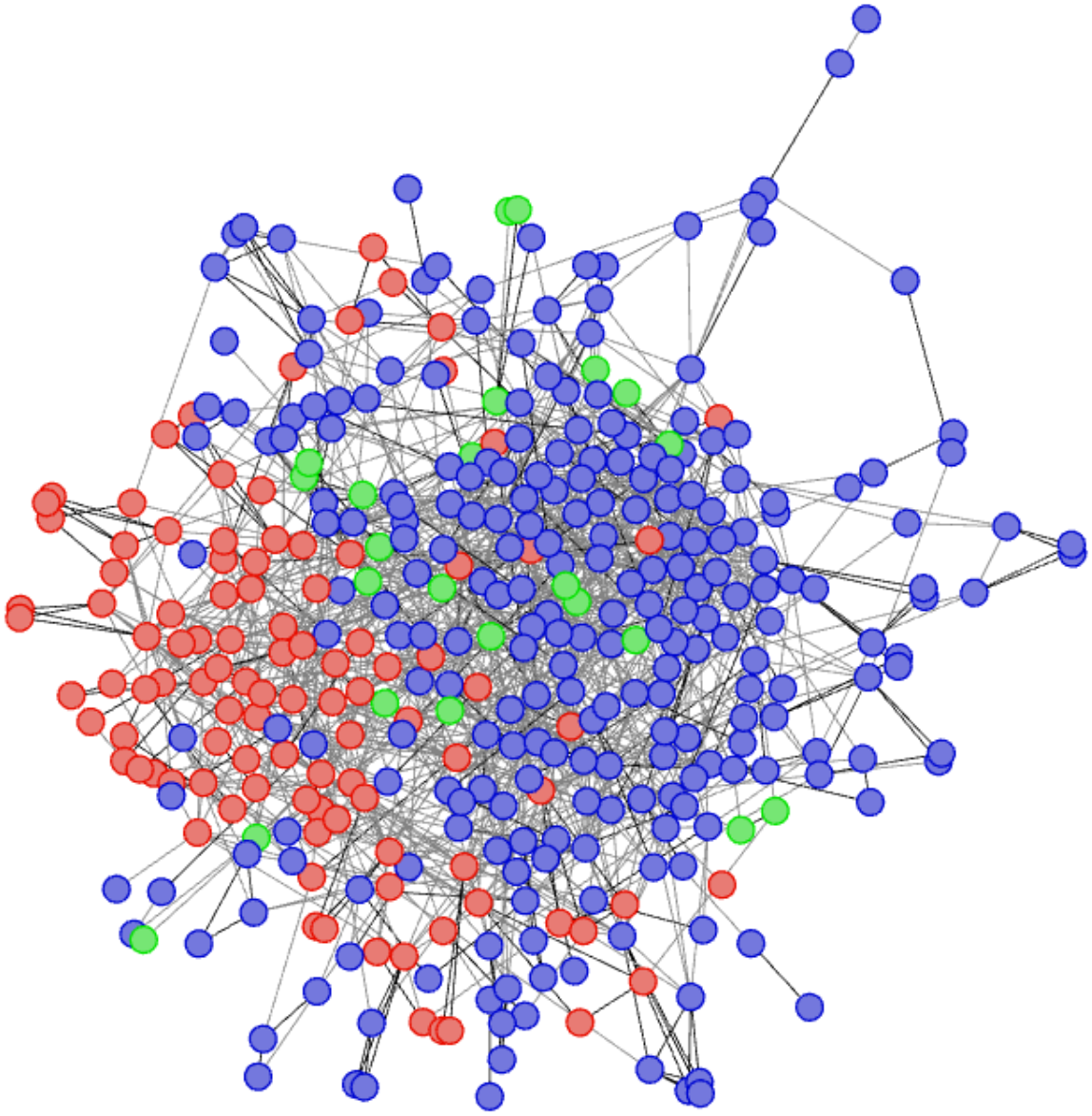


1945: (person 712) did not vote
1946: (person 712) started at (workplace 31)
1947: (person 712)(aged 29) moved from (patch 4 2) to (patch 5 3) due to moving to an empty home
1947: (person 712) partners with (person 698) at (patch 5 3)
1950: (person 712) did not vote
1951: (person 712) separates from (person 698) at (patch 5 3)
1951: (person 712)(aged 33) moved from (patch 5 3) to (patch 4 2) due to moving back to last household after separation
1951: (person 712) did not vote
1952: (person 712) partners with (person 189) at (patch 4 2)
1954: (person 712)(aged 36) moved from (patch 4 2) to (patch 23 15) due to moving to an empty home
1955: (person 712) did not vote
1964: (person 712) started at (activity2-place 71)
1964: (person 712) voted for the red party
1966: (person 712) voted for the red party
1970: (person 712) voted for the red party
1971: (person 712) started at (workplace 9)
1974: (person 712) voted for the red party
1979: (person 712) voted for the red party
1983: (person 712) died at (patch 23 15)

