Social Simulation
– an introduction

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About Modelling

What is a model?

Something, A, that is used to understand or answer questions about something else, B

- e.g: A scale model to test in a wind tunnel
- e.g: The official accounts of a business
- e.g: The minutes of a meeting
- e.g: A flow chart of a legal process
- e.g: A memory of a past event
- e.g: A computer simulation of the weather
- e.g: The analogy of fashion as a virus

Models usually abstract certain features and have other features that are irrelevant to what is modelled

A simple consequence of this…

- That if you are only exploring a model to find out about the model, then this is useless, unless…:
- This understanding helps one understand other models, for example:
  - An idea about something – *this is generally private but not publically useful knowledge*
  - Or is of SUCH generality it informs us about *SO* many other models that it is worth adsorbing
- Normally we use a model to tell us about something else, something observed (maybe via intermediate models, such as data)

What is a *formal* model?

Something that (in theory) can be written down precisely, whose content is specified without ambiguity

- e.g: mathematical/statistical relations, computer programs, sets of legal rules

Can make exact copies of it

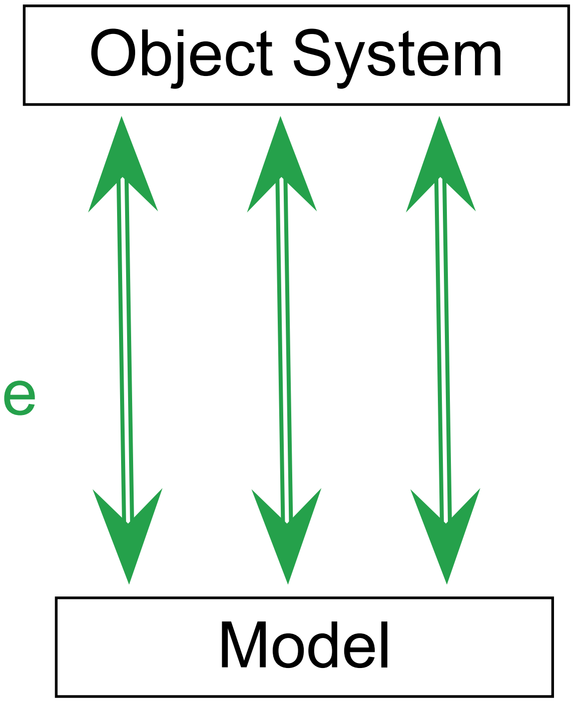
Agreed rules for interpreting/using them

