Case-based methods and agent-based modelling: bridging the divide to harness their respective strengths

Brian Castellani,
Peter Barbrook-Johnson,
Corey Schimpf

ABSTRACT

In terms of studying social complexity, two of the most dominant methodological camps are case-based methods (CBM) and agent-based modelling (ABM). Notwithstanding significant epistemological similarities (i.e., cases and agents are often equivalent), both camps have yet to harness the other's strengths, which has limited both approaches for the study of dynamics. For example, CBM rarely focuses on the interactions amongst cases or their corresponding emergent behaviour; or how complex configurations might change due to different counterfactual scenarios. In turn, ABM has yet to use CBM to develop its agents or their rules; let alone use CBM to hypothesize how agents might interact based on different combinations of complex causal configurations. These limitations, however, can be overcome, even for those not interested in programming an ABM or building a QCA table. Using examples from the Welsh Index of Multiple Deprivation, we examine how CBM and ABM can be harnessed to extend both approaches and their study of dynamics, as illustrated through the new R-Studio App, *COMPLEX-IT*.
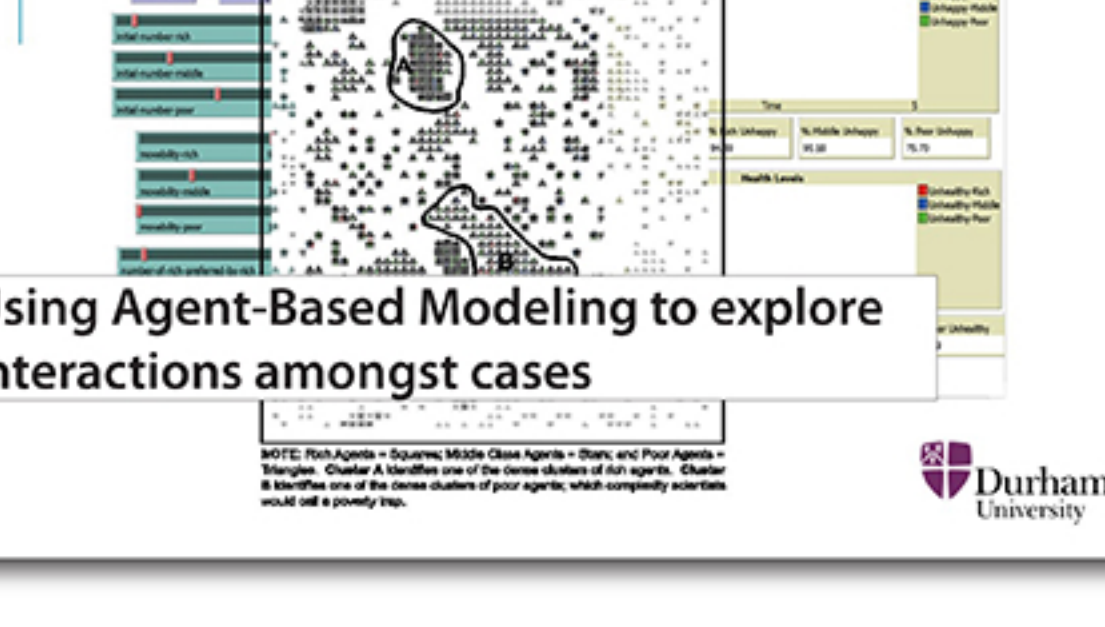
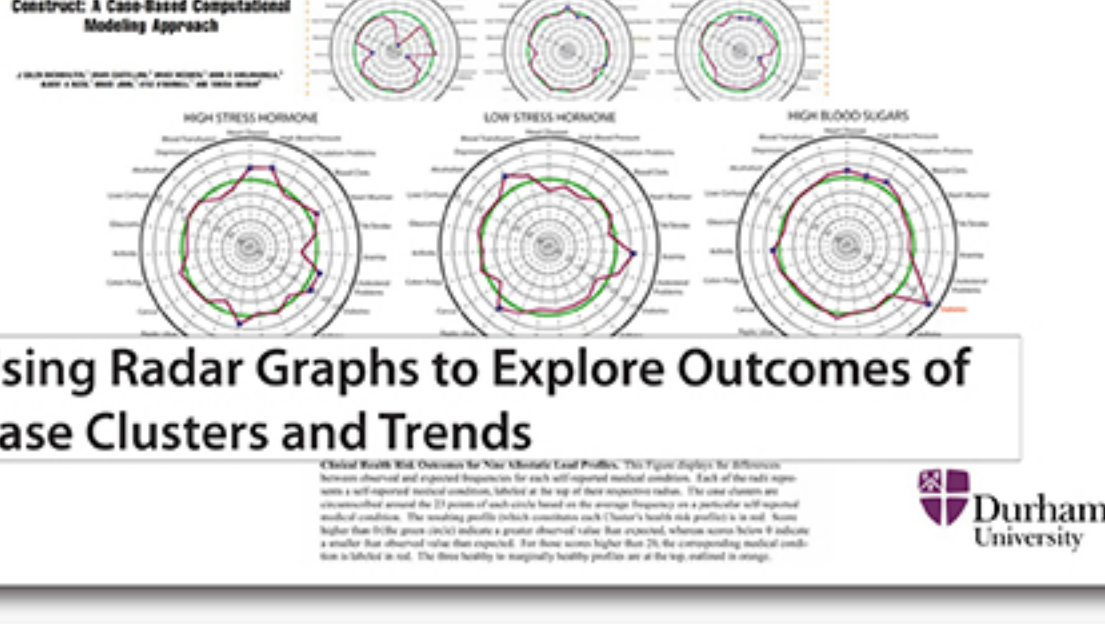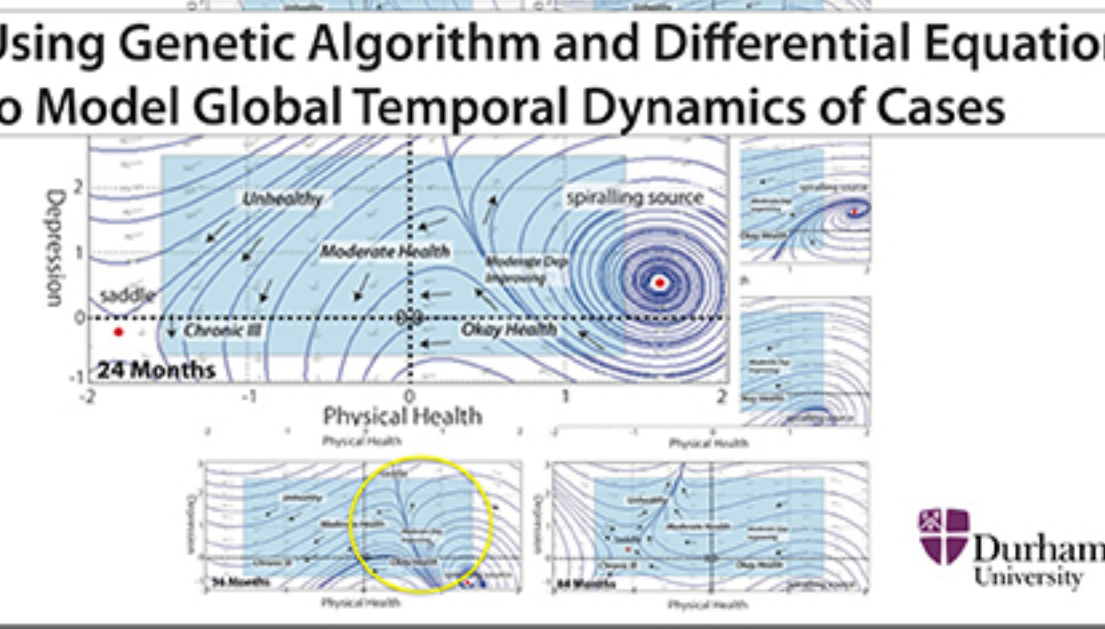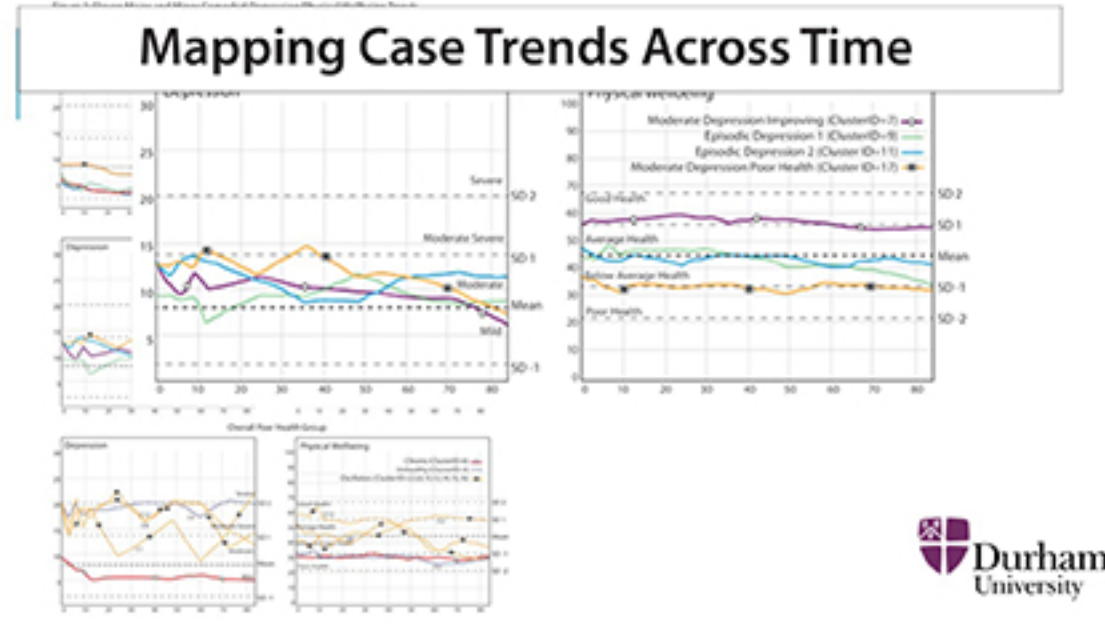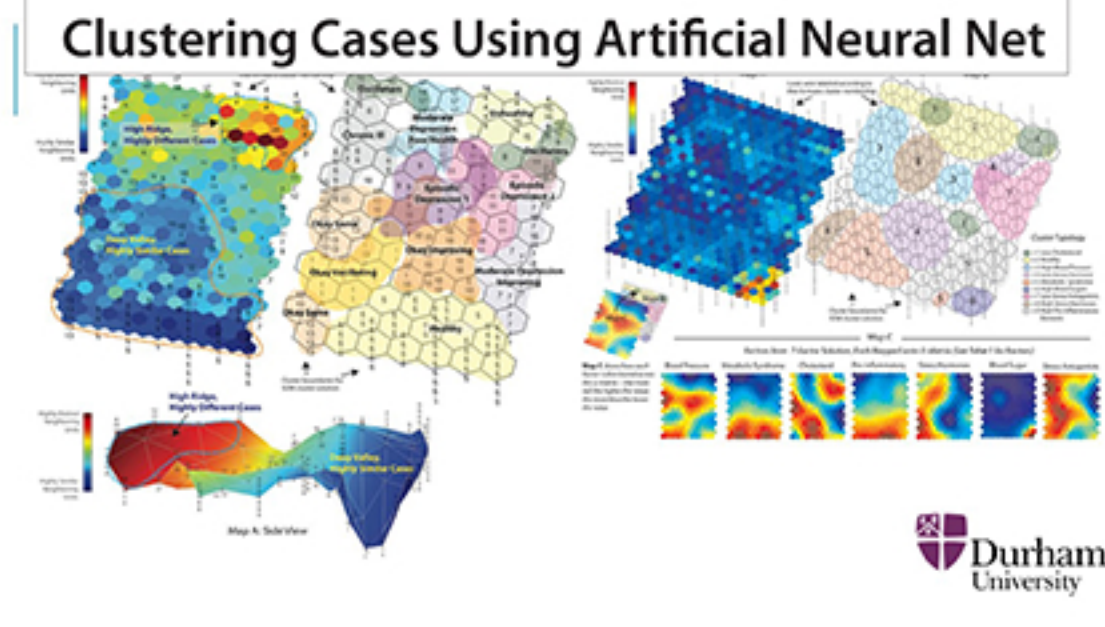2018 Map of the Complexity Sciences by Brian Castellani
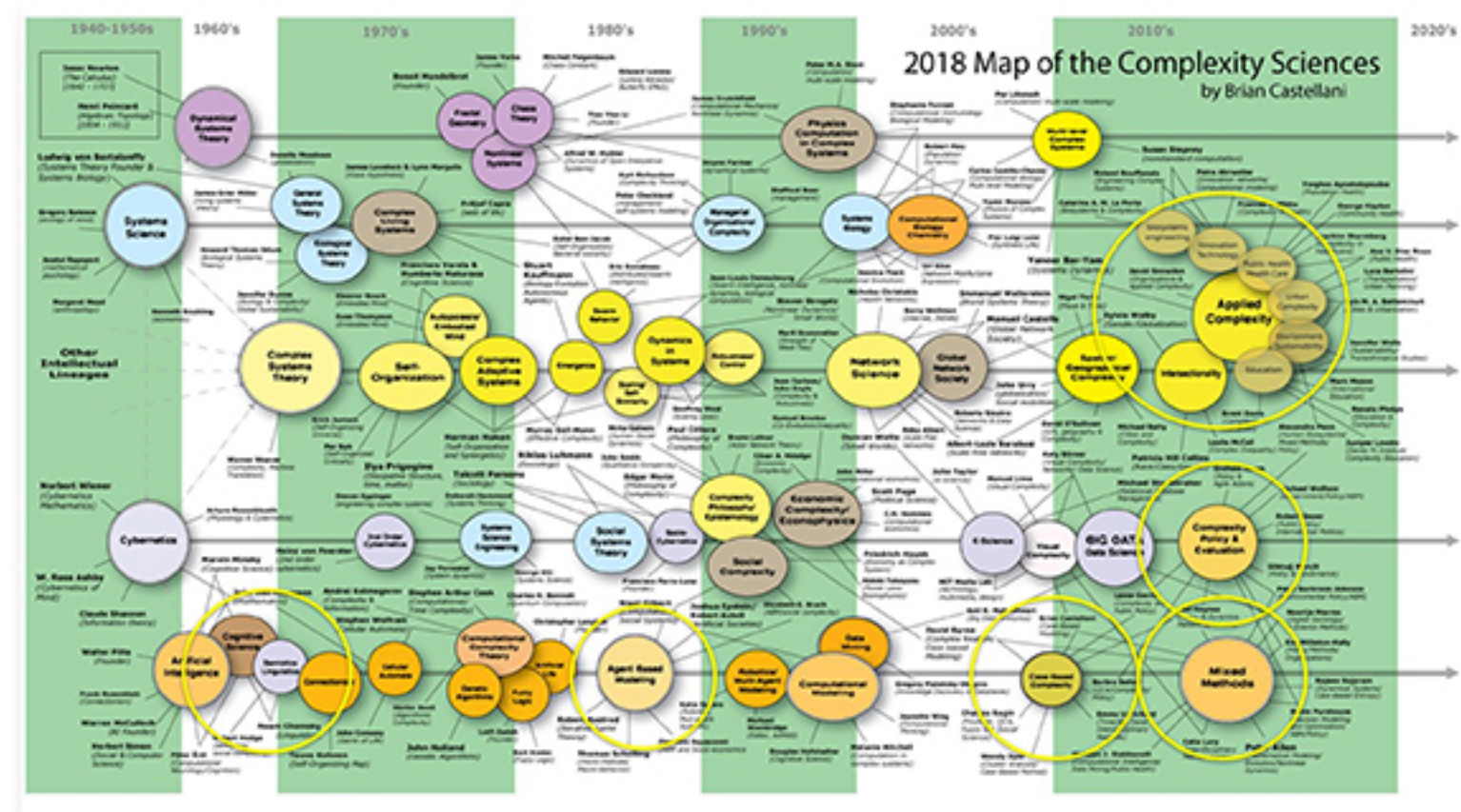
COMPLEXITY THEORY

