Workforce Futures Reimagined

Complexity Thinking for Equitable and Resilient Health Systems

WHO Europe Symposium on Health Workforce Modelling for Action

Durham
University

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CRISIS!

SCIENCE IS BECOMING LESS DISRUPTIVE

Article

Papers and patents are becoming less disruptive over time

https://doi.org/10.1038/s41586-022-05543-x Michael Park[1], Erin Leahey[2] & Russell J. Funk[1]✉

Park and colleagues explored over 45 million scientific papers to determine if disruptive science has diminished over the last 60 years.

They defined disruptive science as that which interrupts, unsettles or overturns existing knowledge in a field, rendering current conventions in theory or methods outdated or antiquated, and driving science and technology in new directions.

Park and colleagues found that there is, indeed, a marked decline in disruptive science over the past sixty years.

CRISIS!

Persistent social problems have not significantly change or been resolved over the last sixty years, despite decades of research, funding, and intervention.

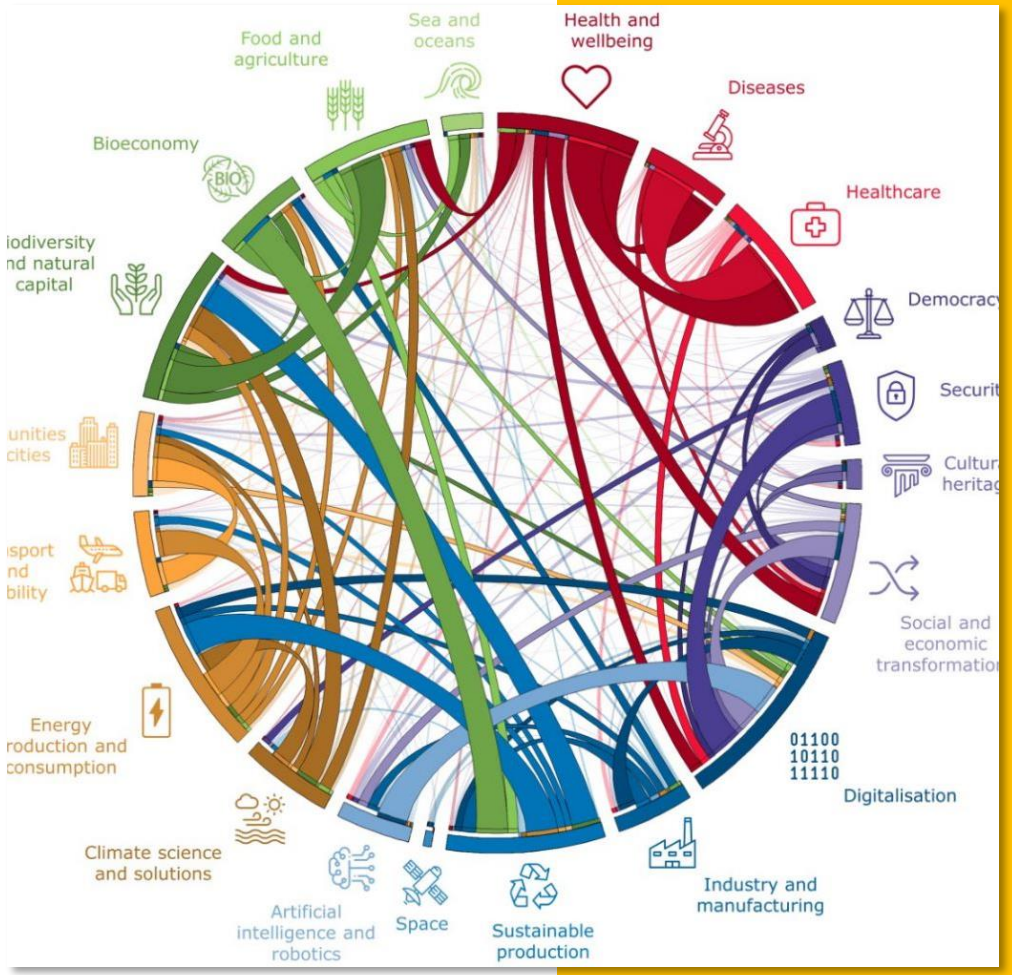
1. Health inequalities between social classes
2. Racial and ethnic health disparities
3. Gender-based health inequities
4. Underfunded and overstretched health services
5. Chronic staff shortages and burnout in health and social care
6. Rising levels of child poverty
7. Structural racism and discrimination in healthcare and institutions
8. Poor access to care for migrants and refugees
9. Environmental injustice (e.g. pollution exposure in low-income areas)
10. Urban-rural health divides
11. Air pollution and related chronic diseases
12. Climate change impacts on vulnerable populations
13. Commercial influences on health (e.g. alcohol, tobacco, junk food)
14. Inadequate long-term care for ageing populations
15. Failure to integrate health and social care systems
16. Slow policy response despite strong evidence base

CRISIS!

Why?