Can make *certain* inferences from them

- *Not*: an analogy, a memory, a physical thing

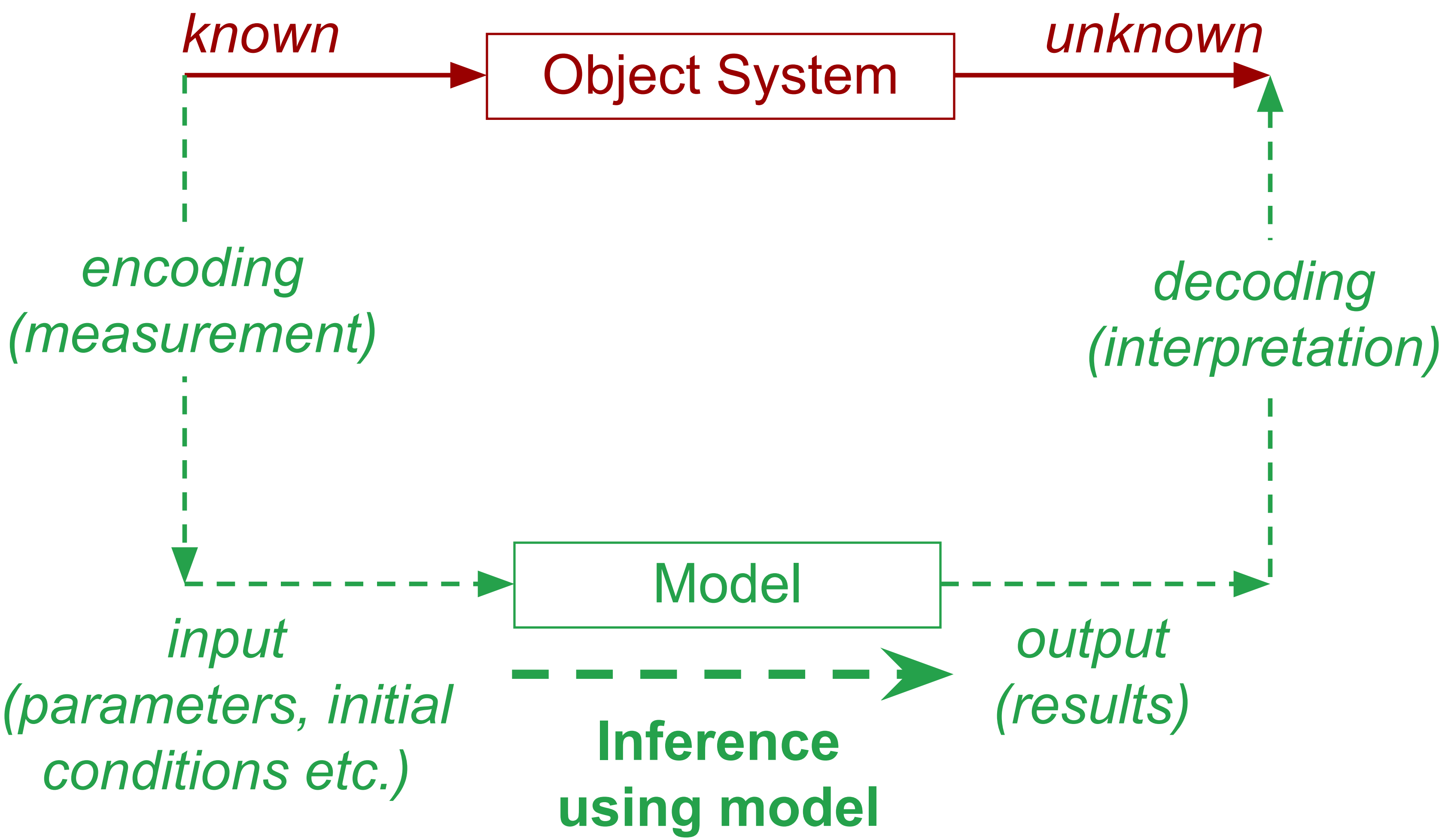
The Model and its Target

The mapping between formal model and what the parts refer to

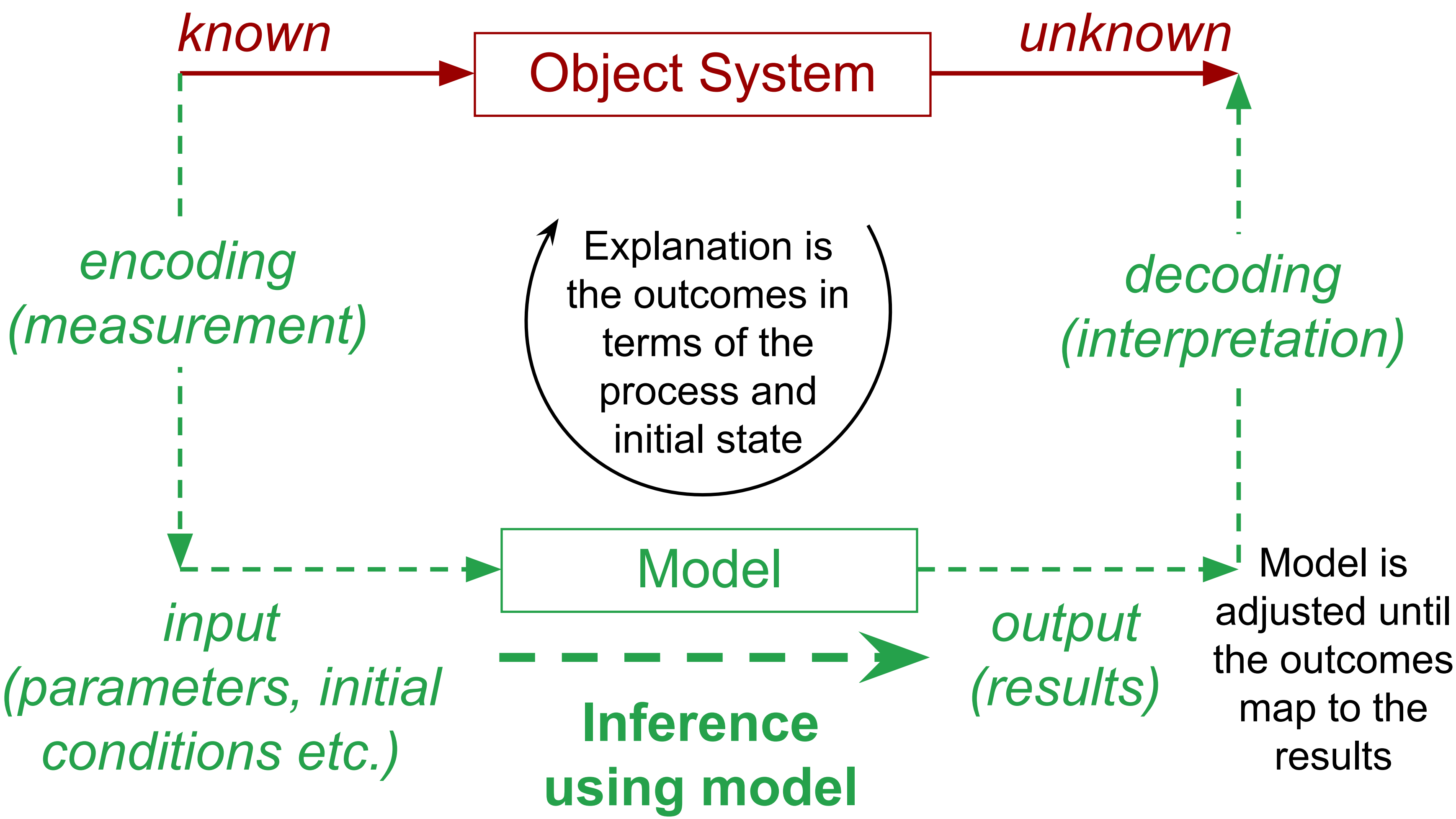


- A formal model is not a model at all without this mapping relation telling us the intended meaning of its parts

A Model used for prediction of unknown data



A Model used for explanation of known data in terms of mapping



The Whole Modelling Chain

- In both prediction and explanation…
- to get anything useful out…
- One has to traverse the whole modelling chain, three steps:
  1. From target system to model
  2. Inference using the model
  3. From model back to target system
- The “usefullness” of the model, roughly speaking, comes from the strength of the whole chain
- If one strengths one part only to critically weaken another part this does not help

Modelling Purposes

All modelling has a purpose (or several)

Including:

- Description
- Prediction
- Establishing/suggesting explanations
- Illustration/communication
- Exploration
- Analogy

These are frequently conflated!

The Modelling Context

All modelling has a context

- The background or situation in which the modelling occurs and should be interpreted
- Whether explicit or (more normally) implicit
- Usually can be identified reliably but not described precisely and completely
- The context inevitably hides many implicit assumptions, facts and processes

Modelling only works if there is a reliably identifiable context to model *within*

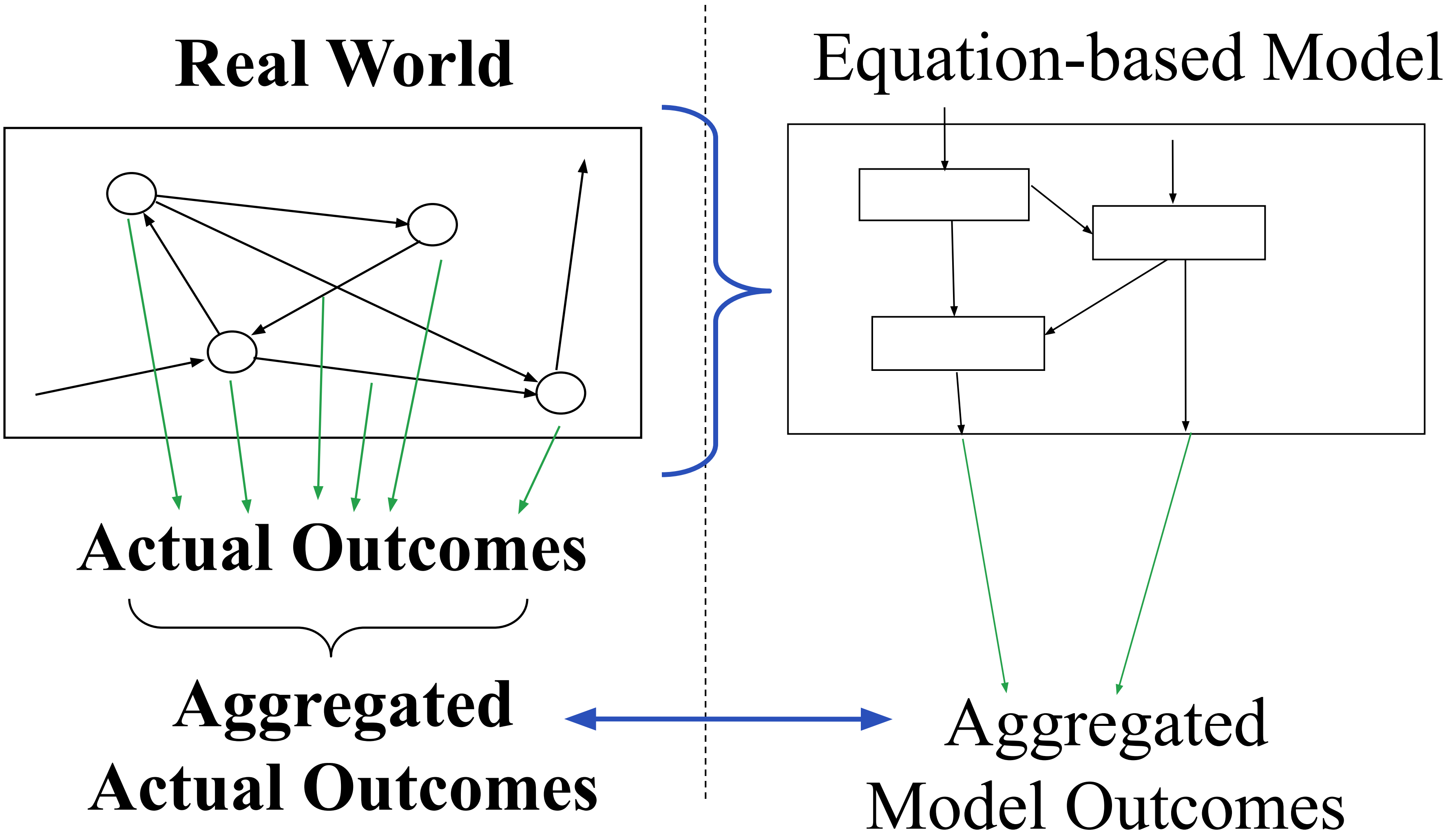
Analytic **formal models**

Where the model is expressed in terms that allow for formal inferences about its general properties to be made

- e.g. Mathematical formulae
- Where you don't have to compute the consequences but can *derive* them logically
- Usually requires numerical representation of what is observed (but not always)

Only fairly "simple" mathematical models can be treated analytically – the rest have to be simulated/calculated

Equation-based or statistical modelling



Computational **models**

Where a process is modelled in a series of precise instructions (the program) that can be "run" on a computer

- The same program always produces the same results (essentially) but...
- ...may use a "random seed" to randomise certain aspects
- Can be simple or very complex
- Often tries to capture more "qualitative" aspects of phenomena
- A computational model of social phenomena is a **social simulation**

Origins of Social Simulation

(Occasionally) Interacting Streams:

- Sociology, including social network analysis
- Distributed Computer Science Programming Languages
- Artificial Intelligence & Machine Learning
- Ecological Modelling

(Strangely) *Not much from*:

- (Mainstream) Economics
- Cognitive Modelling
- Numerical Simulation
- System Dynamics

Two Different Directions

1. Towards the detailed interaction between entities
   - Trying to capture how the complex interaction between decision-making actors might result in the "unexpected" *emergence* of outcomes
   - Roughly this is **Agent-based simulation**
2. Towards the detail of circumstance
   - Trying to use data that allows different regions or cases to be captured by different models
   - Roughly this is **Microsimulation**