Ontological complexity!

As argued by David Byrne and my colleagues in the complex realist tradition, in terms of ontology, *social reality* is best viewed (*although not always*) in complex systems terms.

That is, it is emergent, self-organizing, nonlinear, dynamic, open-ended, context-dependent, evolving along multiple and different trends, ecologically and biologically grounded, comprised of multiple intersecting systems, and presenting to sociologists a complex series of wicked problems and nexus issues.

Case-Based Modeling & The SACS Toolkit
A New Approach to Modeling Complex Social Systems

SEE PAPERS BELOW

VISIT: http://www.personal.kent.edu/~bcastel3/

EXAMPLES OF VISUAL OUTPUT OF SACS TOOLKIT

Clustering Cases Using Artificial Neural Net

Durham University

Mapping Case Trends Across Time

Durham University

Using Genetic Algorithm and Differential Equations to Model Global Temporal Dynamics of Cases

Durham University

Using Radar Graphs to Explore Outcomes of Case Clusters and Trends

Durham University

Using Agent-Based Modeling to explore interactions amongst cases

Durham University

ARGUMENT OUTLINE

- A bit of complexity science history:
  - Case-Based methods (CBM) and agent-based modeling (ABM) have developed along different intellectual trajectories, becoming very popular, but serving very different purposes
  - Both ABM and CBM are comprised of a variety of different approaches, and therefore are not singular approaches.
- For example, QCA (qualitative comparative analysis) is the main player in case-based methods.
- Byrne developed a particular approach to QCA by linking it to complexity, but many in QCA remain resistant to thinking about cases in complex systems terms.
  - Despite their ontological similarities, CBM and ABM treat cases and agents as different.
  - They also view complexity differently
- The configurational complexity of CBM and the QCA table
- The interactive complexity of ABM and simulated world
- Wider changes:
- Complexity and mixed methods have become popular across the social and health sciences and policy.
- There is a realization that statistics and qualitative inquiry alone are insufficient.
- There is also a realization that mixed methods are needed, particularly in the face of complex and big data.
- Policy evaluators and social and health scientists want to know when and how to use each method, and in particular how they work together!

- The time is ripe to explore how these two approaches can be harnessed to improve each the other and, for those willing, be used together to model or data mine social complexity. Examples: Mario Luis Small's article on how mixed-methods are everywhere now! And, Benoît Rihoux's article on the future of QCA, and the need for mixed-methods research

- How and When Are Cases and Agents Equivalent?
  - In What is a Case? Exploring the Foundations of Social Inquiry (Ragin & Becker), Abbott states, "By asking what cases do, I am assuming the case is an agent" (p. 53). This means cases have histories and intentions and actions and interactions. In turn, whenever you ask what an agent is about, you are talking about cases -- describing the agent and its complex configuration.
- How CBM informs ABM
  - Narratives and Stories about cases and social life
  - Bridges the qualitative-quantitative divide
  - Case-Based Holism
  - Focused on cases, which can be used to identify agents and their corresponding different complex configurations (profiles of factors). In other words, the focus is on cases, not variables, and therefore keeps ABM oriented toward its overall goal (how variables go together) from the beginning, rather than having to stitch things together later!
  - Provide complex causality better than conventional statistics
  - Focuses on the link between cases and outcomes!
  - Allows for easier rule extraction

  - How ABM informs CBM
  - The importance of counterfactuals (thinking non-observed cases)
  - Interactions and inter-(re)actions
  - How cases influence one another
  - How cases respond or change in relation to one another
  - The importance of time and trajectory
  - Individual case-base trajectories
  - How cases evolve across time
  - Emergent behavior and global-temporal dynamics

  - For those not interested in either building and ABM or constructing a truth table for QCA, these two approaches nonetheless can be used to inspire one another.

COMPLEX-IT

Designed to make the otherwise highly complex tools and techniques of data mining accessible to a wider and less technical audience.

Currently, COMPLEX-IT's suite includes:
- k-means cluster analysis
- the Kohonen topographical neural net
- a series of data visualization techniques
- case prediction
- a tab for simulating policy scenarios
- a tab for designing an agent-based model

COMPLEX-IT also includes a step-by-step series of questions that, concurrent with the actual process of data analysis, take the user through the model design process – all of which ends with a generated report on the results of one's study.

VISIT: http://www.personal.kent.edu/~bcastel3/complexit.html

EXAMPLES OF VISUAL OUTPUT OF COMPLEX-IT

Clustering Cases Using k-means and an Artificial Neural Net

Visualizing Results Using Visual Complexity

Using Simulation to explore different case-based scenarios and counterfactuals