Emergence and social dynamics

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Overview

- Computational social science
- Agent-based models
- Emergence in sociology
- Types of emergence
- An example
- The implications

What is computational social science?

- Models
  - Programs as models
- Mechanisms
  - Realist accounts of the way the social world works
- Experiments
  - Experimenting on the model, as a second best to experimenting on the social world

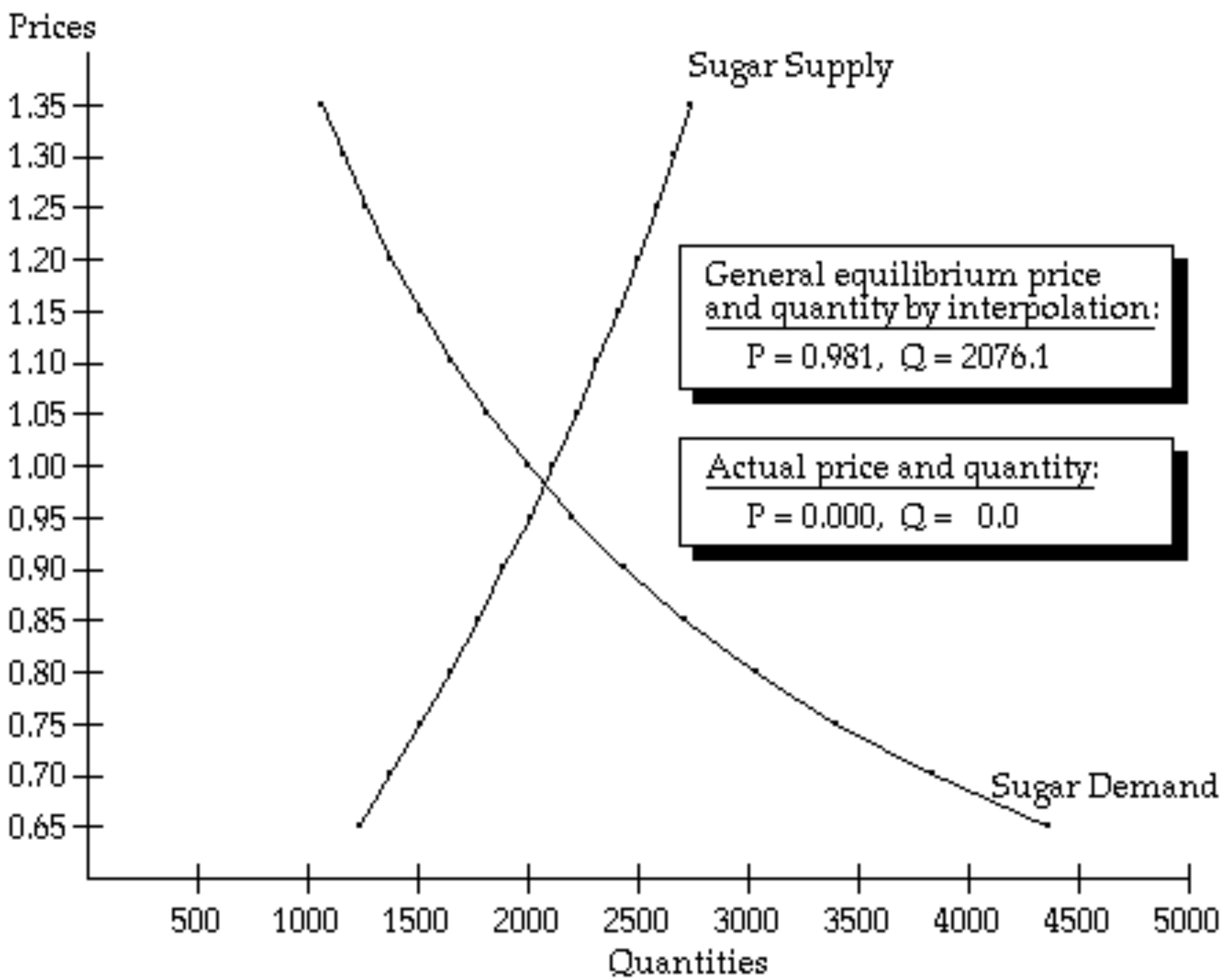
Example: Market

- Many agents trading with each other
- Each trying to maximise its own welfare
- Neo-classical economics assumes that markets are at equilibrium, where the price is such that supply equals demand
- But with a cellular automata, we can model markets in which the price varies between localities according to local supply and demand

Example: Sugarscape

- Agents located on a grid of cells
- Trade with local neighbours
- Two commodities: sugar and spice. All agents consume both these, but at different rates
- Each agent has its own welfare function, relating its relative preference for sugar or spice to the amount it has 'in stock' and the amount it needs
- Agents trade at a price negotiated between them when both would gain in welfare