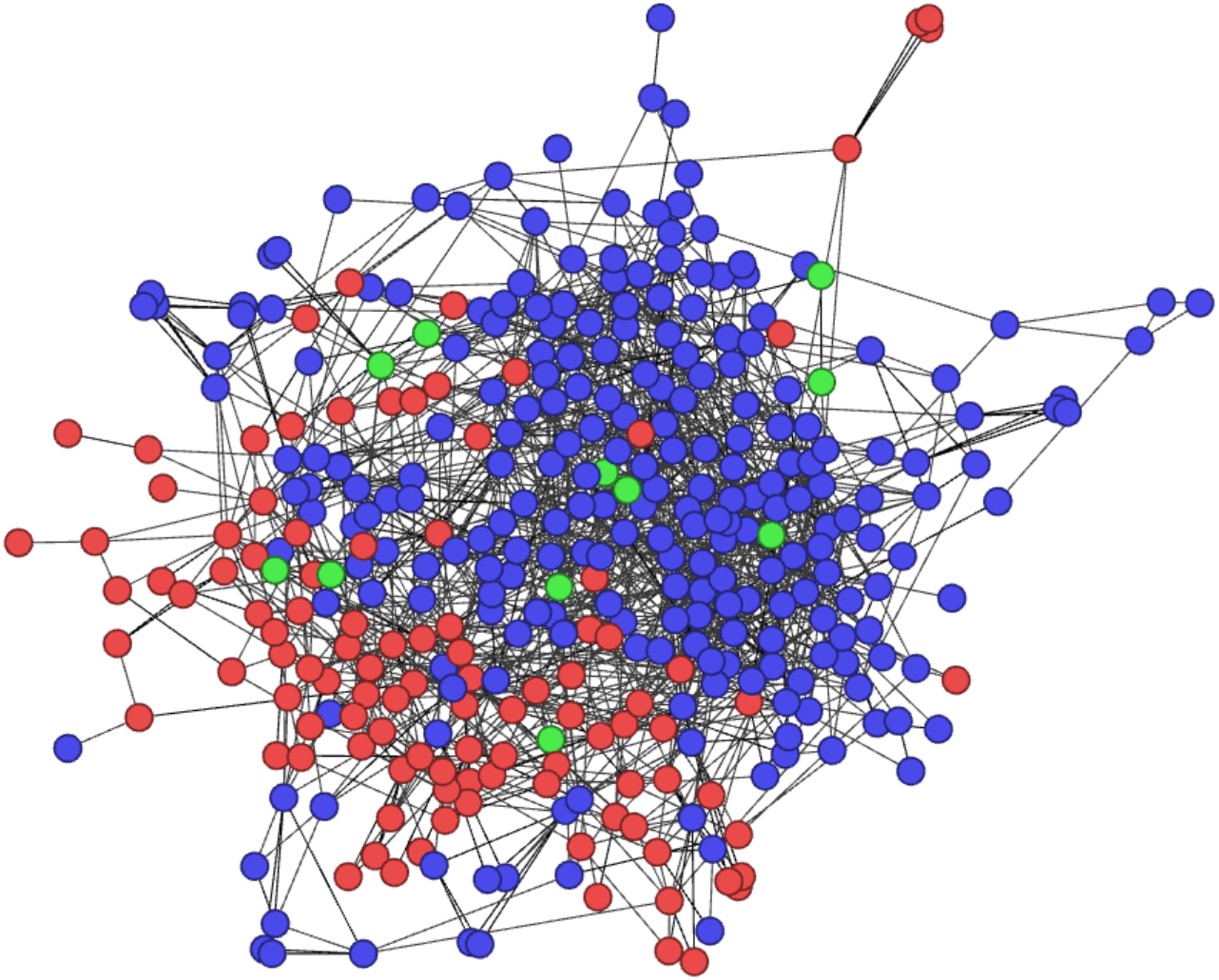
Social Network at 1950



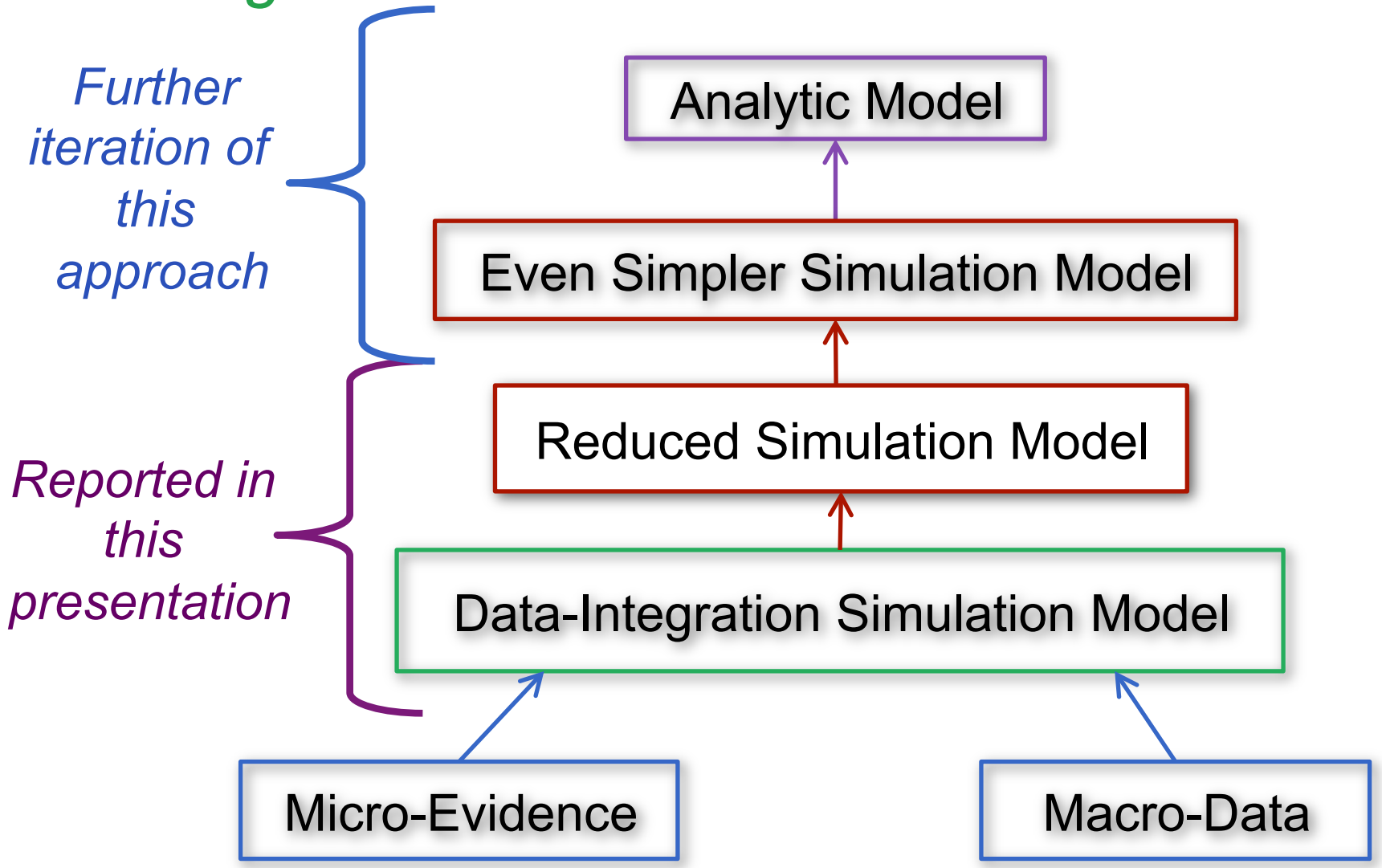
Social Network at 1980



Social Network at 2010



Final Picture – *indirect but staged knowledge*!