First, these problems are deeply systemic, resistant to technical fixes, and often entangled with political, economic, and cultural structures, making them complex and “wicked” in nature.

Second, researchers rely on an increasingly narrower set of existing knowledge. The same people in the same room applying the same methods and asking the same questions and getting the same results, which perpetuates the same problems they are addressing instead of changing them.



CRISIS!

We face the same crisis in our healthcare workforce

1. Health inequalities between social classes
2. Racial and ethnic health disparities
3. Gender-based health inequities
4. Underfunded and overstretched health services
5. Chronic staff shortages and burnout in health and social care
6. Rising levels of child poverty
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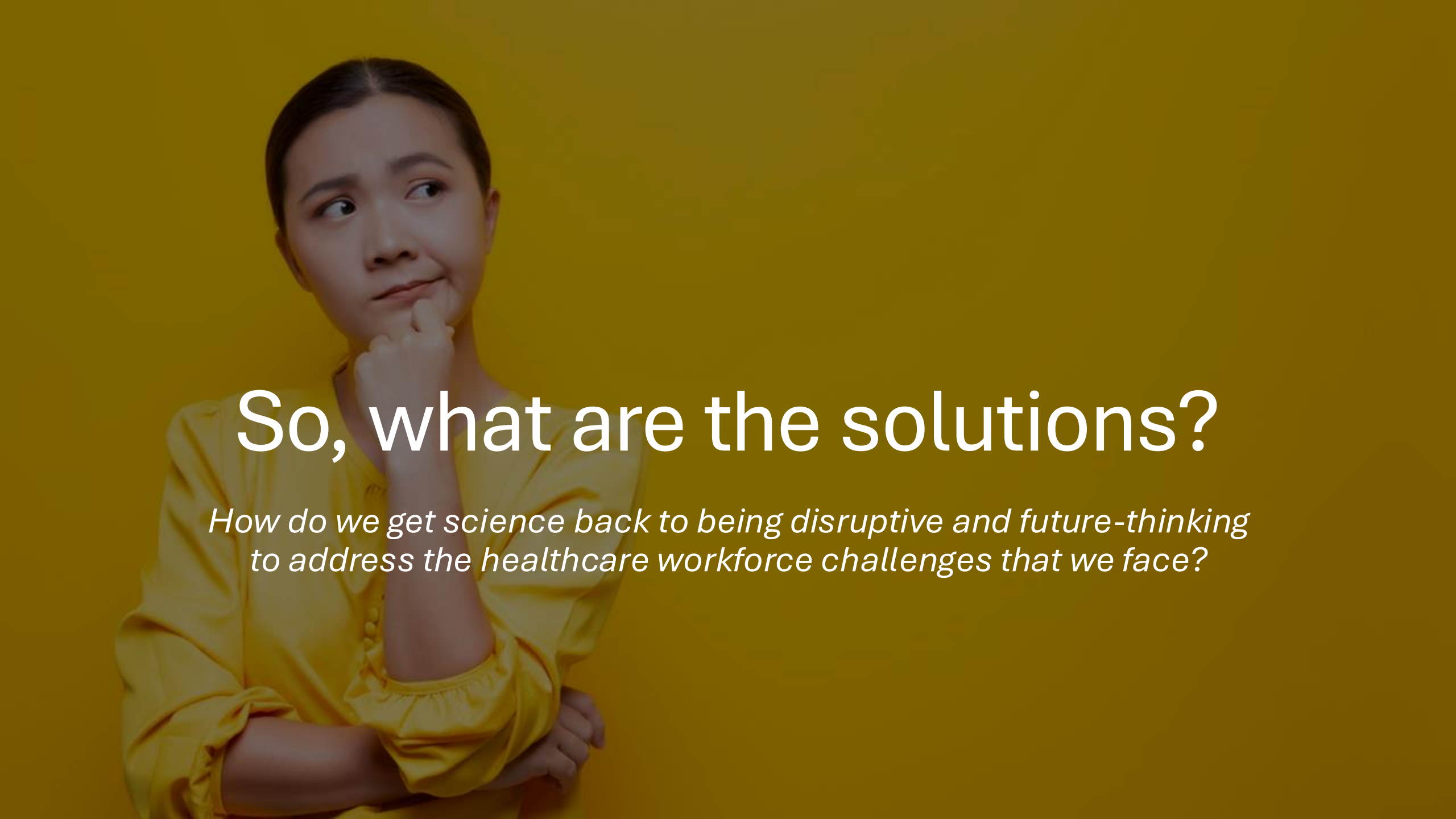

So, what are the solutions?

How do we get science back to being disruptive and future-thinking to address the healthcare workforce challenges that we face?