Example: Sugarscape

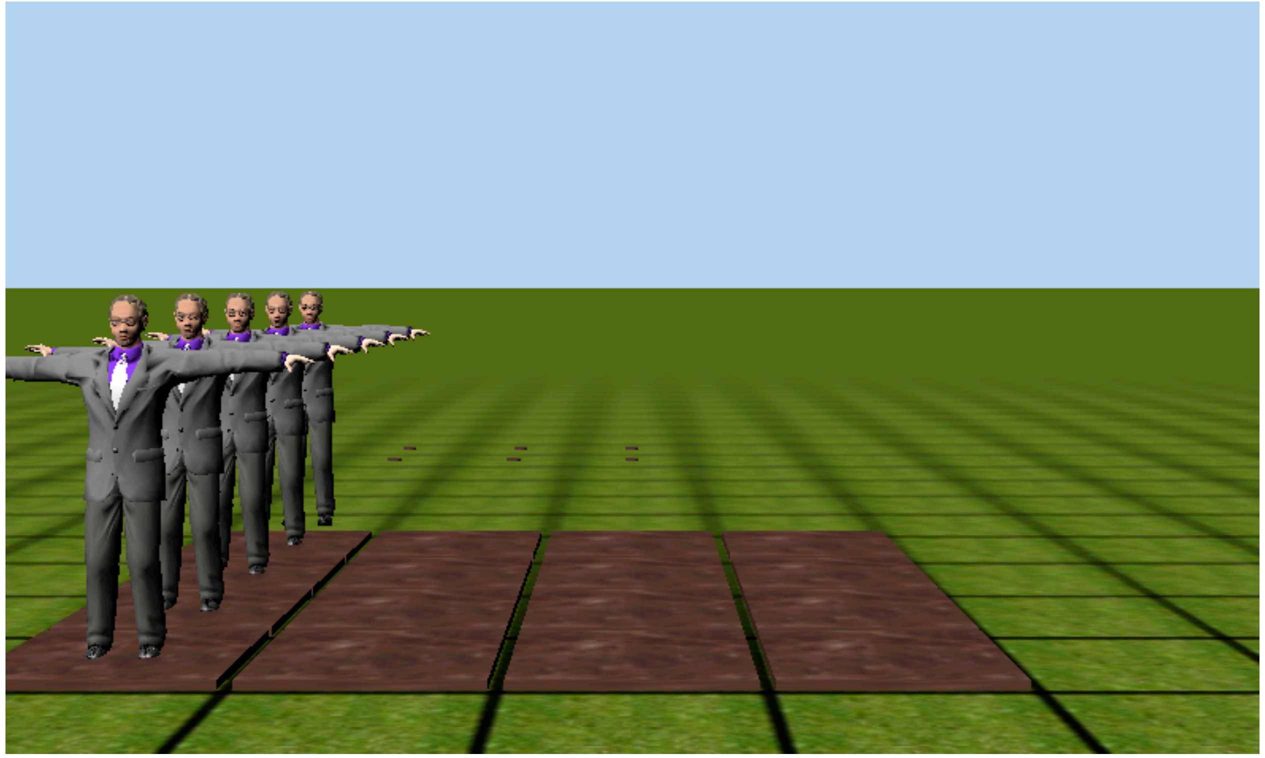


Results

- The expected market clearing price emerges from the many bilateral trades (but with some remaining variations)
- The quantity of trade is less than that predicted by neoclassical theory
    - since agents are unable to trade with others than their neighbours
- And...
    - the effect of trade is to make the distribution of wealth (measured in sugar) more unequal

Agent-based models

- Agents are units that have behaviour
- They act within a (simulated) environment
- Agents can react to other agents, pursue goals, communicate with other agents, move around within the environment
- Macro-level features can emerge from the interaction of agents



Emergence

- Some individual particles
  - ✦ people
  - ✦ groups
  - ✦ organisations
  - ✦ nations
- A system of which these are components
  - ✦ a society
  - ✦ an institution
  - ✦ a firm
- A complex system
  - ✦ particles interact in a non-linear way
- The system has properties that are characteristic of the system, but not of the particles
  - ✦ inequality
  - ✦ status
  - ✦ language

Emergence

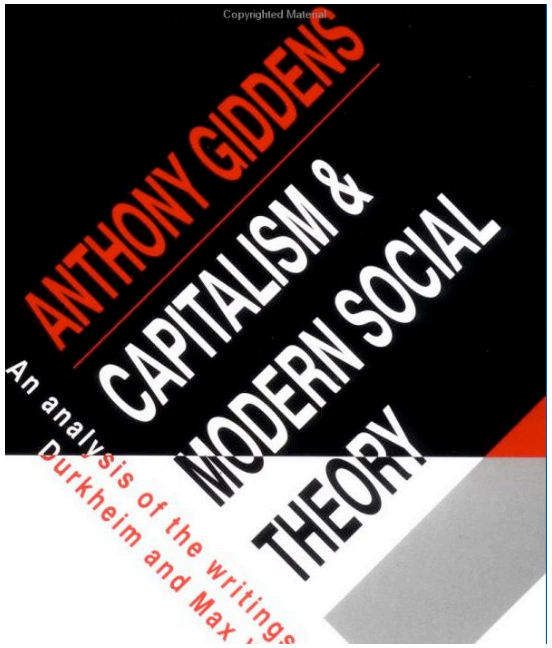
- Methodological individualism
  - e.g. Max Weber (1864 - 1920)
  - he argued that individual actions and beliefs (e.g the Protestant Ethic) led to the mergence of social institutions (e.g. capitalism)
- Methodological collectivism
  - e.g. Emile Durkheim (1858 - 1917)
  - He argued that social facts had an independent existence greater and more objective than the actions of the individuals that composed society and could only be explained by other social facts

Emergence

- Ever since, there have been controversies about whether social explanations should be formulated primarily in terms of structure or of agency, or how some synthesis can be achieved

- Computational social science provides the opportunity to dissolve such disputes!

- Agent-based models can provide the experimental laboratory to investigate emergence



Examples of social emergence

- In space
- In time
- Second-order emergence

State opening of Parliament of Trinidad and Tobago

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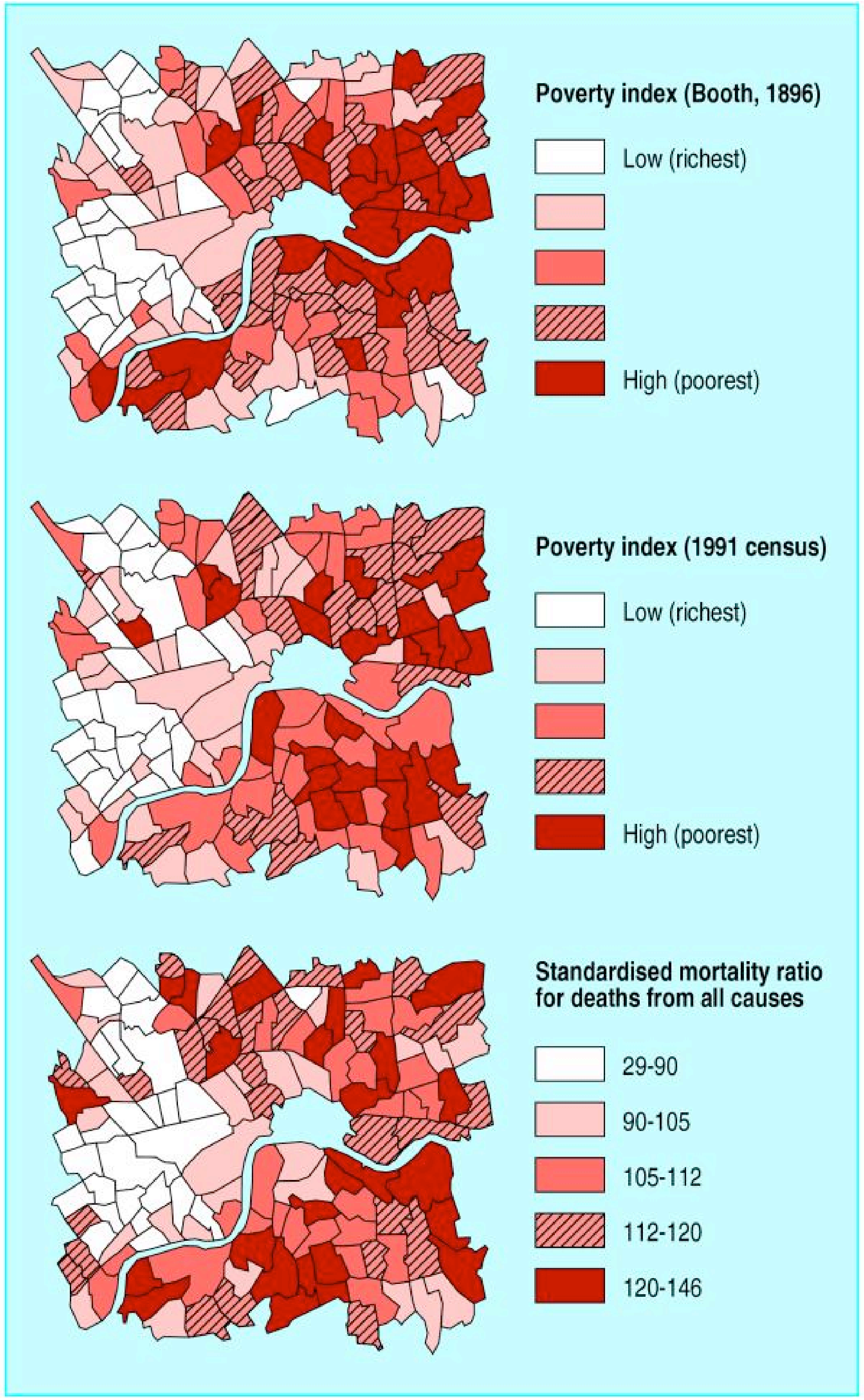
Emergence in space