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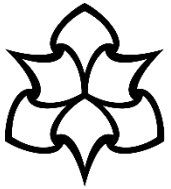
A model of Arab Spring Riots based on qualitative research of actor viewpoint

CSNE Analysis Framework

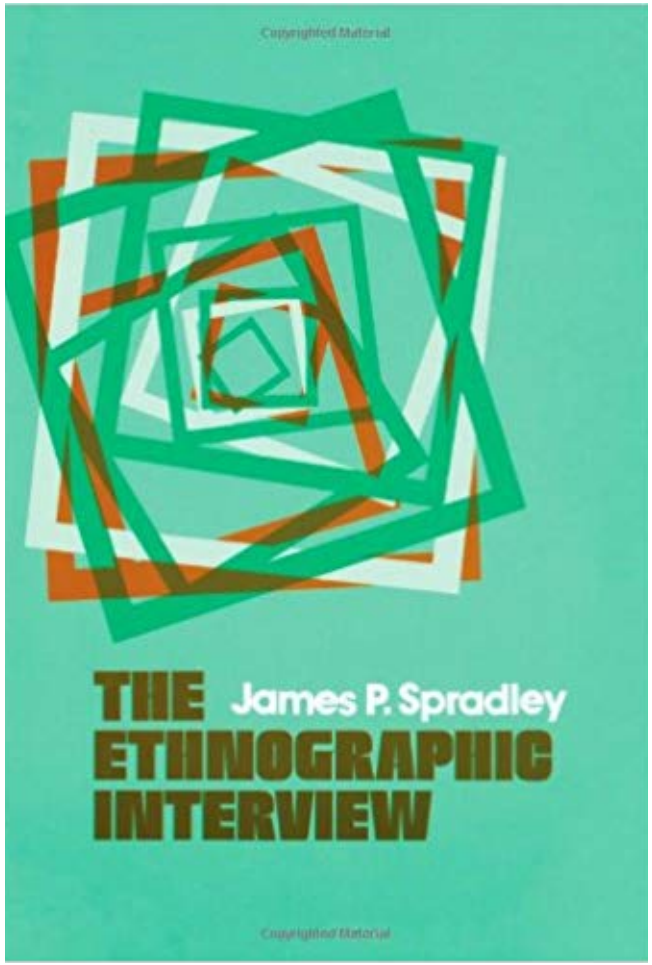


CSNE Aspect	Corresponding Property
Context	Relevance
Scope	Applicability
Narrative Element	Local: cause-effect pairs, decision points, sequences, alternatives etc.

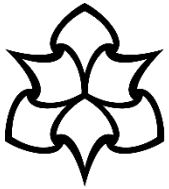
1. Context: the kind of situation one is in that determines the 'bundle' of knowledge that is relevant to that kind of situation
2. Scope: what is and is not possible given the current situation and observations
3. Narrative Elements: the narrative elements that are mentioned assuming the context and scope

Identifying narrative elements

Data collection



Data construction



Qualitative coding procedures: open and axial coding (Corbin and Strauss)

Breaking sentences into narrative elements

- any factor addressed by a sentence, e.g. external events, emotions, structural conditions, etc.

- inferences, connections between factors: “I felt afraid **because** I saw the government attack the protestors” (attack -> fear)

- decisions for actions, protest vs non-protest (factor -> factor -> … -> decision)