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The Curious Wavefunction

Stephen Hawking's advice for twenty-first century grads: Embrace complexity

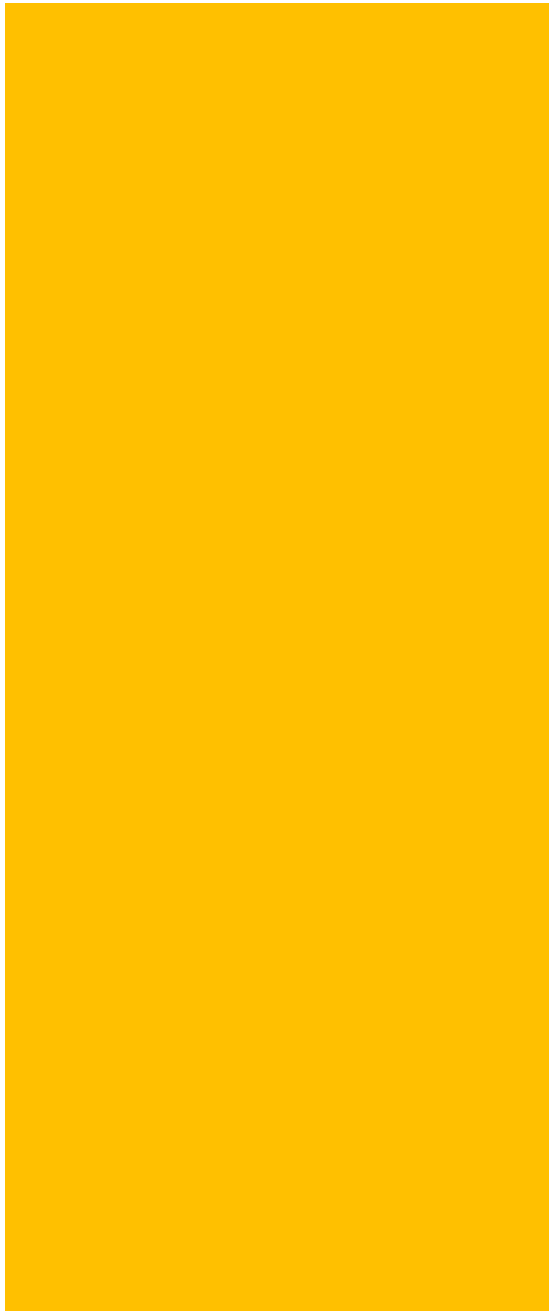
By Ashutosh Jogalekar on April 23, 2013

CAVEAT!!!

Social complexity theory is **not** the only solution to the problem.

Nor is it a panacea fix.

But it does have the capacity to disrupt if done correctly – which is what we will explore here in this talk.



So, let’s engaged in a dialogue about

the **value of a complexity framework**

for the **themes of our conference**

to **inspire future thinking**

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ЕВРОПЕЙСКОЕ РЕГИОНАЛЬНОЕ БЮРО

WHO Europe Symposium on Health Workforce Modelling for Action
28-30 April 2025
Copenhagen, Denmark

1. **AI, Information and Digital Data**

- Leveraging AI to Optimize Workloads and Build Sustainable Healthcare Systems
- Information to Intelligence: Integrating diverse data into modelling
- Information to Intelligence: Integrating sub-national models
- Effective data architecture for better models

2. **Optimization and Demand Models**

- Demand models
- Optimization of the Health and Care Workforce
- Challenges and opportunities in workforce optimization – policy imperatives for member states
- Developing impact measures for Workforce Optimization

3. **Leadership and policy making**

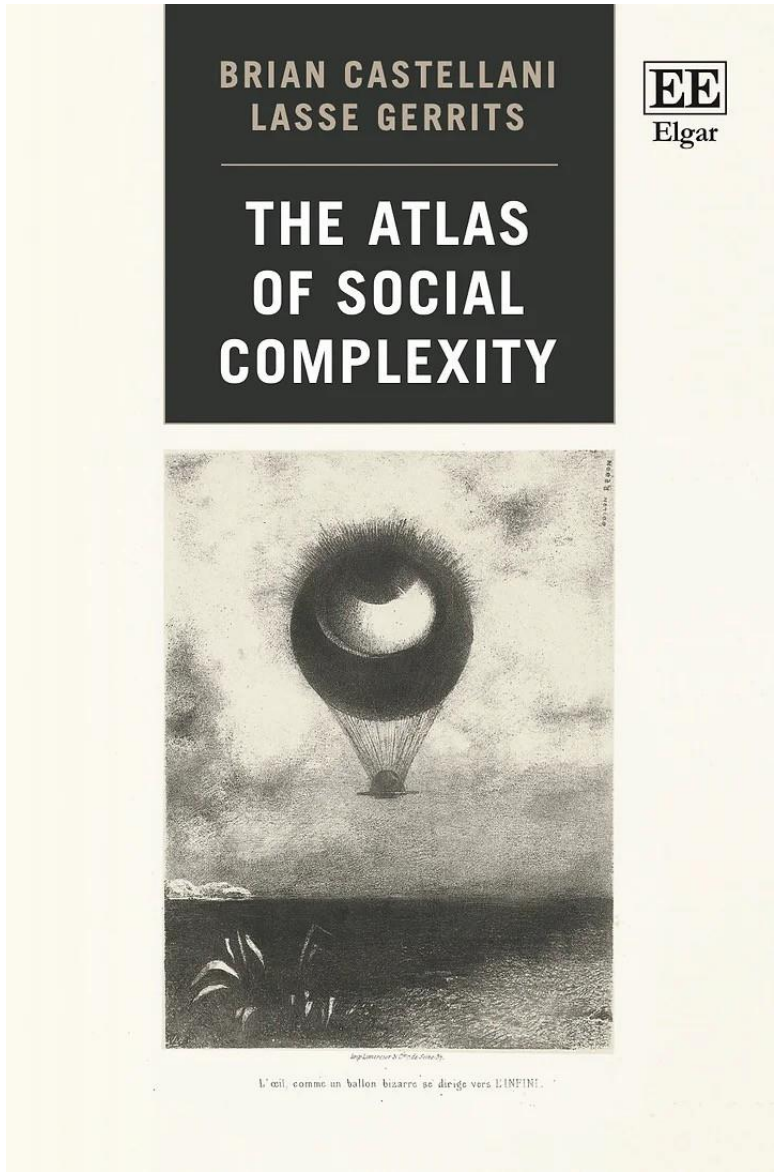
- How can effective models and system thinking support the policy making process?
- Plenary panel: Leadership and systemic change: Modelling, planning, and optimisation in the realm of professionalisation, power structures, hierarchy, incentives.
- Leadership, ethics, and modelling