Central London:

Poverty 1896
(deep red = poorest)

Poverty 1991
(deep red = poorest)

Standardised mortality ratio, 1991
(~ lifespan)

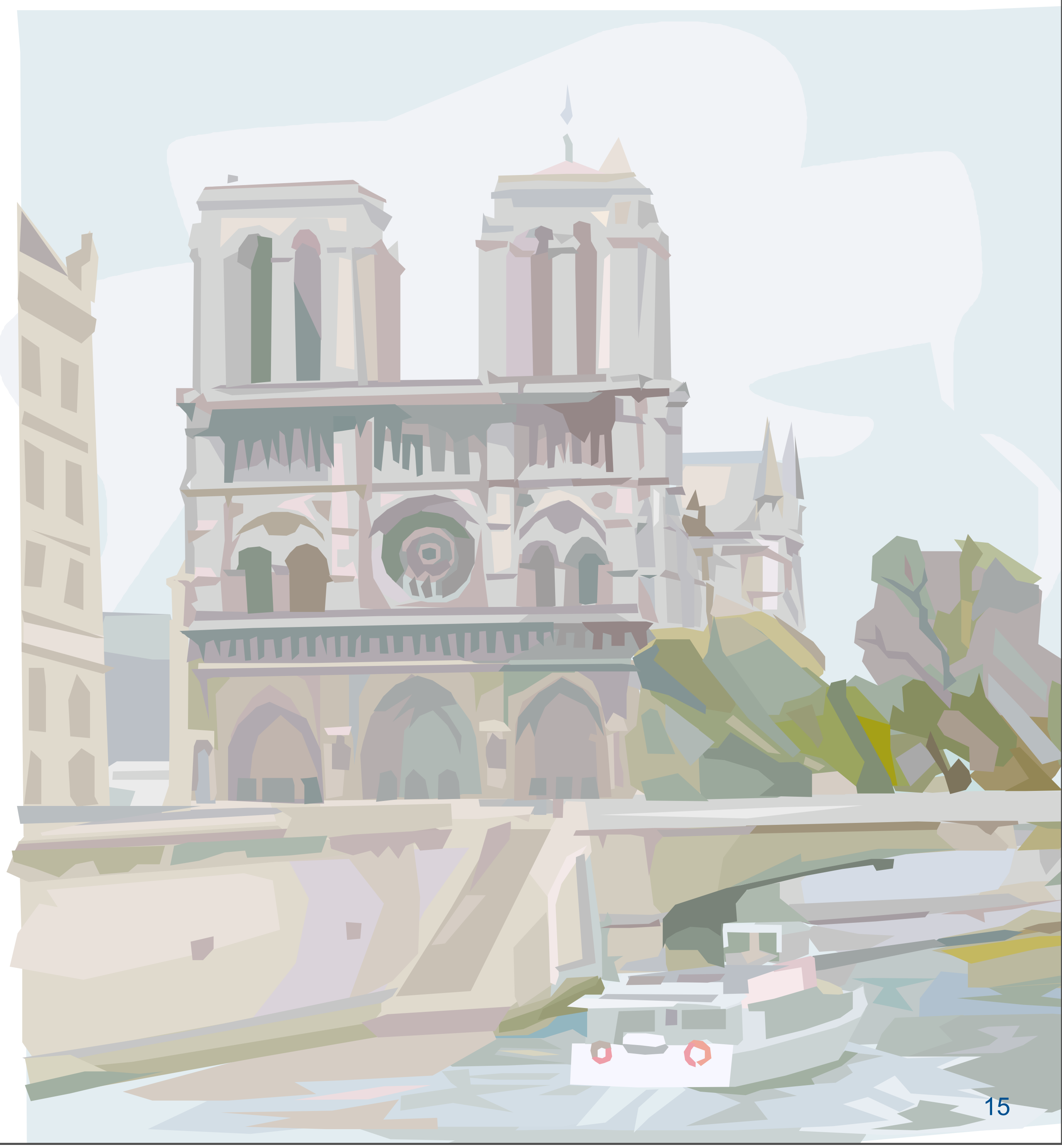


Danny Dorling, Richard Mitchell, Mary Shaw, Scott Orford, George Davey Smith (2000) The Ghost of Christmas Past: health effects of poverty in London in 1896 and 1991 *BMJ*. December 23; 321(7276): 1547–1551.

Emergence in time

Second-order emergence

- Individual action leads to emergent social structures
  - Social structure = rules, norms and regularities
- These structures are the matrix in which action takes place
- This action maintains and changes the structures



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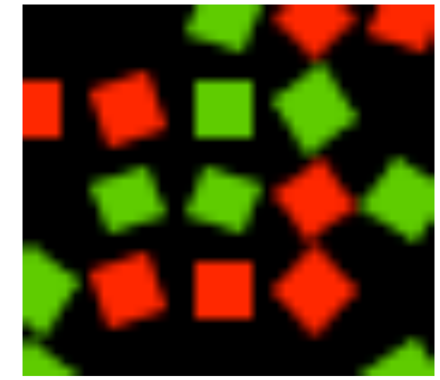
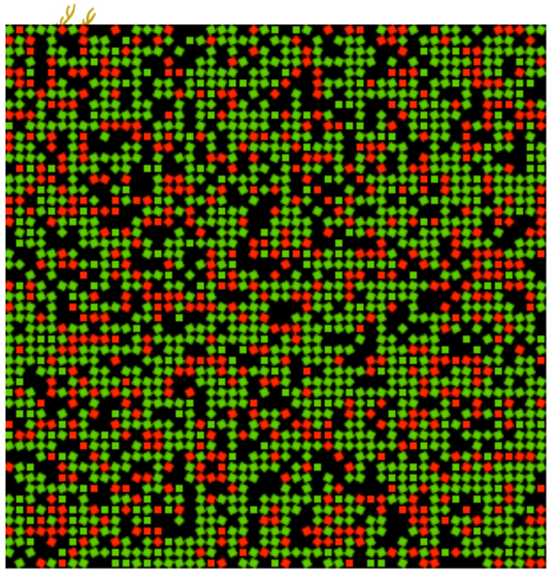
An example of emergence using an ABM



- Thomas Schelling proposed a theory[†] to explain the persistence of racial segregation in an environment of growing tolerance
- He proposed: If individuals will tolerate racial diversity, but will not tolerate being in a minority in their locality, segregation will still be the equilibrium situation

[†]Schelling, Thomas C. (1971) Dynamic Models of Segregation. Journal of Mathematical Sociology **1**:143–186.