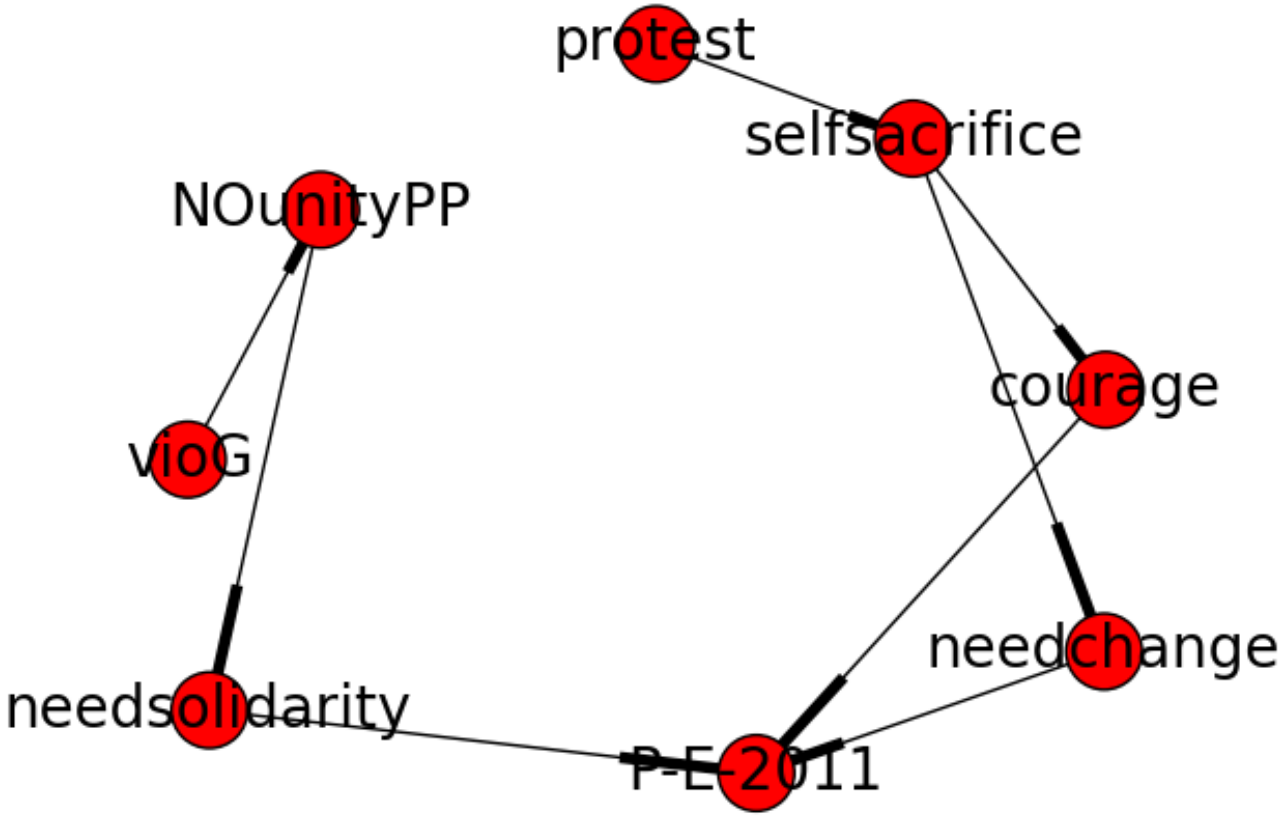
The data

121 narratives that end in decisions about protest

53 protest decisions (interviews and Facebook)

68 decisions to stay at home (interviews only)

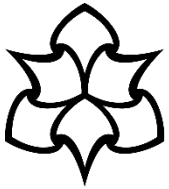
Resulting narrative structures



Nodes: Factors

Edges: Inferences (including and- and or-

Identifying rules for ABM



Positive emotions trigger protest decisions

- Emotion -> protest

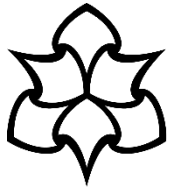
Observing others protest triggers positive emotions

- Protest observation -> positive emotion

Safety considerations trigger decisions against protest

- Safety -> non-protest

Identifying rules for ABM continued



The role of governmental attacks:

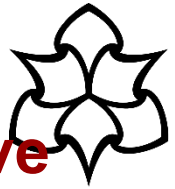
dampening effect:

attack -> safety consideration -> non-protest

spurring effect:

attack -> courage -> protest

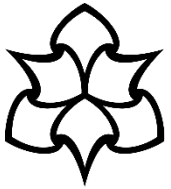
Adding rules
(based on questions from the modeler to the qualitative researcher)



Contexts of protest observations (key factor of narratives):

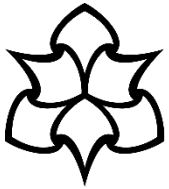
1) Walking on the street
2) Talking to friends, family members, strangers
3) Watching satellite TV (AJ)
4) Following social media

How agents may differ



- Employed/unemployed
- Susceptibility to emotion
- Whether on facebook
- What personal friends they have (others they would text/phone)
- Where they are
- Current knowledge of attacks, protests
- Whether protesting, whether attacked
- Current emotional level

Different Modelling Contexts



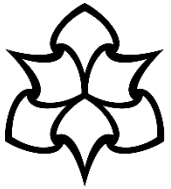
Different locations:

- Home – away from active involvement, but still in contact via phone and FaceBook
- Street – socialising area, vulnerable to attack, face-face emotional influence, start of protests
- Square – where critical mass is achieved, protests persist

Different times of day:

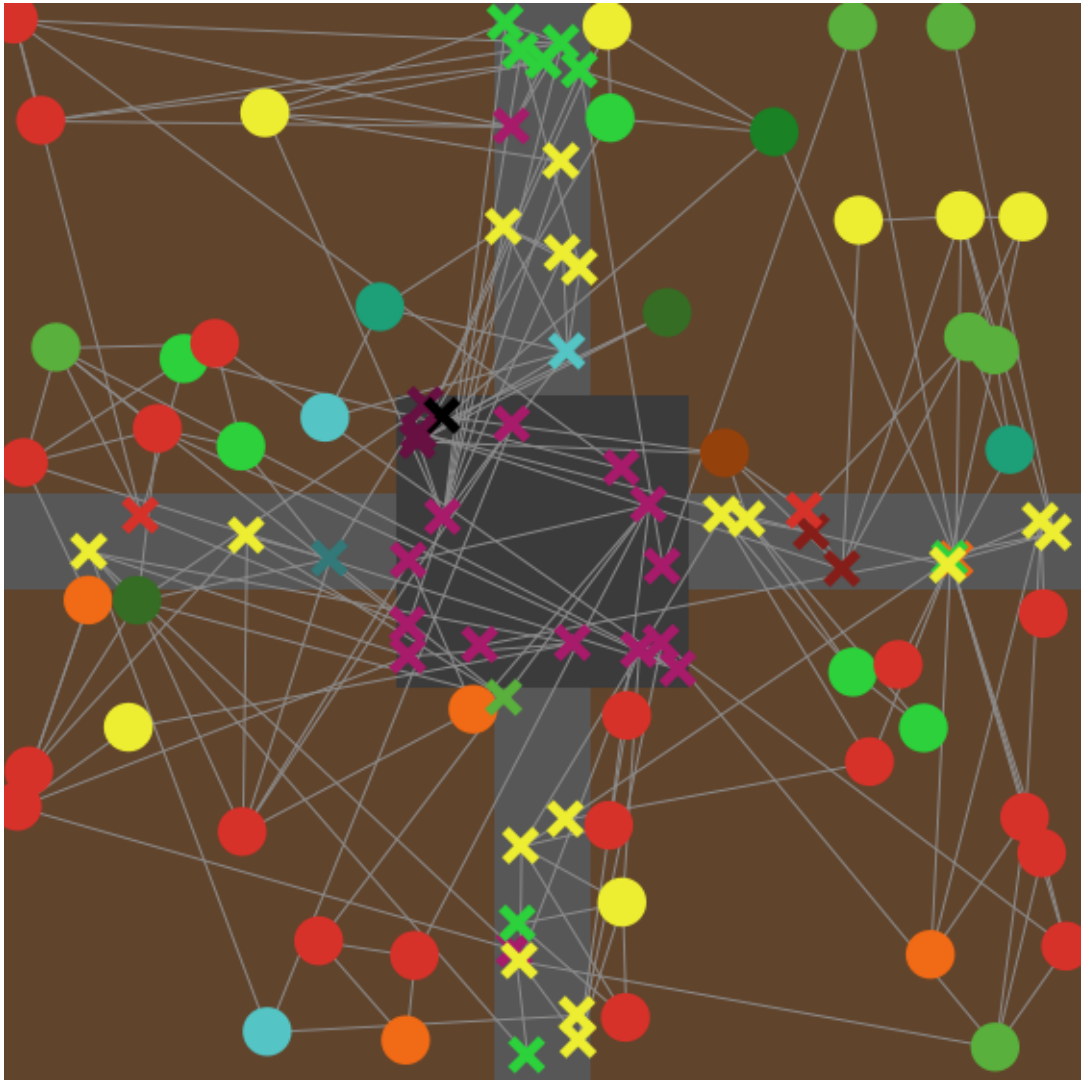
- Waking – calmer at start of day but with variation, clean slate as to knowledge of protests, attacks
- Daytime – unemployed socialise on street, might move to square
- Evening – all socialise in street, might move to square
- Night – employed go home, unemployed might go home

Social Influence

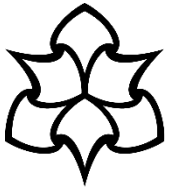


- Knowledge (e.g. of attacks or protests that day) spreads by face-face, phone (friends) or facebook (if on and they have it)
- Emotional influence spreads face-face – increasing up to the average of the others on the same patch
- Both emotion and knowledge reset each morning (emotion reduces and changes somewhat randomly)