Other kinds of social simulation model

- Cellular Automaton Models – where patches in a surface change state in response to their neighbours' states
- System Dynamic Models – where a system of equations representing top-level, aggregate variables are related, then computationally simulated (sometimes with animation)
- Population Dynamics Models – where a statistical distribution represents a collection of individuals plus how these distributions change over time

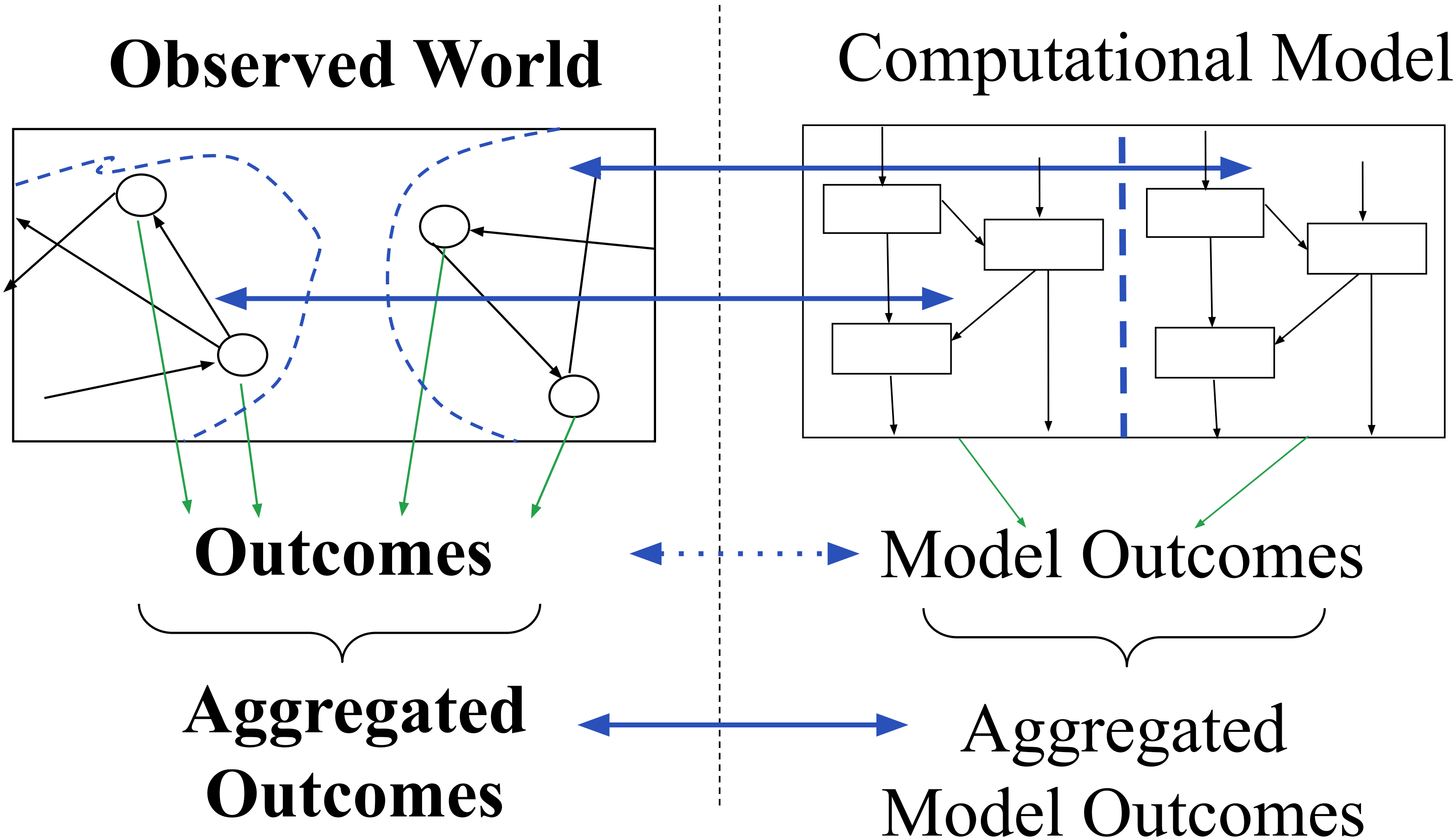
A little bit about

Microsimulation

About Microsimulation

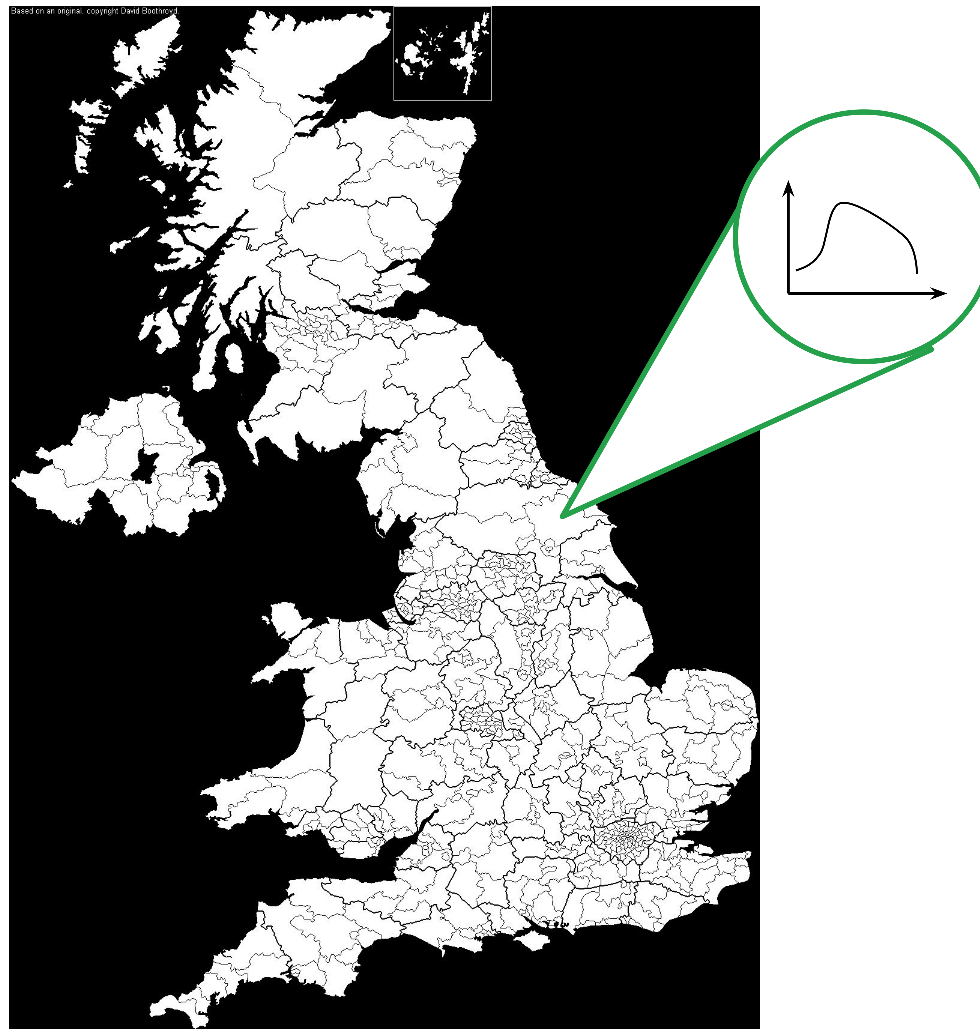
- Instead of having a generic process over all relevant situations one has a model for each situation
- This is limited and determined by available data for each of these situations
- Often these situations are geographical regions
- Often each model is a population dynamics model with a different distribution for each region, trained on available data (usually each distribution come from a family which encode assumptions about the processes)
- Thus variation is not handled by some generic "noise" but rather aggregation is put off to a post-hoc summary of the complex results retaining the context-specificity
- This approach is heavily data-driven
- You have to look at each separate region to determine if the local model is a good fit in each case