A segregation model



- Grid 500 by 500
- 1500 agents, 1050 green, 450 red
  - so: 1000 vacant patches
- Each agent has a tolerance
  - A green agent is 'happy' when the ratio of greens to reds in its Moore neighbourhood (i.e. in the 8 surrounding patches) is more than its tolerance
  - and vice versa for reds

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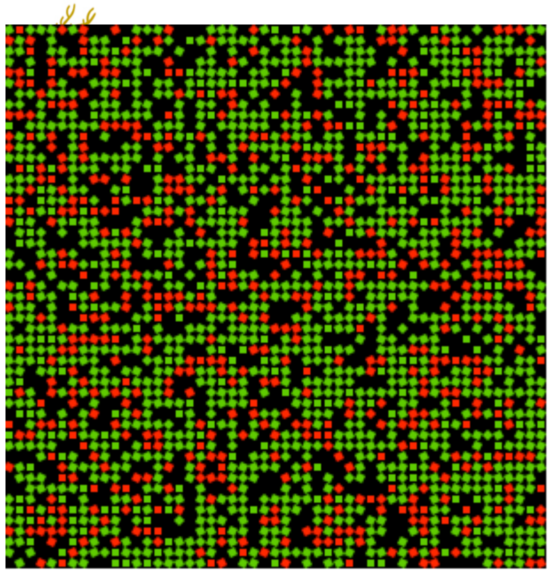
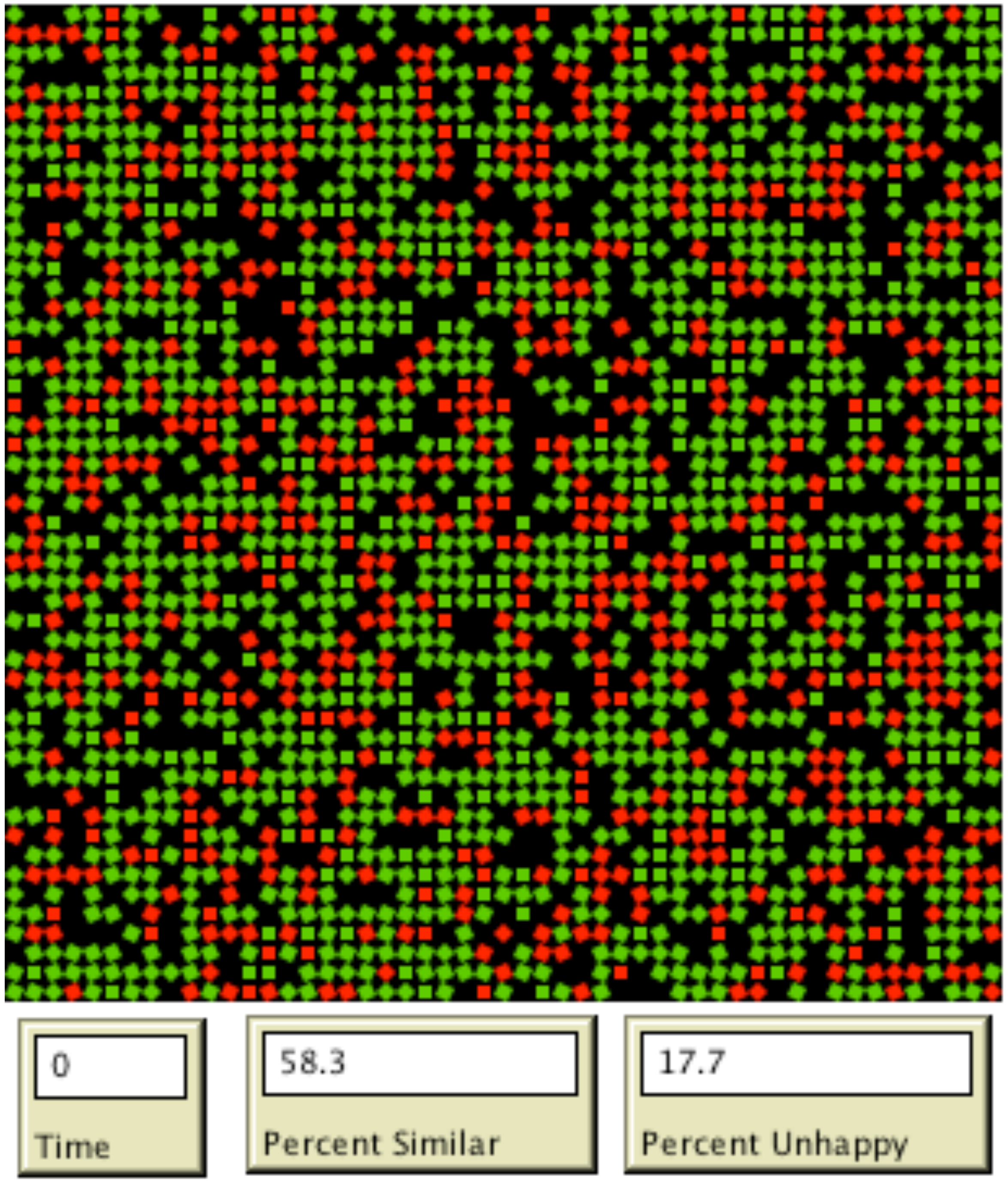
Aggregation



- With a tolerance of 40%, an agent is happy even when up to 60% of its neighbours (a slight majority) are the other colour
- Randomly allocate reds and greens to patches
- Then the average number of neighbours of the same colour is 58% (about 5)
- And about 18% of the agents are unhappy

Aggregation

- No dynamics
- No emergence
- No patterns of segregation
- Features are just the aggregation of the cells' characteristics
- Percents similar and unhappy can easily be calculated from an analytic formula
- So this is the 'base case'