4. **Justice and Equity: Power, Inequality, Discrimination**

- Towards more inclusive and just health systems: Addressing gender violence and systemic discrimination against healthcare workers
- Towards a Paradigm Shift: Integrating intersectional equity and systems thinking in strategic health workforce planning and decision making

5. **Workforce management**

- Modelling for multiprofessional teams
- Retention as a critical component of workforce approaches
- Digital skills are a key challenge and opportunity to turn Health Workforce modelling into action.



Biographical Summary

Brian Castellani (PhD, FAcSS) is Professor and Director of the *Durham Research Methods Centre* and *Wolfson Research Institute for Health and Wellbeing*, Durham University (UK). He is also adjunct professor of psychiatry, Northeastern Ohio Medical University (USA).

Lasse Gerrits (Dr.Dr.) is Professor and Academic Director, *Institute for Housing and Urban Development Studies*, Erasmus University Rotterdam

Durham University

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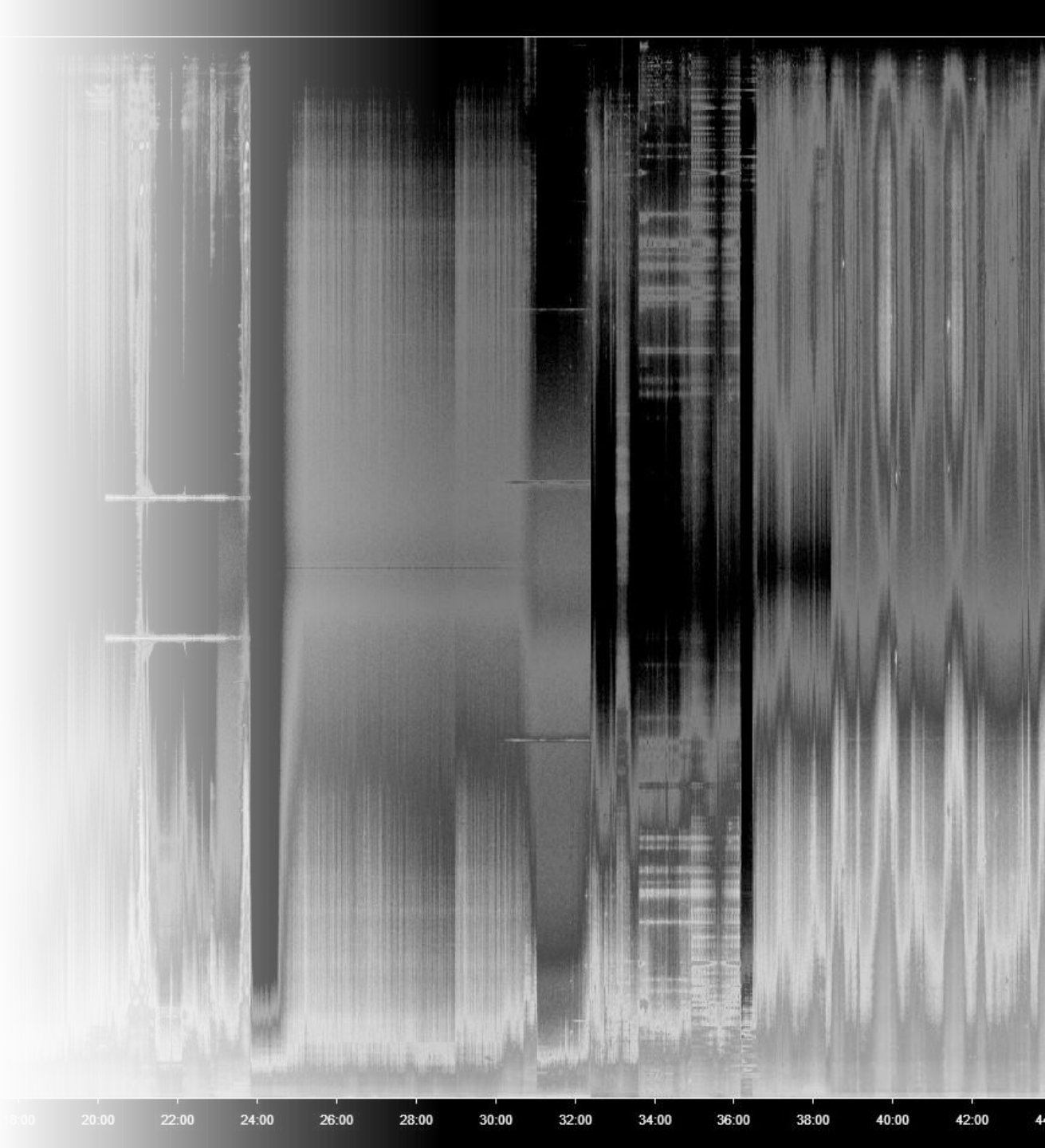
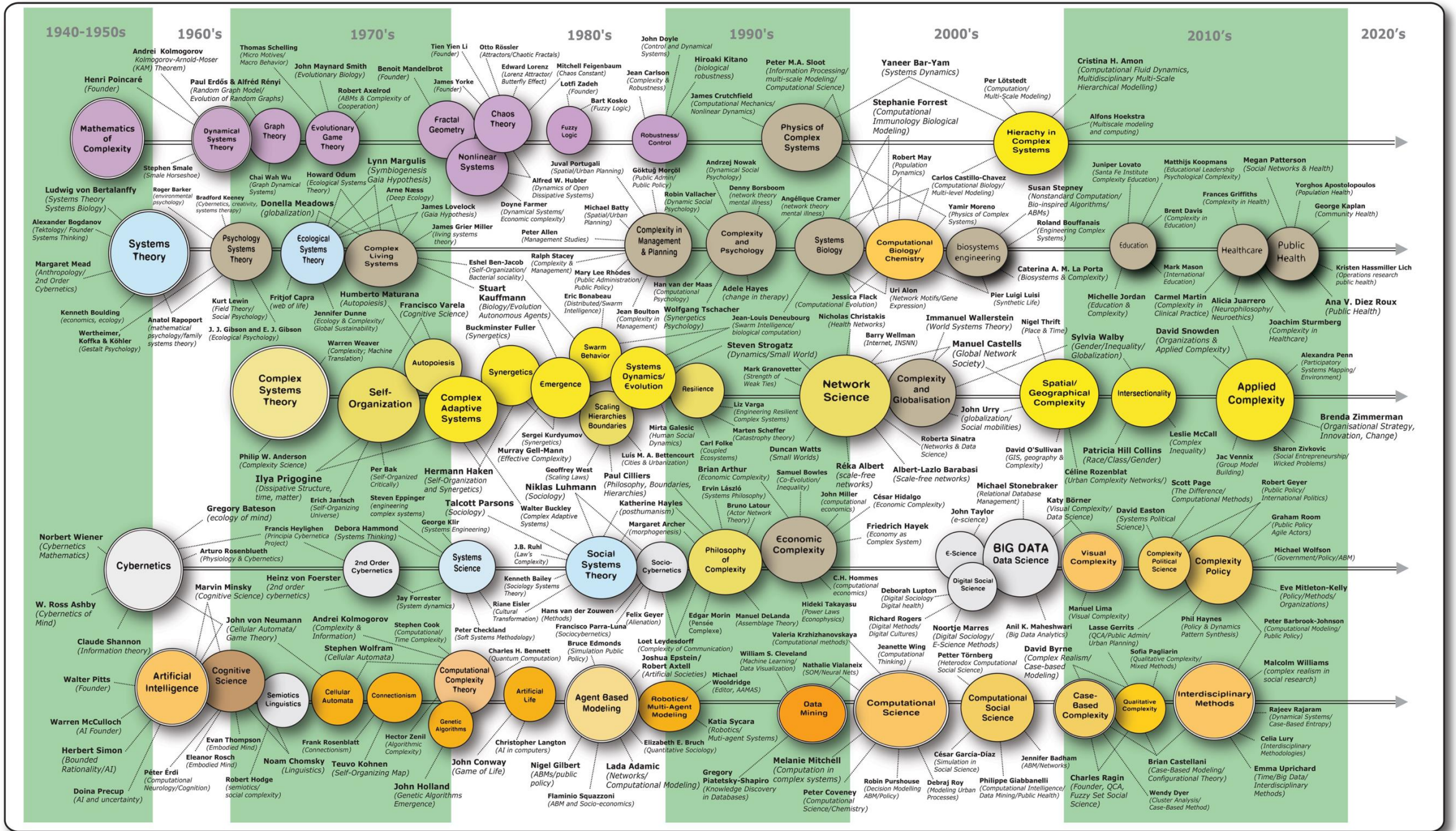
Quick timeline