Microsimulation

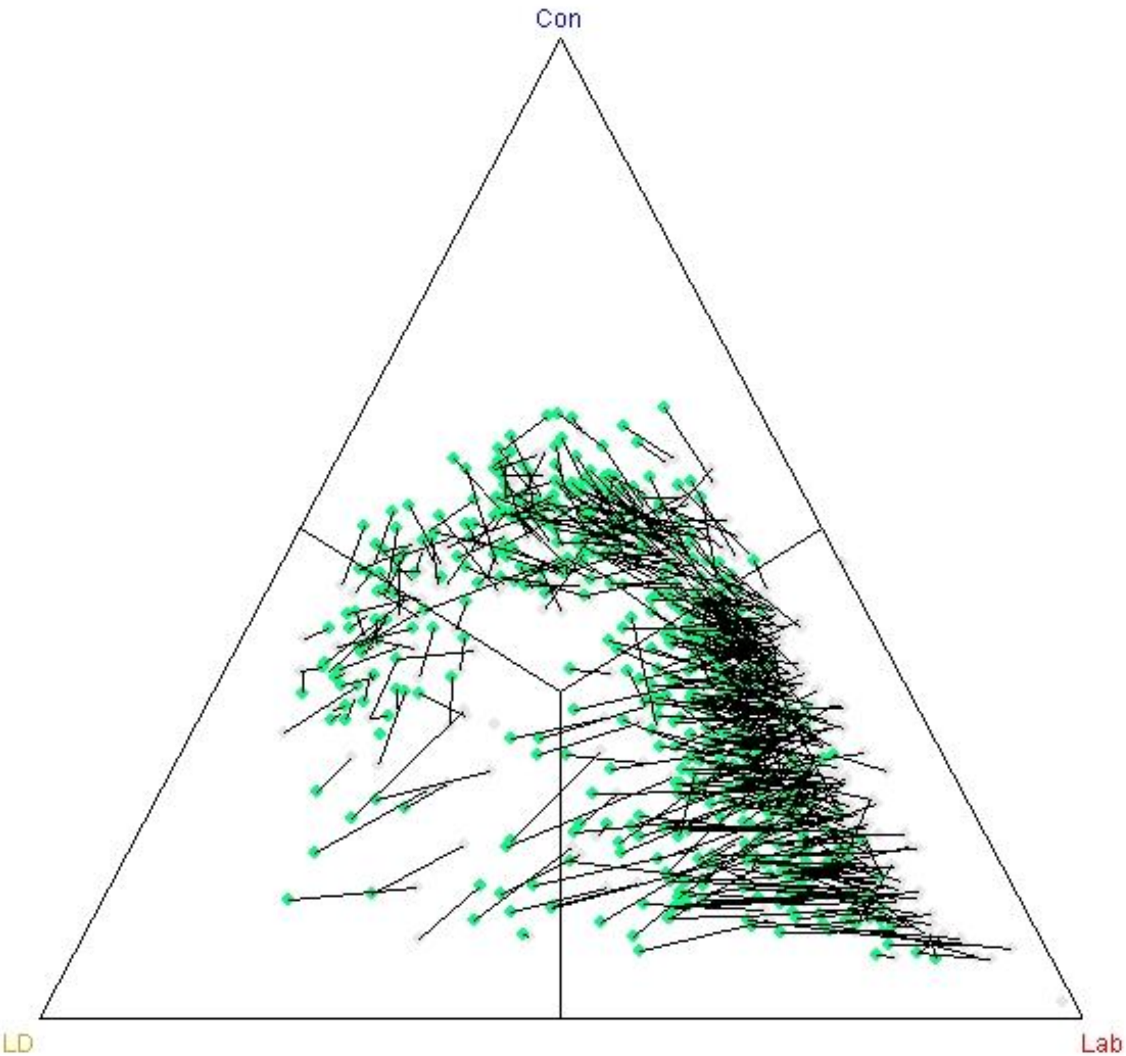


Example 1: *General Election Forecasting*

- John Curtice (Strathclyde) and David Firth (Warwick) (+ input from others)
- Each constituency is statistically modelled as a three-way split (Lab, Con, LD) based on how much this swung with the general trend according to past data



Example 1: *General Election Forecasting*



- Each line is the 3-way vote share for each constituency in UK general elections,
- green spots show 2005 shares, tail is the 2001 shares

Pros and Cons of Microsimulation

Advantages

- Data-driven
- Allows for local differences (context-sensitive)
- Assumptions are statistical rather than behavioural
- Relates well to maps and hence results are readily communicable

Disadvantages

- Needs a lot of data at the granularity being modelled
- Does not (without extension) capture interactions between regions
- Can take a lot of computer power
- Does not result in a simple explanation or abstraction