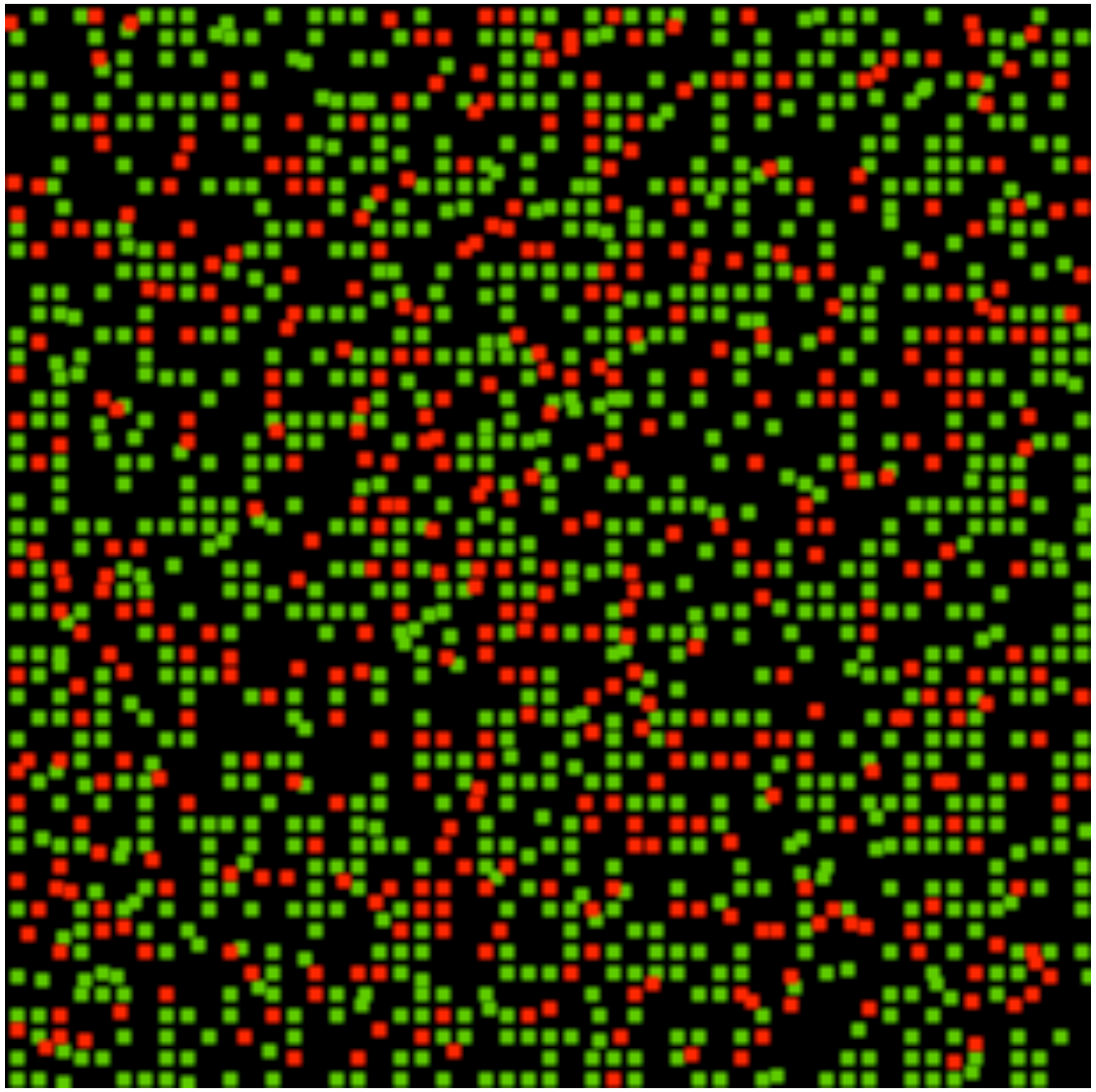


Adding dynamics

- Unhappy agents move along a random walk to a patch where they are happy
- Emergence is a result of 'tipping'
  - If one red enters a neighbourhood with 4 reds already there, a previously happy green will become unhappy and move elsewhere, either contributing to a green cluster or possibly upsetting previously happy reds and so on…

Emergence

- The Schelling model is used as a standard example of emergence
- Values of tolerance above 30% give clear display of clustering: ‘ghettos’
- Even though agents can tolerate 70% of their neighbours being of the other colour in their neighbourhood, the average percentage of same-colour neighbours is typically 75 - 80% after everyone has moved to a satisfactory location (risen from 58% before relocations)