- 1900s and back – initial systems thinking
- 1940s - Emergence of systems science
- 1980s – Santa Fe Institute
  - Waldrop's Complexity
- 1990s – Complexity turn in social sciences
  - Urry special issue in Theory, Culture, Society
- 2020s – **Social science turn** in complexity




1940-1950s
1960's
1970's
1980's
1990's
2000's
2010's
2020's
Mathematics of Complexity
Dynamical Systems Theory
Graph Theory
Evolutionary Game Theory
Fractal Geometry
Chaos Theory
Nonlinear Systems
Fuzzy Logic
Robustness/ Control
Physics of Complex Systems
Hierachy in Complex Systems
Systems Theory
Psychology Systems Theory
Ecological Systems Theory
Complex Living Systems
Complexity in Management & Planning
Complexity and Psychology
Systems Biology
Computational Biology/ Chemistry
biosystems engineering
Education
Healthcare
Public Health
Complex Systems Theory
Self-Organization
Autopoiesis
Complex Adaptive Systems
Synergetics
Emergence
Swarm Behavior
Systems Dynamics/ Evolution
Resilience
Scaling Hierarchies Boundaries
Network Science
Complexity and Globalisation
Spatial/ Geographical Complexity
Intersectionality
Applied Complexity
Cybernetics
2nd Order Cybernetics
Systems Science
Social Systems Theory
Socio-Cybernetics
Philosophy of Complexity
Economic Complexity
E-Science
Digital Social Science
BIG DATA Data Science
Visual Complexity
Complexity Political Science
Complexity Policy
Artificial Intelligence
Cognitive Science
Semiotics Linguistics
Cellular Automata
Connectionism
Computational Complexity Theory
Genetic Algorithms
Artificial Life
Agent Based Modeling
Robotics/ Multi-Agent Modeling
Data Mining
Computational Science
Computational Social Science
Case-Based Complexity
Qualitative Complexity
Interdisciplinary Methods
Henri Poincaré (Founder)
Andrei Kolmogorov (Kolmogorov-Arnold-Moser (KAM) Theorem)
Paul Erdős & Alfréd Rényi (Random Graph Model/ Evolution of Random Graphs)
Thomas Schelling (Micro Motives/ Macro Behavior)
John Maynard Smith (Evolutionary Biology)
Robert Axelrod (ABMs & Complexity of Cooperation)
Benoit Mandelbrot (Founder)
James Yorke (Founder)
Tien Yien Li (Founder)
Otto Rössler (Attractors/Chaotic Fractals)
Edward Lorenz (Lorenz Attractor/ Butterfly Effect)
Mitchell Feigenbaum (Chaos Constant)
Lotfi Zadeh (Founder)
Bart Kosko (Fuzzy Logic)
John Doyle (Control and Dynamical Systems)
Jean Carlson (Complexity & Robustness)
Hiroaki Kitano (biological robustness)
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Yaneer Bar-Yam (Systems Dynamics)
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Per Lötstedt (Computation/ Multi-Scale Modeling)
Cristina H. Amon (Computational Fluid Dynamics, Multidisciplinary Multi-Scale Hierarchical Modelling)
Alfons Hoekstra (Multiscale modeling and computing)
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Chai Wah Wu (Graph Dynamical Systems)
Howard Odum (Ecological Systems Theory)
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Arne Næss (Deep Ecology)
Donella Meadows (globalization)
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Céline Rozenblat (Urban Complexity Networks/)
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Mirta Galesic (Human Social Dynamics)
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Luís M. A. Bettencourt (Cities & Urbanization)
Duncan Watts (Small Worlds)
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Albert-Lazlo Barabasi (Scale-free networks)
Per Bak (Self-Organized Critically)
Hermann Haken (Self-Organization and Synergetics)
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Petter Törnberg (Heterodox Computational Social Science)
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Claude Shannon (Information theory)
Andrei Kolmogorov (Complexity & Information)
Stephen Cook (Computational/ Time Complexity)
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César García-Díaz (Simulation in Social Science)
Philippe Giabbanelli (Computational Intelligence/ Data Mining/Public Health)
Jennifer Badham (ABM/Networks)
Charles Ragin (Founder, QCA, Fuzzy Set Social Science)
Brian Castellani (Case-Based Modeling/ Configurational Theory)
Wendy Dyer (Cluster Analysis/ Case-Based Method)

Complex socio-ecological systems are:

case-based,
adaptive,
self-organising,
emergent,
nonlinear,
evolving,
casually complex,
comprised of multiple trajectories and outcomes,
nested within other complex systems and environmental forces,
network-based,
structurally open-ended,
and variously constrained and enabled via hierarchies and boundaries
and different forms of organisational closure.