Much more about

Agent-Based Social Simulation

Some Key Historical Figures

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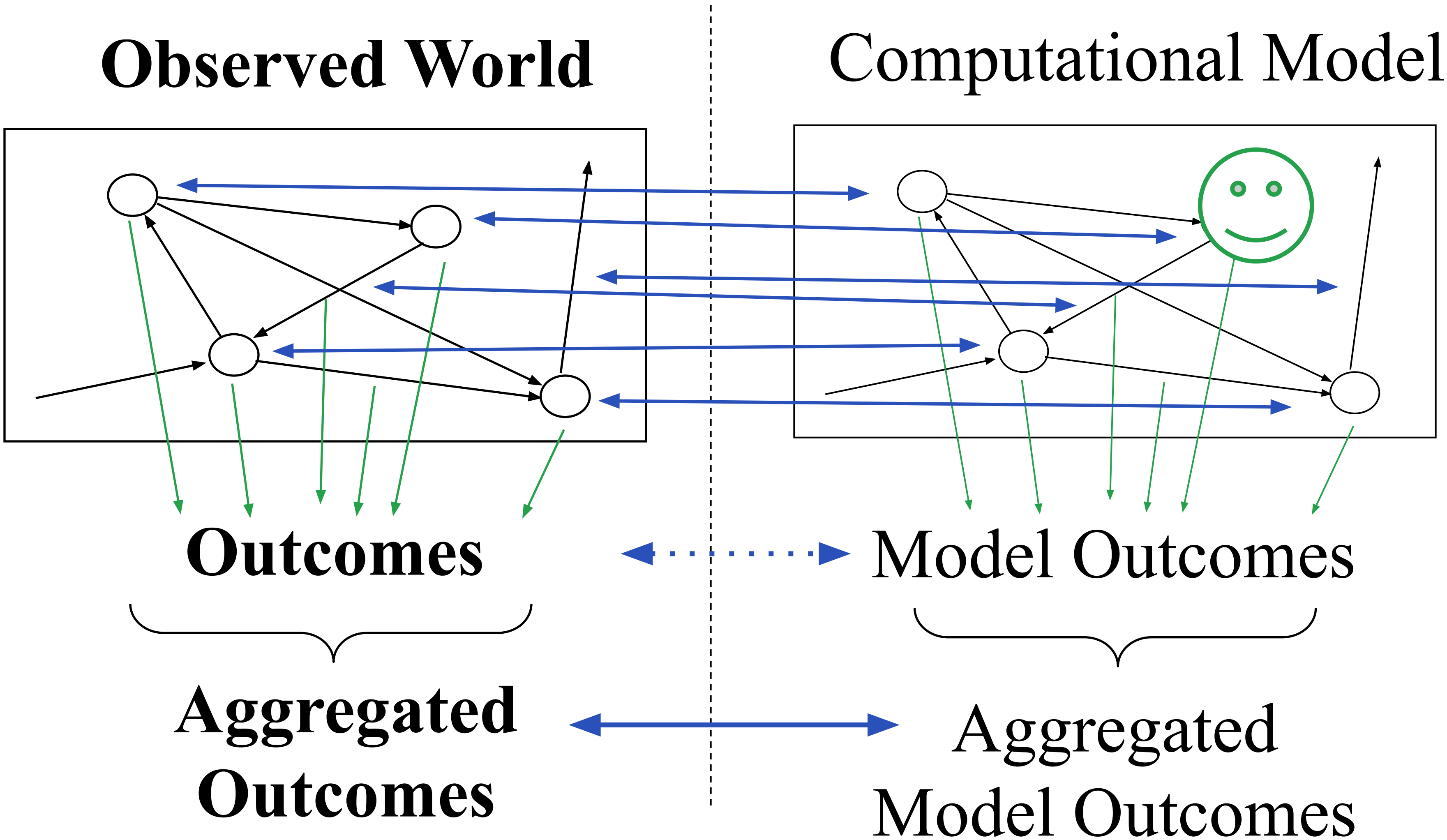
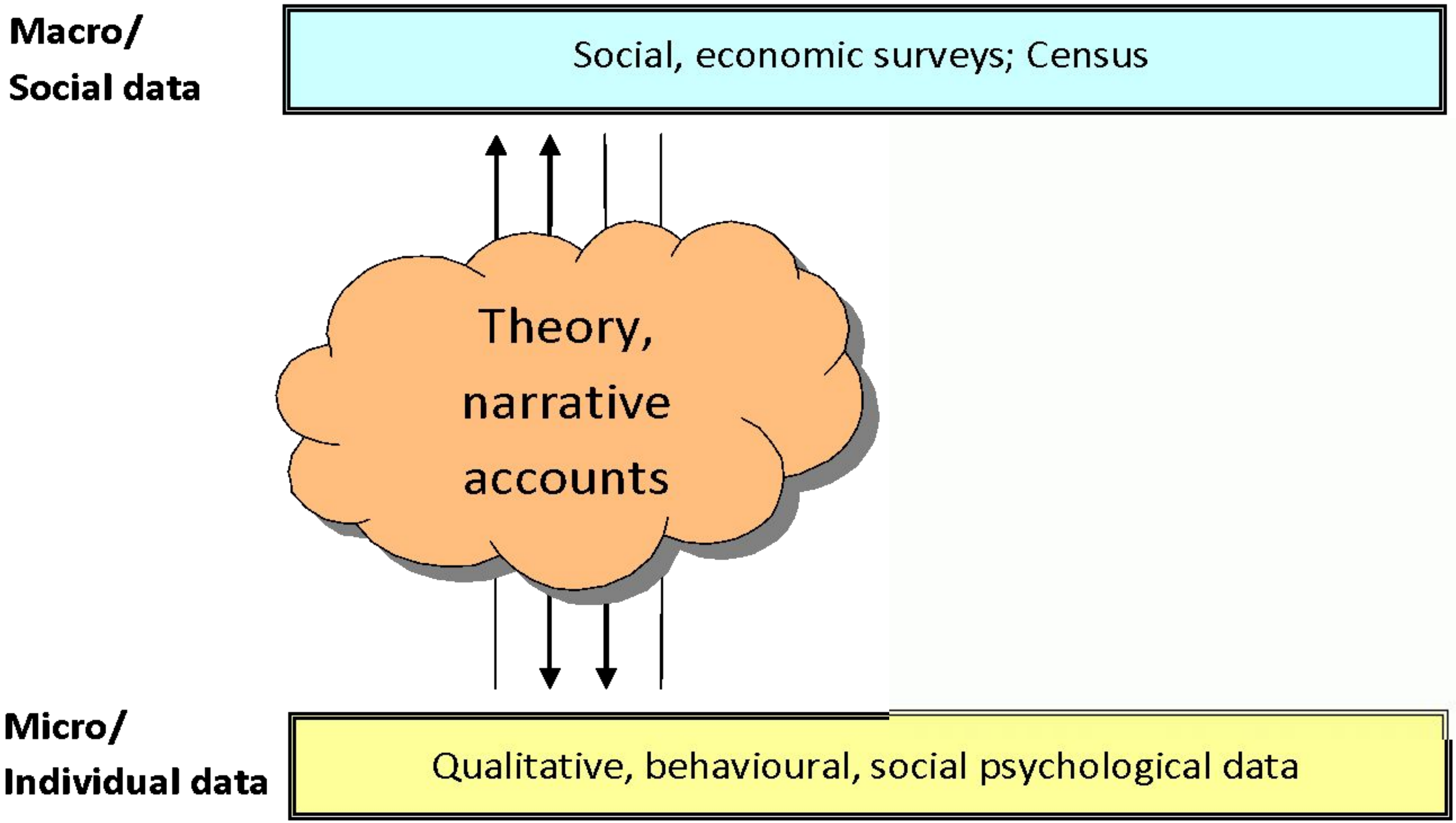
- Herbert Simon
  - Observed administrative behaviour and described it using algorithms – '*procedural rationality*' (rather than optimisation of utility)
  - Also (with Alan Newell) produced first computational models of aspects of cognition
- Thomas Schelling
  - A simple but effective example of individual-based modelling (in the coming slides) showing power of simulation establishing a micro-macro link
- Mark Granovetter
  - Distinguished the importance of tracing individual interactions, '*social embeddedness*'
  - Highlighted such processes and structure ('ties')

Agent-based simulation



Micro-Macro Relationships

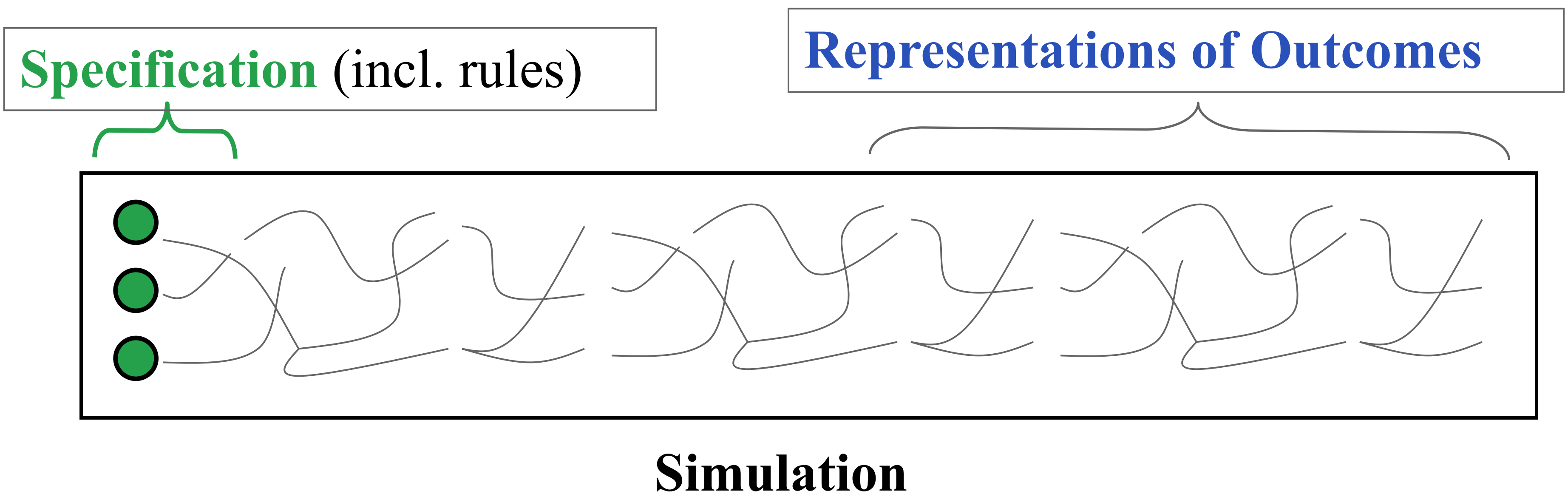


Characteristics of agent-based modelling

- 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 complex themselves

What happens in ABSS

- Entities in simulation are decided up
- Behavioural Rules for each agent specified (e.g. sets of rules like: if *this has happened* then *do this*)
- Repeatedly evaluated in parallel to see what happens
- Outcomes are inspected, graphed, pictured, measured and interpreted in different ways