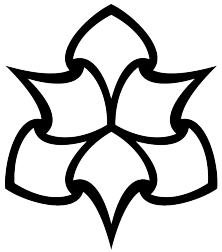
The Simulation



Still developing



- Now looking at “pattern-based” validation (Grimm et al. 2005, Science)
- Relating what happens to agents in the simulation back to the qualitative accounts
- Investigating the characteristics of the model more
- Reviewing and improving the process of the qualitative to simulation specification process



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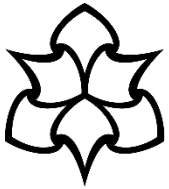
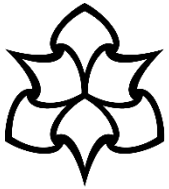
Conclusions

So how could ABM help CSI?



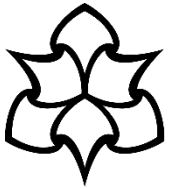
- Can relate elements of a bottom-up actor viewpoint with a top-down systemic view
- Good for integrating different kinds of evidence including: first-person accounts, time-series, survey, geographical data, etc. into a coherent, dynamic and formal representation
- Then discussed experimented on and evaluated
- Can aid inter-view communication by providing common but specific points points of reference
- Can be a good basis for further, staged, abstraction
- *Not* good for prediction, but good for a kind of uncertainty analysis

The Cons of ABM



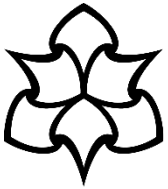
- Representing semantically rich characteristics is hard (have to build the basis for the meaning *into* the model)
- Different assumptions can result in very different outcomes
- Can be more persuasive than their empirical grounding warrants (Kuhnian Spectacles)
- Can themselves be complex, messy and generally hard to understand
- Time-consuming to develop
- Needs lots and lots of empirical grounding to get beyond just being an analogy or illustration
- Have to think clearly about what the purpose a model is and the consequences of this!

More about ABM



- *Videos of introductions to ABM, Methods@Manchester.* http://methods.manchester.ac.uk/methods/abss
- *Simulation for the Social Scientist*, 2nd Edition. Gilbert and Troitzsch (2005) Open University Press. http://cress.soc.surrey.ac.uk/s4ss/
- Simulating Social Complexity – a handbook (2017), 2nd Edition. Edmonds & Meyer (eds.) Springer.
- *Journal of Artificial Societies and Social Simulation* http://jasss.soc.surrey.ac.uk
- *European Social Simulation Association* and their conference "*Social Simulation*", http://essa.eu.org
- *NetLogo*, a relatively accessible system for doing ABM with a big library of example models http://ccl.northwestern.edu/netlogo

References



CC:DEW model

- *Final project report* at: http://cfpm.org/ccdew
- *Olivier Bartelemy's Thesis*: http://cfpm.org/theses/olivier/

SCID Voter model

- *Base Model Description*: Fieldhouse et al. (2016) Cascade or echo chamber? A complex agent-based simulation of voter turnout. *Party Politics.* *http://dx.doi.org/10.1177/1354068815605671*
- *First meta-modelling step:* Lafuerza et al. (2016) *Staged Models for Interdisciplinary Research*. PLoS ONE. https://doi.org/10.1371/journal.pone.0157261
- Second meta-modelling step: Lafuerza et al. (2016) implification and analysis of a model of social interaction in voting, European Physical Journal B. http://dx.doi.org/10.1140/epjb/e2016-70062-2%20

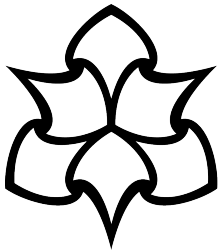
Arab Spring model

- *Slides & Model*: Dornschneider & Edmonds (2019) A Simulation of Arab Spring Protests Informed by Qualitative Evidence, Social Simulation 2019. http://cfpm.org/models/237

Other

- *CSNE framework*: Edmonds (2015) A Context- and Scope-Sensitive Analysis of Narrative Data to Aid the Specification of Agent Behaviour, JASSS, http://jasss.soc.surrey.ac.uk/18/1/17.html
- *Modelling Purposes*: Edmonds et al. (2019) Different Modelling Purposes, JASSS, http://jasss.soc.surrey.ac.uk/22/3/6.html

The End!



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