Complex socio-ecological systems are:

But they are also:

Comprised of relations of power.

Involve issues of inequality, exploitation, domination, governance, resistance, conflict, etc.

Comprised of varying levels of complex psychology, from the individual to the collective.

In need of different interventions and approaches to change, as wicked problems are not easily sorted or if ever solved.

The 13 Situations

Situation	Characteristics
1. No philosophy of complexity	Few attempts to define an epistemology and ontology for social complexity
2. A failure to engage the wider social sciences	Assumption that the social sciences can be ignored because the complexity sciences would offer superior insights
3. Reinventing the wheel	Reinventing existing insights from the social sciences that are then presented as new insights
4. Old words, new words	Rebranding existing insights using terms from the complexity sciences
5. Obscurantism and mystification	Scientific overreach and complicated jargon combine to suggest that life's biggest questions are uncovered
6. The need for multilevel thinking and modelling	Despite the transdisciplinary approach of social complexity, almost all research focuses on a single level of analysis.
7. Technique in the absence of theory	Focus on computational methods and big data pushes social theory out of sight
8. Learning tools vs. predictive machines	The ability to learn from simulations is replaced by a desire to predict and control social complexity
9. Minor role of qualitative research	Dominance of quantitative research and quantification of data established a blind spot for qualitative data and methods
10. Methodological closing of social scientific mind	Shying away from advances in computational methods sees many social scientists becoming illiterate with such methods
11. The dire sound of technicalities	Going into a spiral of ever-smaller technical refinement while losing the bigger picture out of sight.
12. Being tone-deaf about the real world	Advanced analyses are coupled to crude recommendations that fail to appreciate the complexity in the target domain
13. Practice does not make perfect	Pragmatic and rushed adoption of the complexity sciences by practitioners constitutes verbal detritus

- We need both the social complexity literature and the health and social science literature.
- We need computational, statistical and qualitative interdisciplinary methods platforms.
- We need transdisciplinary engagement.