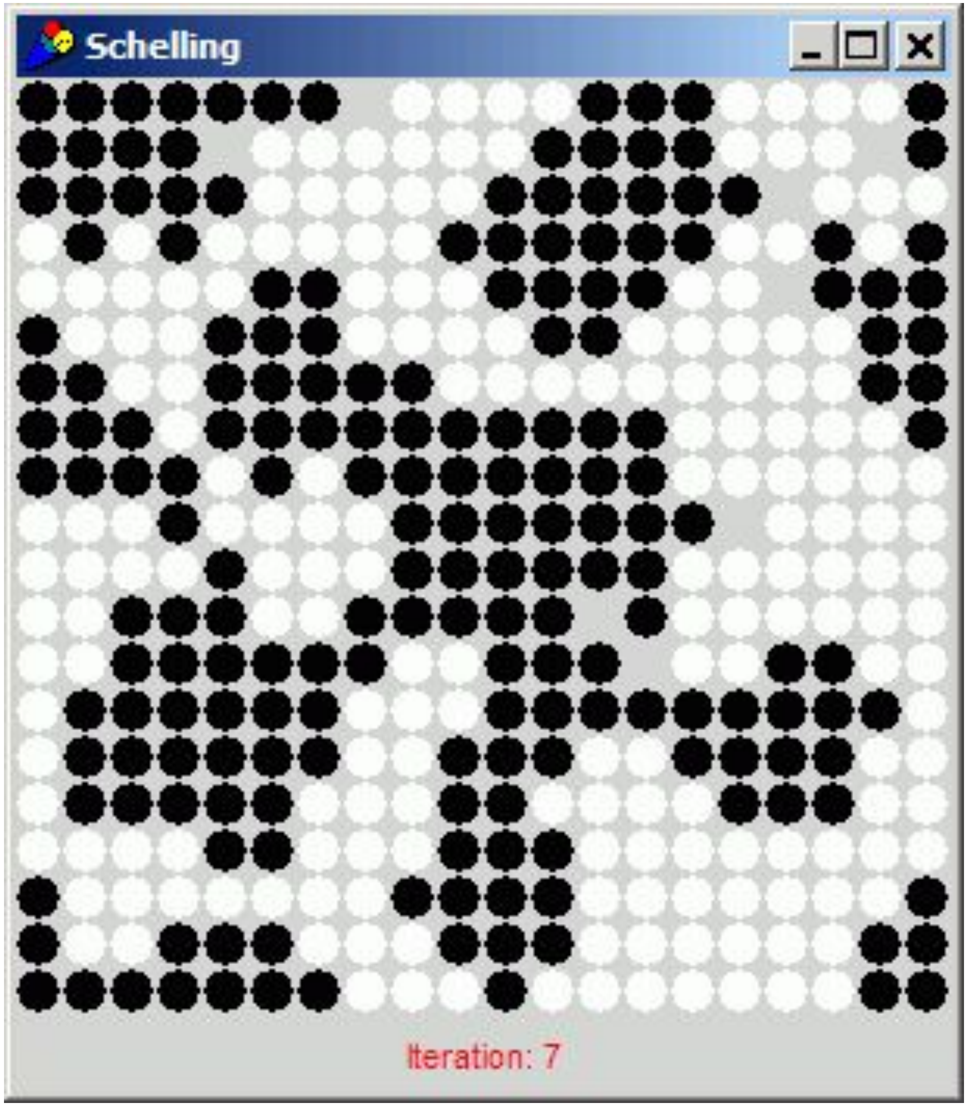
Example 2: *Schelling's Segregation Model*

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:

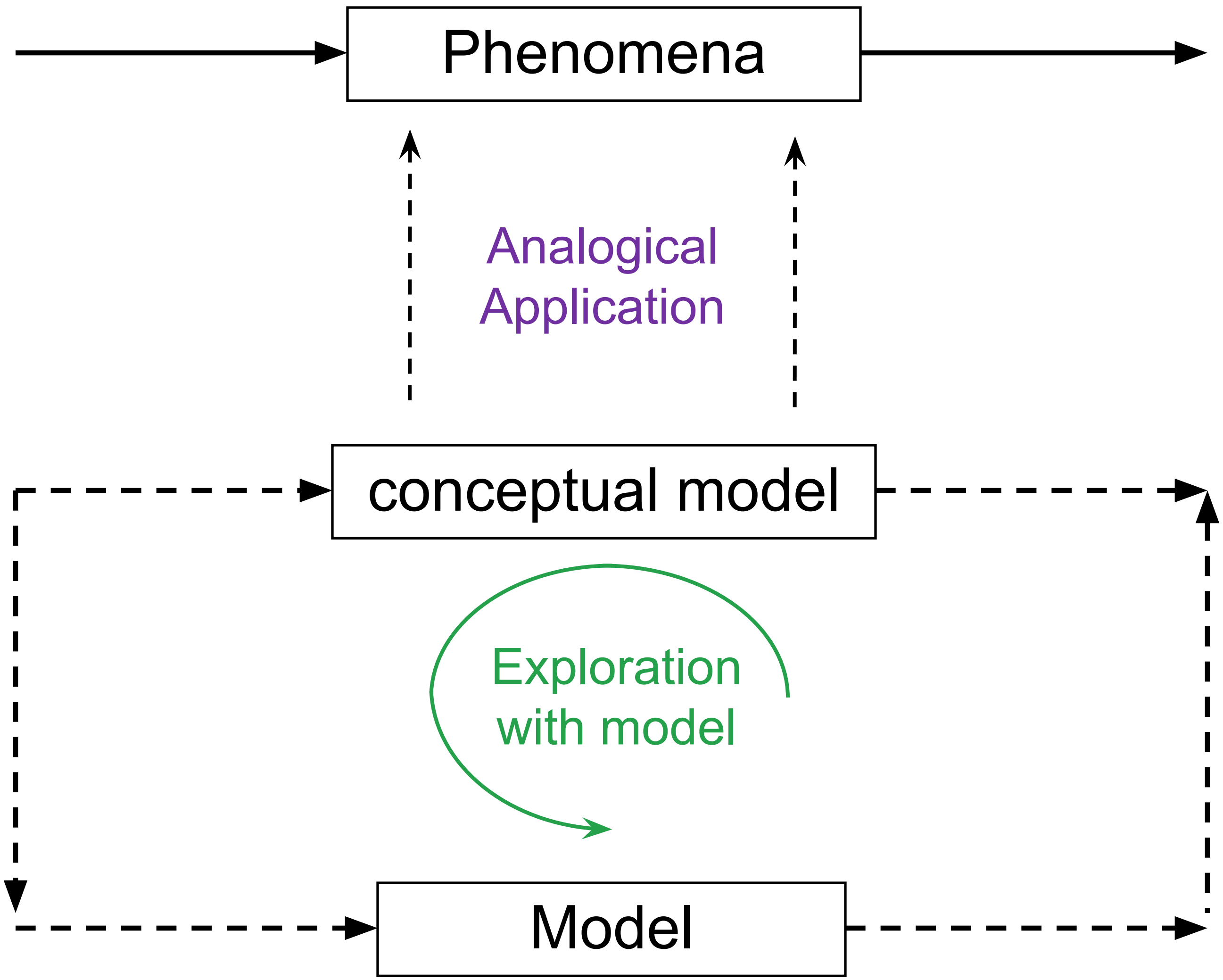
Segregation can result from wanting only a few neighbours of a like colour



Simple, Conceptual Simulations Such as Schelling's

- Are highly suggestive
- Once you play with them, you start to "see" the world in terms of you model – a strong version of Kuhn's *theoretical spectacles*
- They can help persuade beyond the limit of their reliability
- They may well not be directly related to any observations of social phenomena
- Are more a model of an idea than any observed phenomena
- Can be used as a counter-example