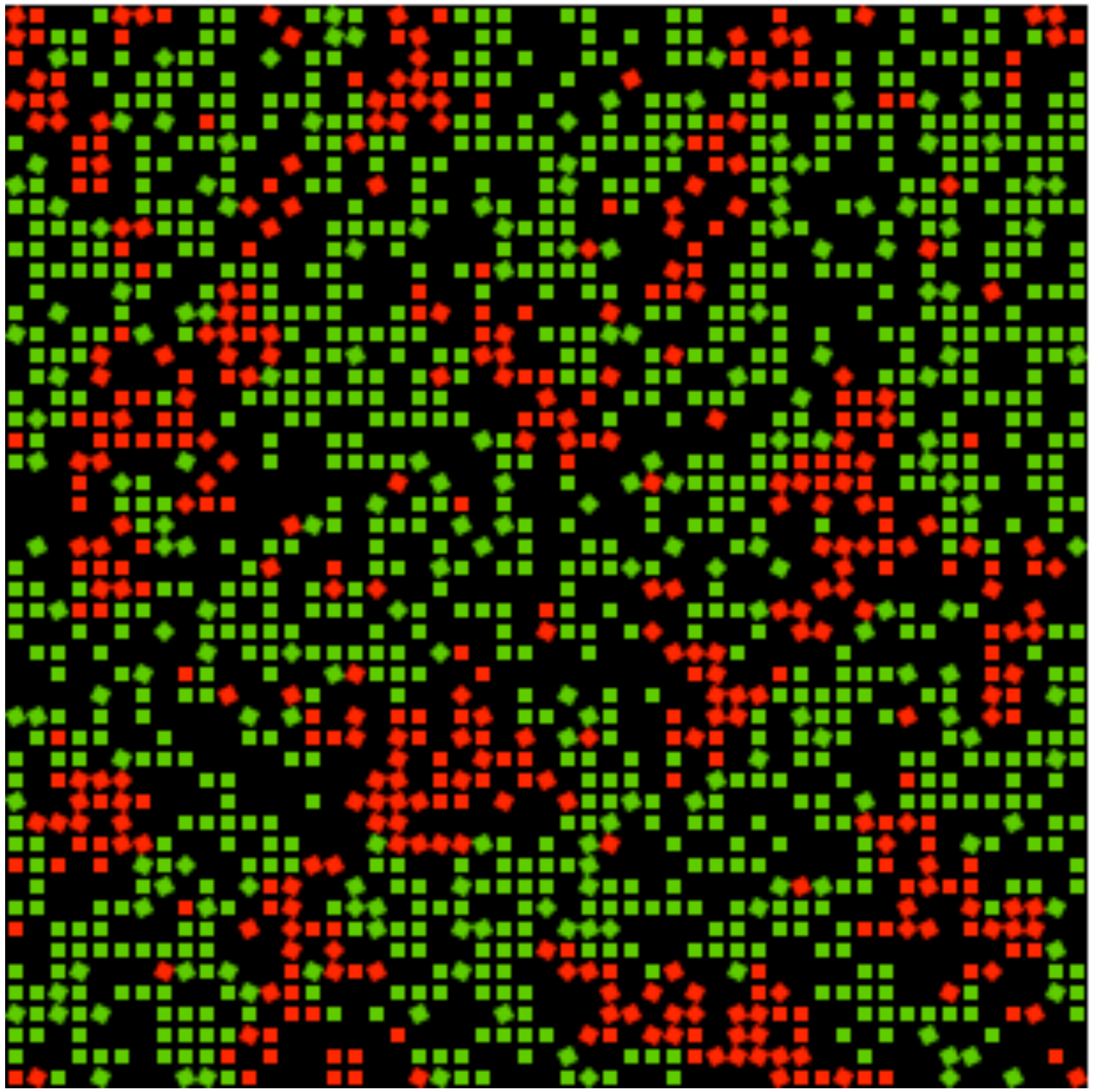


Emergence and self-organisation

- Eventually, in this model, all agents find a resting place, resulting in a static equilibrium
- But this is not typical of the social world, where agents are constantly on the move
  - Immigration, emigration, births, deaths…
- Self-organisation occurs in social situations when there are emergent patterns, even though the agents are changing their identity
  - Compare John Holland's example of a bow wave:

Clusters remain even when agents come and go

5% of agents ‘die’
and are replaced with
agents of random colour
every timestep



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There are also many other examples of locational clusters…

- Ethnic businesses
  - Chinese and Turkish restaurants
- Immigrant communities
  - German and English in Majorca
- Religious communities
  - Protestant and Catholic in N. Ireland
- Wealthy neighbourhoods
  - Notting Hill
- Technology clusters
  - Cambridge Science Park

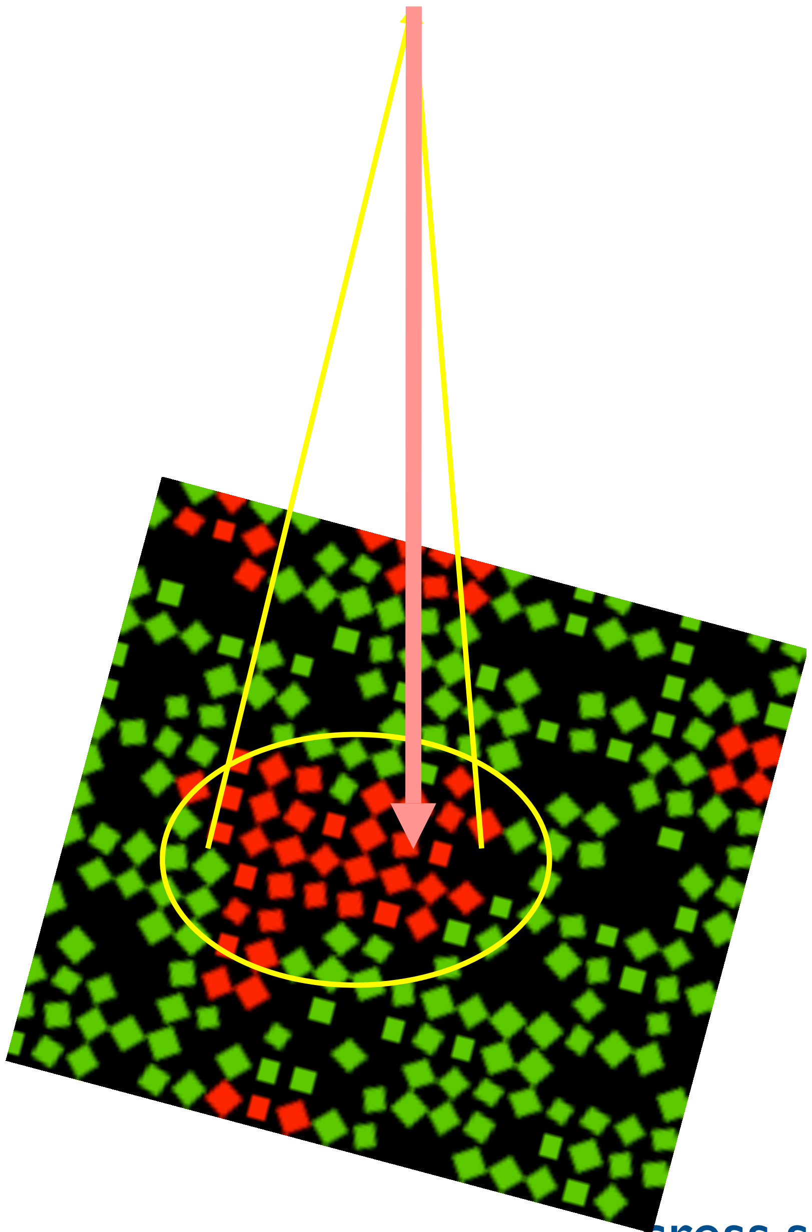
Does this make it an adequate model of ethnic segregation?

- The Schelling model is (presumably) equally applicable to
  - Coagulations of particles
  - Packs of animals
  - Etc.
- So it has been regarded as a prototypical model of how simple models can be applied to complex social phenomena

But this can only be done by ignoring some fundamental characteristics of human societies…

Upward and downward effects

- Individual actions by agents yield macro level features (clusters)
- Clusters constrain individual action