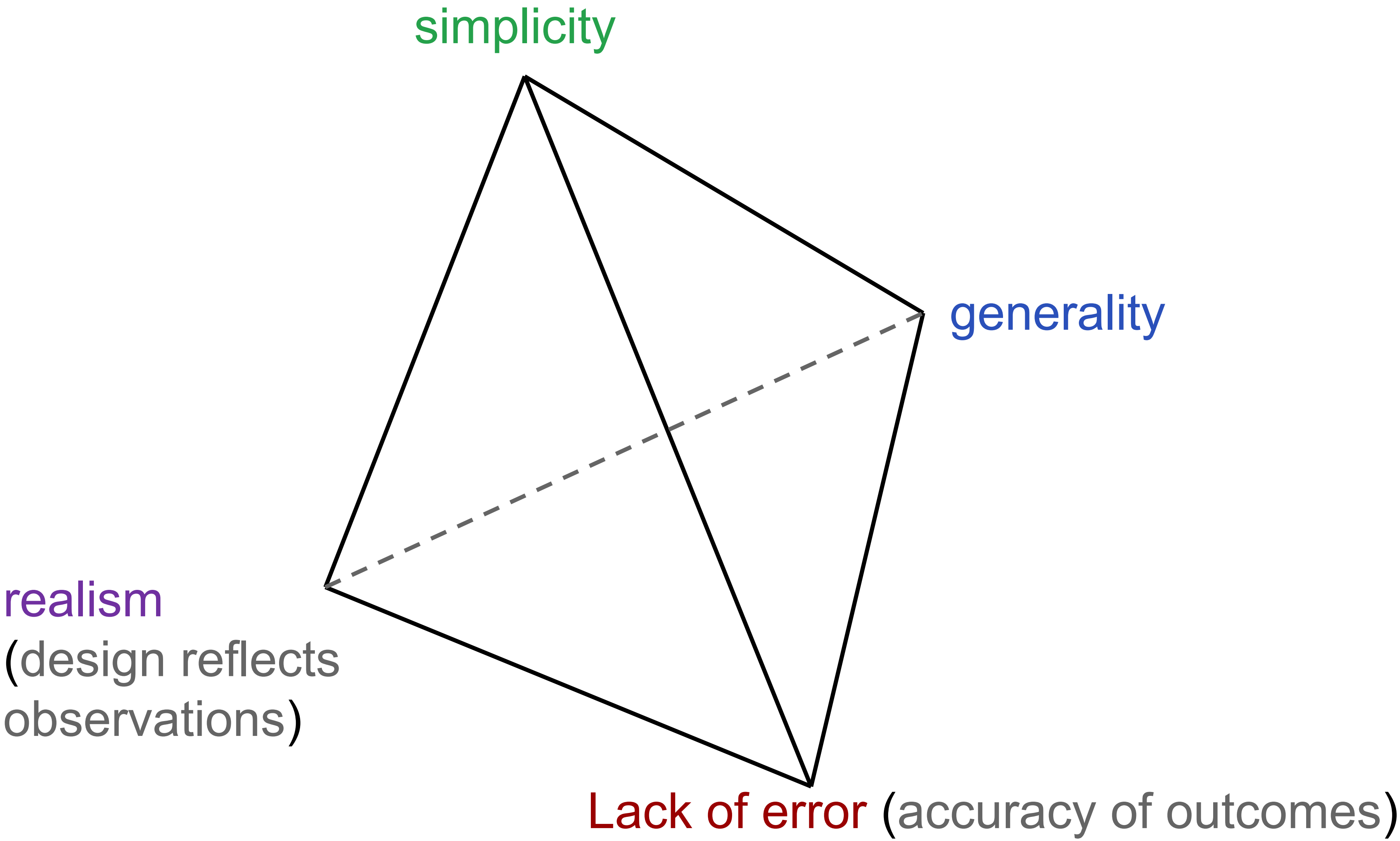
Modelling a concept of something



Some Criteria for Judging a Model

- Soundness of design
  - w.r.t. knowledge of how the object works
  - w.r.t. tradition in a field
- Accuracy (lack of error)
- Simplicity (ease in communication, construction, comprehension etc.)
- Generality (when you can safely use it)
- Sensitivity (relates to goals and object)
- Plausibility (of design, process and results)
- Cost (time, effort, etc.)

Some modelling trade-offs



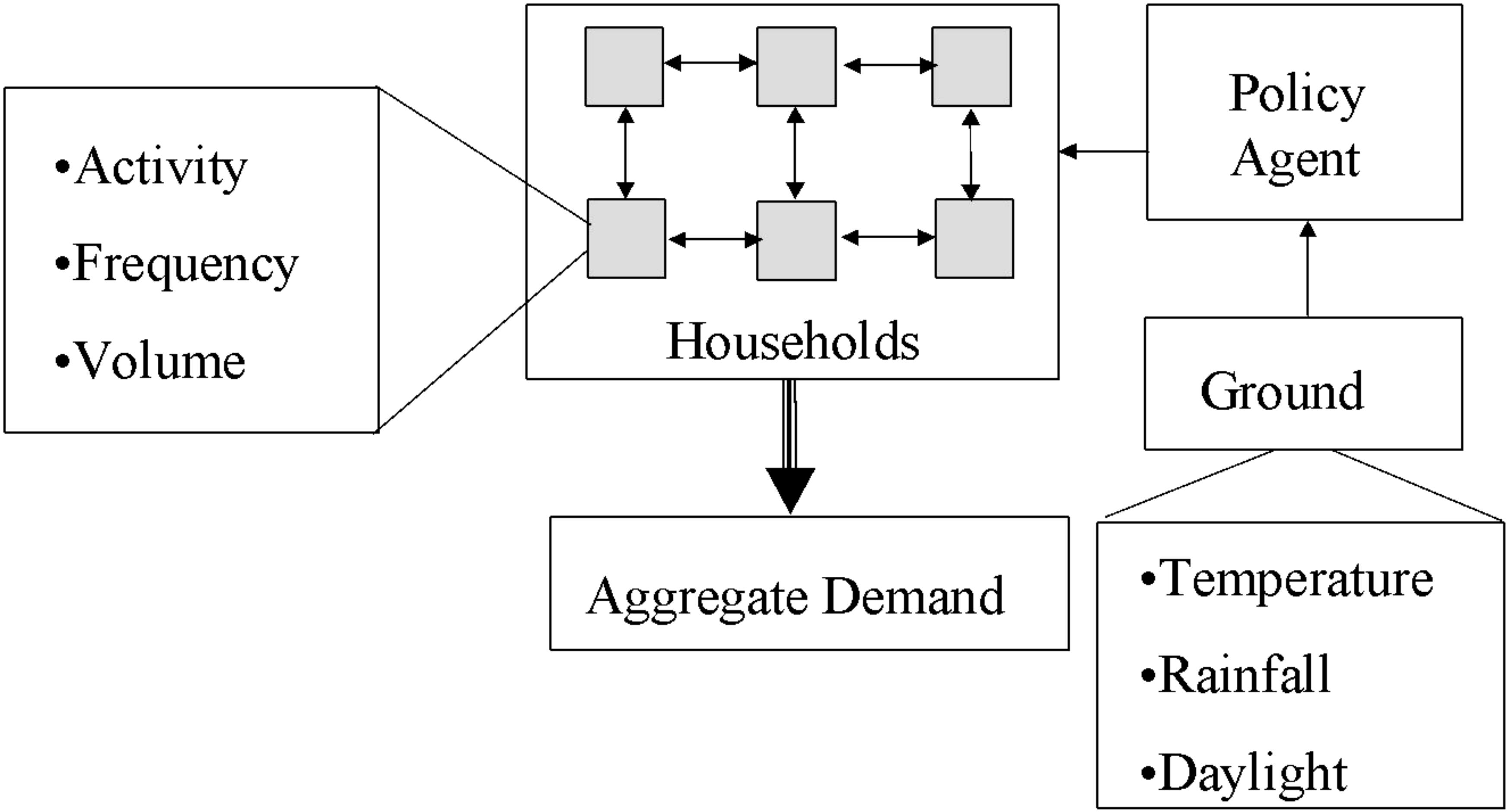
Example 3: *A model of social influence and water demand*