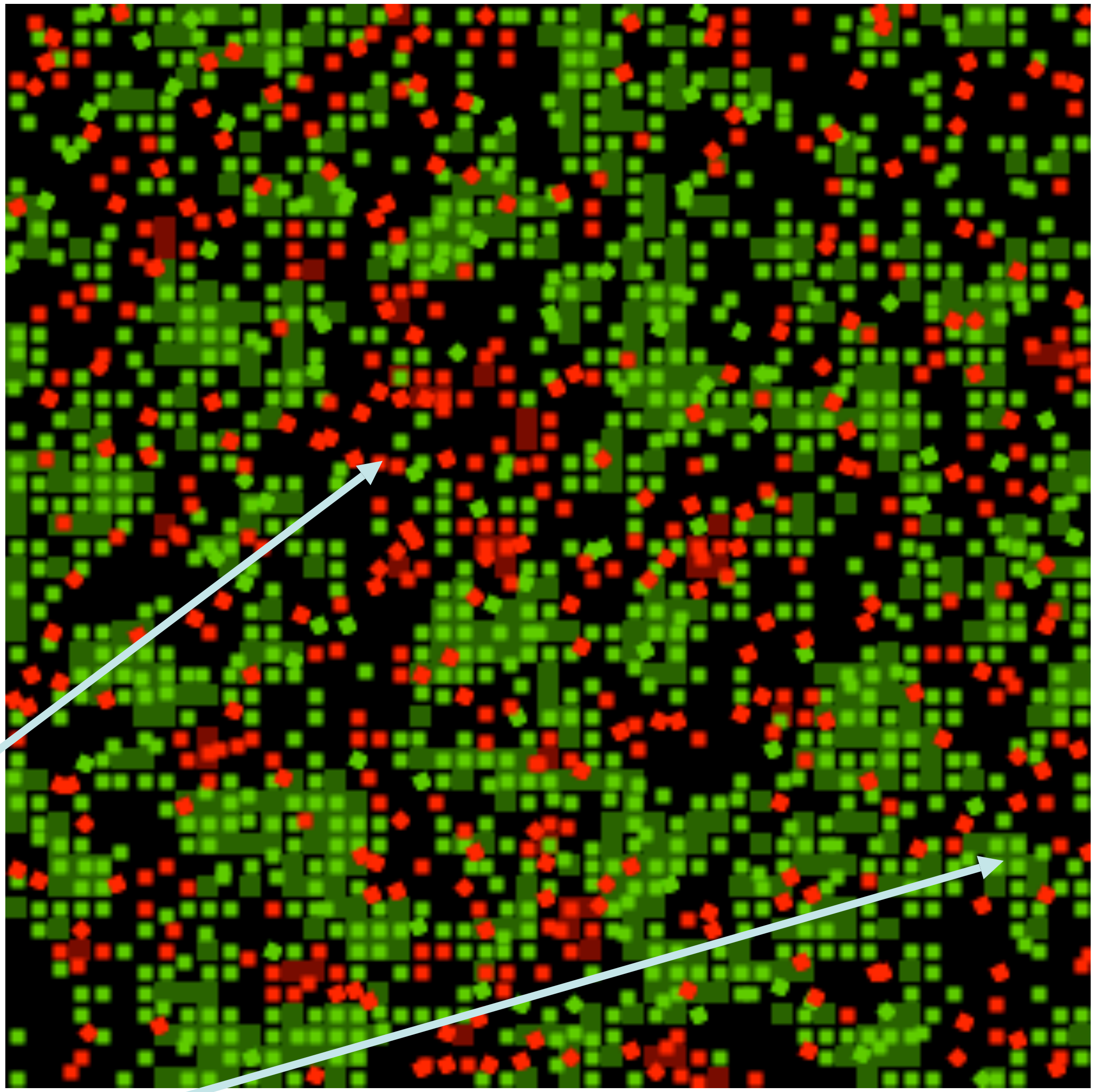


Downward effects

- Assume: Predominantly red areas have higher crime rates
  - Crime rate: a macro-level attribute
- As a result, property within such areas is cheaper
  - Assume property price P = (9 - R) / (9 - G)
  - Where
    - R is the number of red neighbours
    - G is the number of green neighbours
- An agent can only move to a spot where the property price is less than or slightly above the agent's current property value (its wealth)
  - Agent can move if $P_{current} + 1 >= P_{new}$

Consequences

- Reds that are surrounded by other reds are poor because they are in high crime areas and so have cheap homes
- Reds surrounded by greens are wealthy, and move to red areas
- Greens surrounded by reds are poor and can't move to desirable green areas
- Greens surrounded by greens are rich and don't want to move



Background shade marks crime rate (dark: high crime rate, low property values; light: low crime rate, high property values)

Recognising emergent features

- While the observer can see the emergent features, the agents can't
- But in human societies, people can recognise (and act on) emergent features
- Their reactions can in turn affect those features
- Thus, second-order emergence
  - also called
    - The double hermeneutic
    - Immergence

Examples


Junior Audubon Club Members and birdhouses, circa 1915

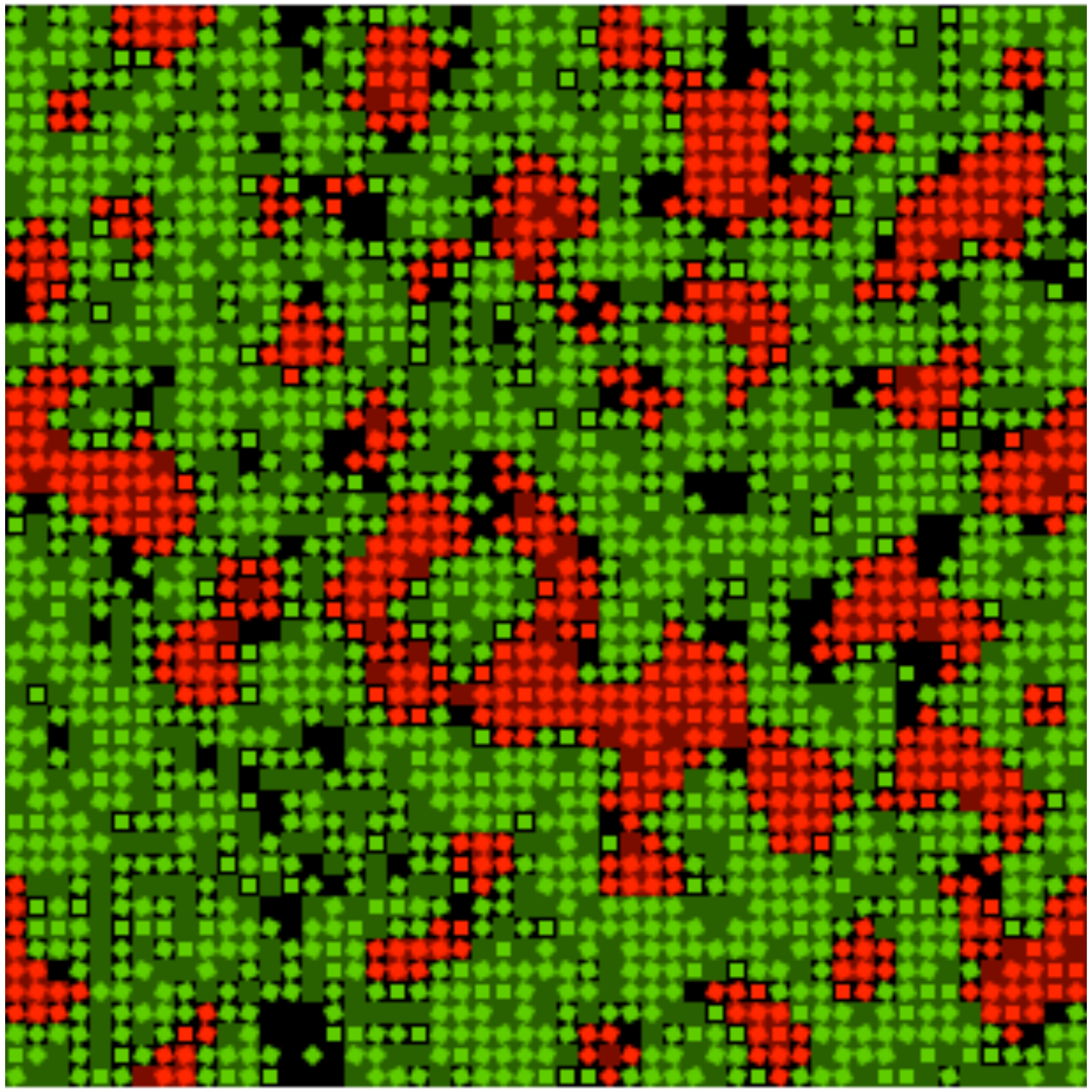
- Clubs and societies
  - Recognised by the participants, with a name for the group
- Formal organisations
  - Companies, universities, hospitals, legislatures
- Institutions
  - The Church, the law,
- Localities
  - Chicago, London, Harlem

In these and other examples, the fact that you are a member (or are not a member) changes the rules of interaction between you and other agents

2nd order emergence in Schelling's model

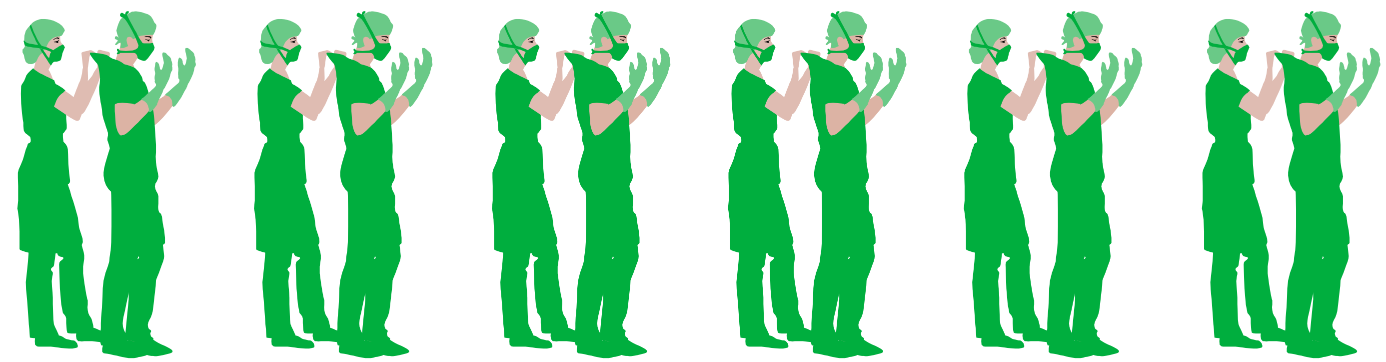
- A patch that is adjacent to 4 or more patches in which there are red agents is labelled a 'red' patch permanently
- And similarly for patches adjacent to 4 or more green agents
- Then red agents will only move to
  - patches that have no label or
  - red patches
- and similarly for green agents
- Thus the agents recognise what is a 'good' patch for them
  - The labels don't always reflect the current situation, but are based on what was the case previously
  - Generates stereotyping of neighbourhoods

The outcome



The colours of the patches (dark red or green) show the labels applied to the districts as a result of the colour of the agents that are there now or were there previously

Heterogeneity



- In previous models, all agents have been identical except for
  - Their location
  - Their colour
- For example, all have exactly the same tolerance.
- This is clearly unrealistic for human groups
  - We can experiment with
    - Random variations in tolerance, to represent unmeasured differences
    - Tolerance correlated with colour, to represent systematic differences such as class, ethnicity etc.

Conclusion

- All these models of segregation are 'right' at some level of abstraction
- A model that is appropriate for particles can also be used to model social phenomena, provided that you accept that it omits characteristic features of human society
- But all models omit something!

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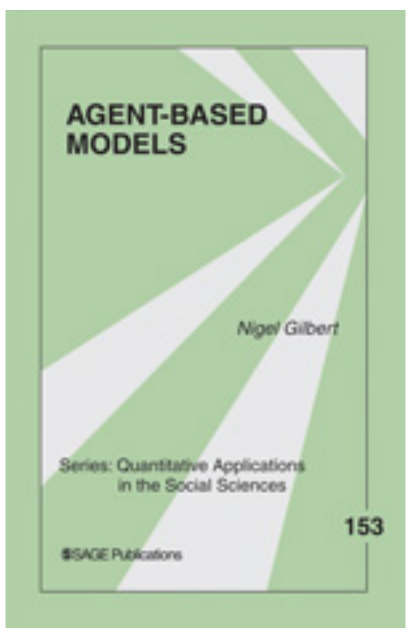
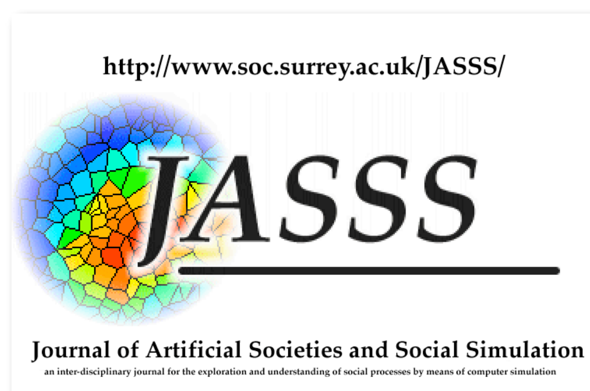
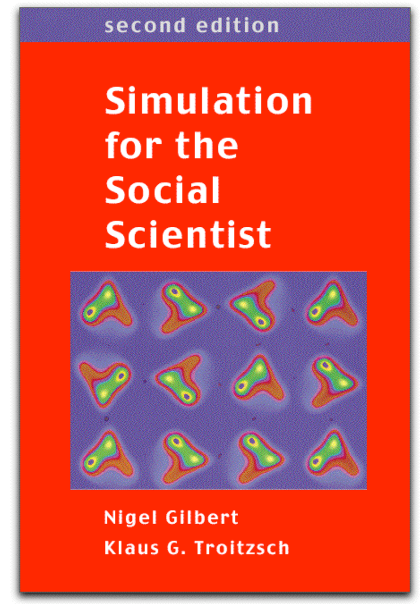
http://www.essa.eu.org







questions?