- 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

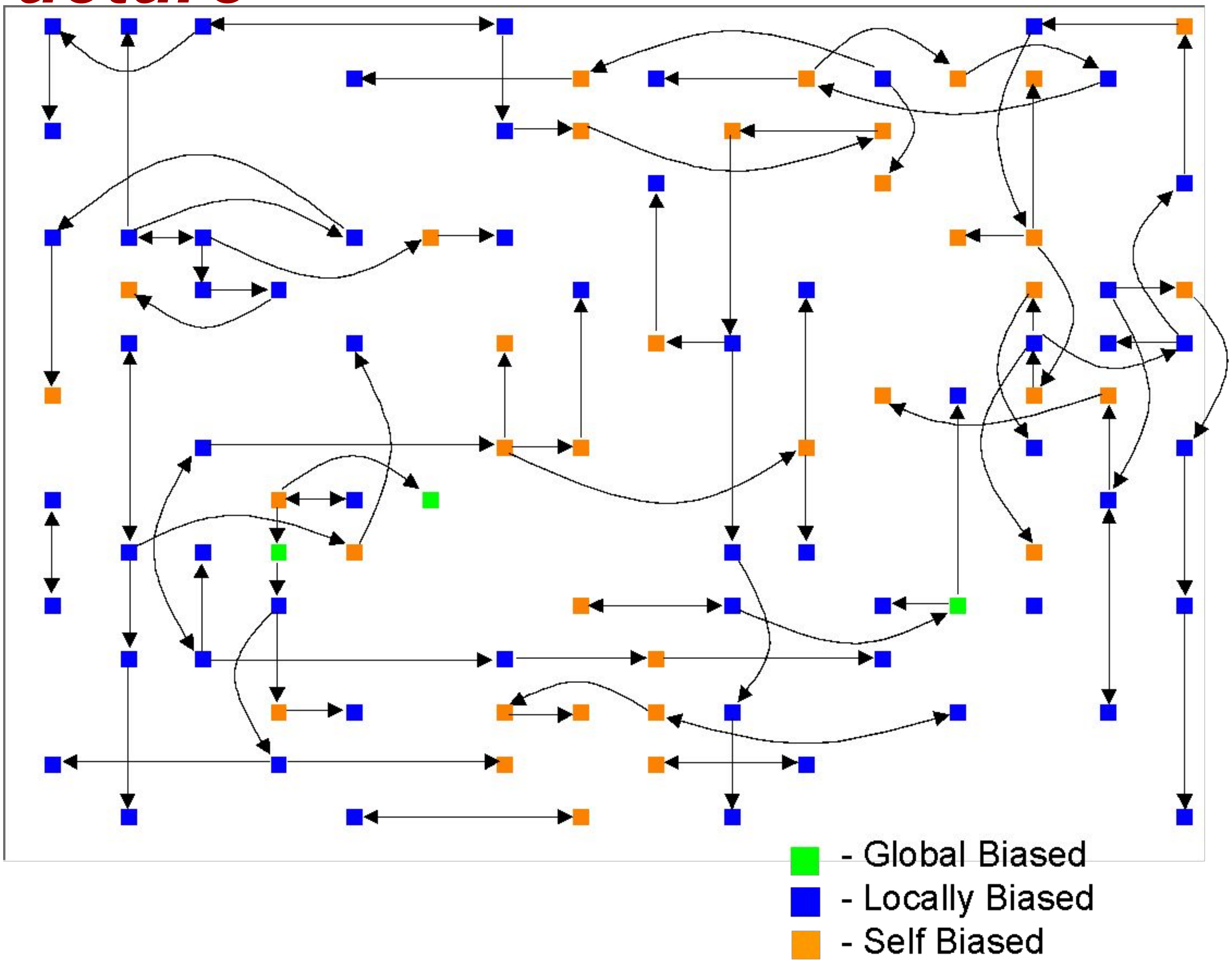
Type, context, purpose

- 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

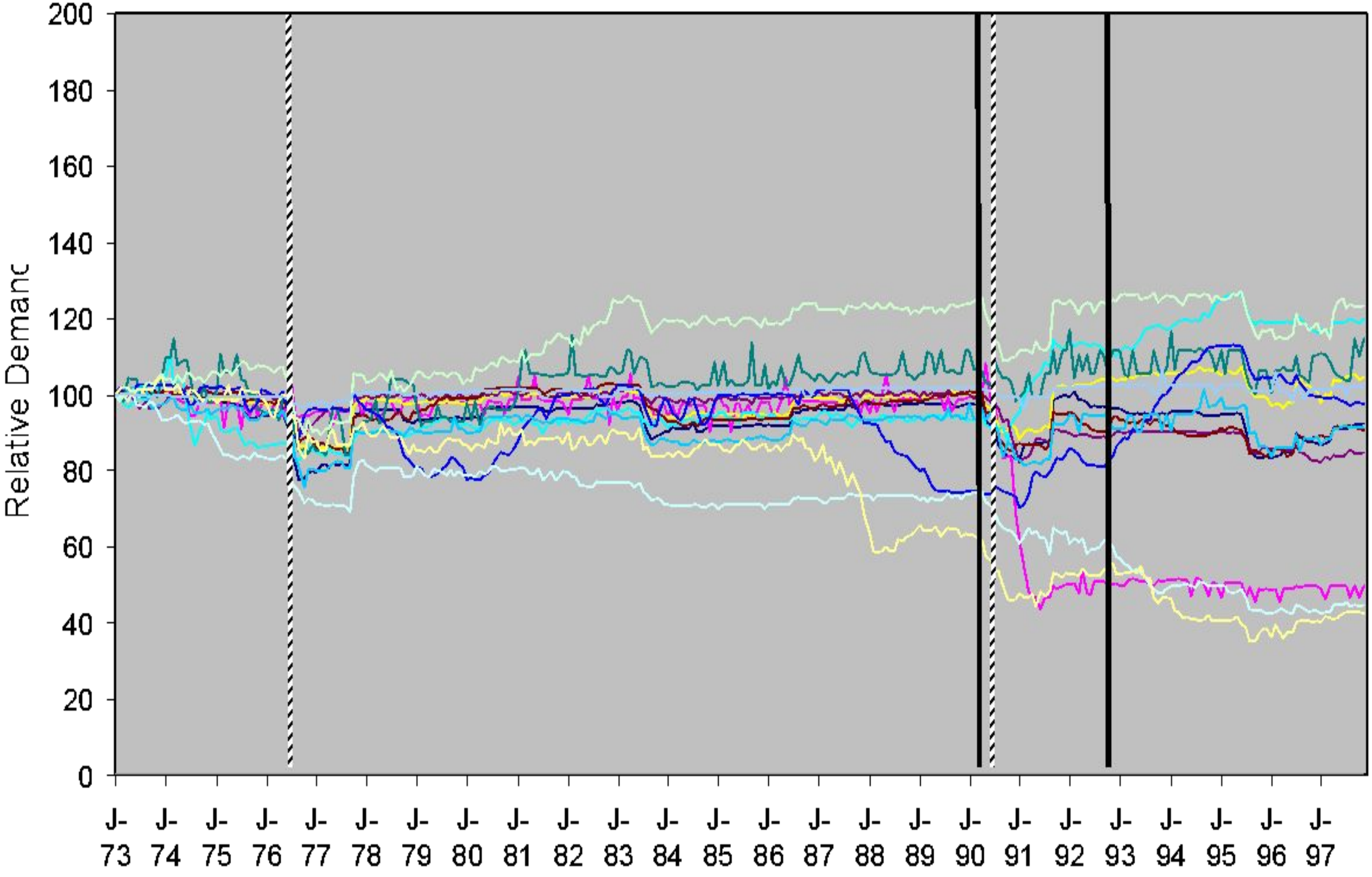
Simulation structure



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
- 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

What ABSS Can Do

- ABSS 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 analytic approaches require to obtain their proofs
- It allows the indefinite experimentation and examination of outcomes (*in vitro*)
- Which can inform our understanding of some of the complex interactions that may be involved in observed (*in vivo*) social phenomena

Conclusion

The *in vitro* and *in vivo* analogy

- *In vivo* is what happens in real life, e.g. between complex chemicals in the cell
  - Any data or experiments here involve the whole complex context of the target system
  - But these are often so complex its impossible to detangle the interactions at this level
- *In vitro* is what happens in the test tube with selected chemicals, it is a model of of the cell
  - This allows experiments and probes to tease out how some of the complex interactions occur
  - But you never know if back in the cell these may be overwhelmed or subverted by other interactions

Discursive vs Simulation Approaches

Natural Language

- Rich, semantic, meaningful, flexible
- But imprecise
- Map to what is observed is often complex and implicit
- Difficult to keep track of complicated interactions and outcomes
- Has “pre-prepared” meaning and referents

Computer Simulation

- Precise, well defined, replicable, flexible
- But brittle
- Semantically thin
- Map to observed *can be* explicit and more direct
- Good at keeping track of complicated interactions and outcomes
- Meaning needs to be established through use

Analytic vs Simulation Approaches

Analytic Modelling

- Precise, well defined, replicable
- Very brittle
- Not Semantic
- Map to observed can be indirect and/or difficult to establish
- Strong checkable inference
- General characterisation of outcomes
- Requires *strong* assumptions to work

Computer Simulation

- Precise, well defined, replicable, flexible
- More expressive descriptive
- Semantically thin
- Map to observed *can be* explicit and more direct
- Inference is more contingent, (sets of) example outcomes
- Can relate more easily to a broader range of evidence

The End

These slides are accessible from the 'slides' link on the
Introduction to Social Simulation Course Page
http://sites.google.com/site/socialsimulationcourse

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