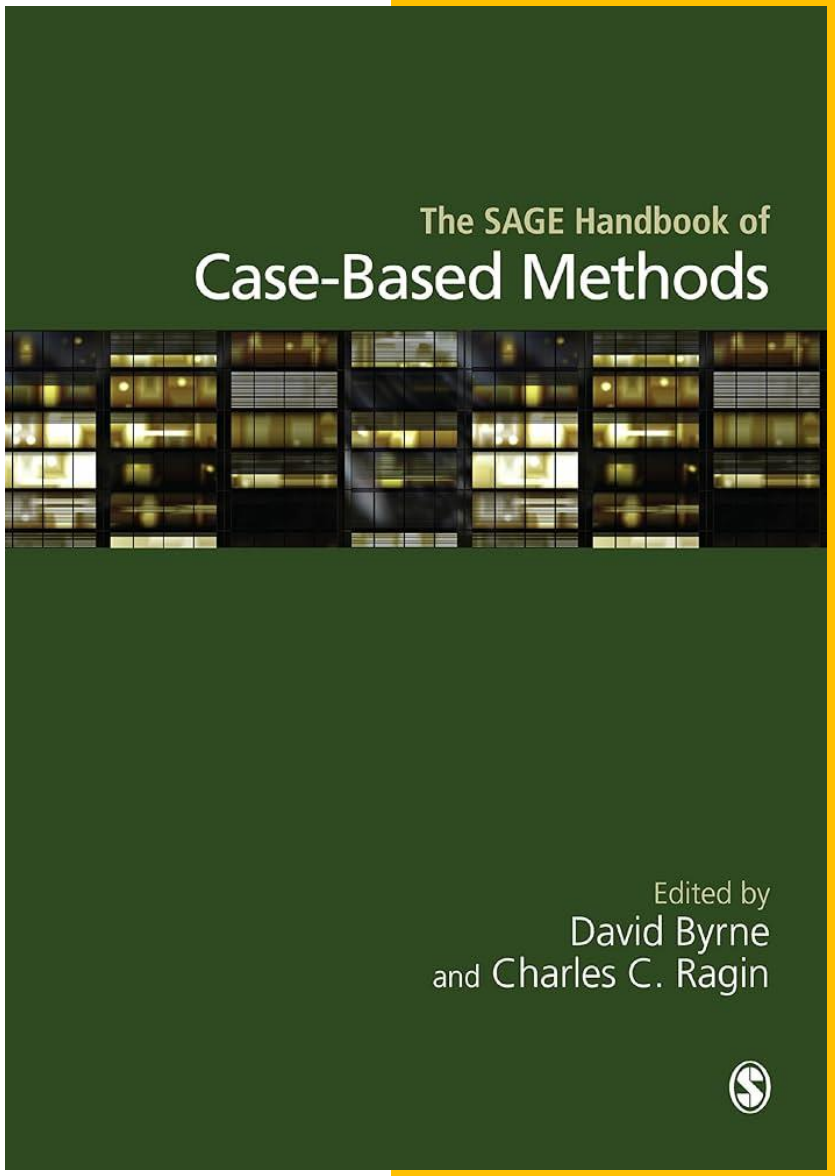
Case-Based Complexity

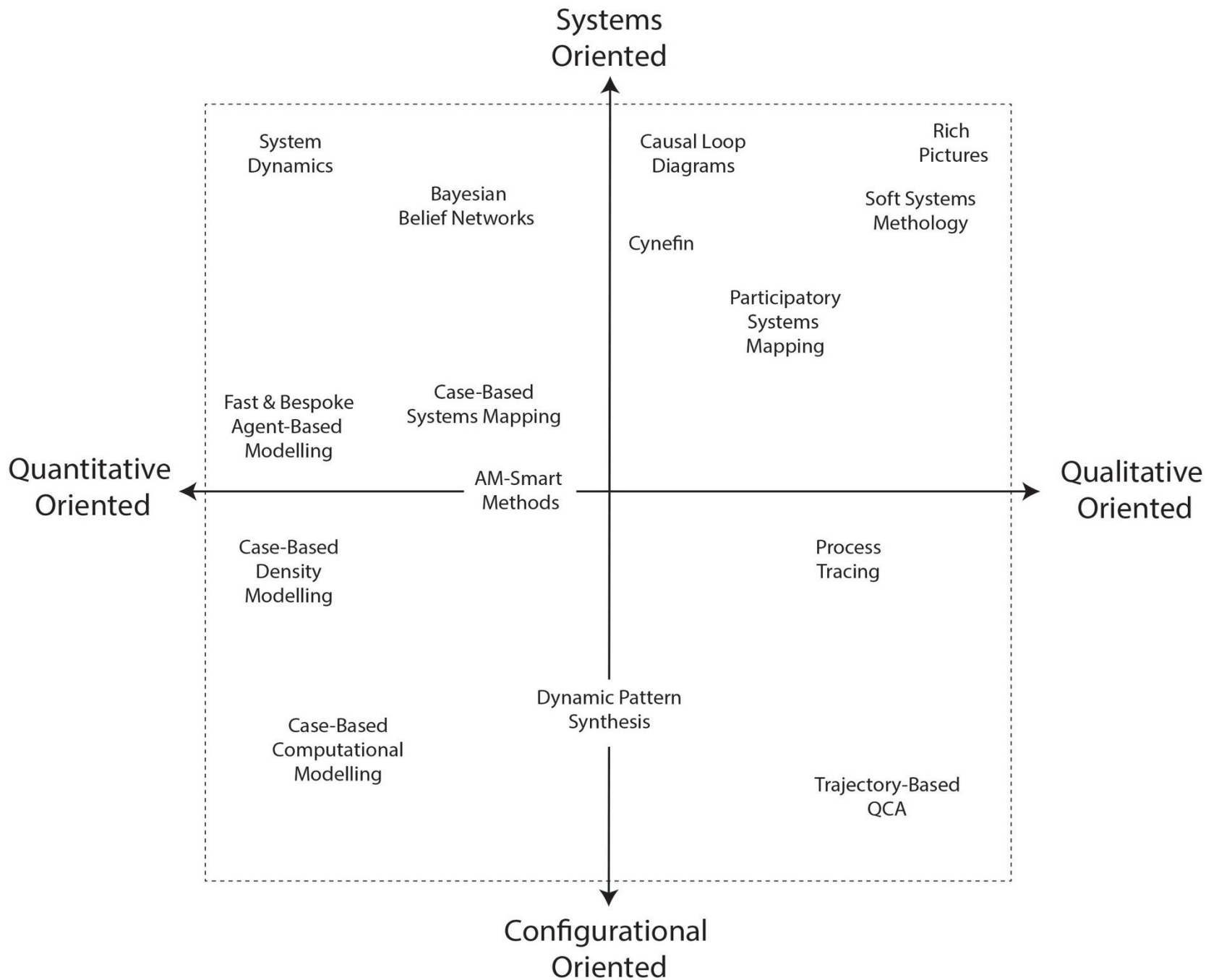
Case-based complexity is a suite of interdisciplinary methods first advanced by David Byrne and colleagues as an improvement on the conventions of cased-based qualitative configurational analysis (QCA).

Case-based complexity is an established field of study, particularly in sociology, policy studies, political science, governance, urban planning and public administration.

Case-based complexity is grounded on Byrne's novel insight that cases meet the definitional critique of complex systems.

An excellent introduction to this methodology is Byrne and Ragin's *Sage handbook of case-based methods*.

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System Dynamics
Causal Loop Diagrams
Rich Pictures
Bayesian Belief Networks
Soft Systems Methology
Cynefin
Participatory Systems Mapping
Fast & Bespoke Agent-Based Modelling
Case-Based Systems Mapping
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Case-Based Computational Modelling
Trajectory-Based QCA
Configurational Oriented

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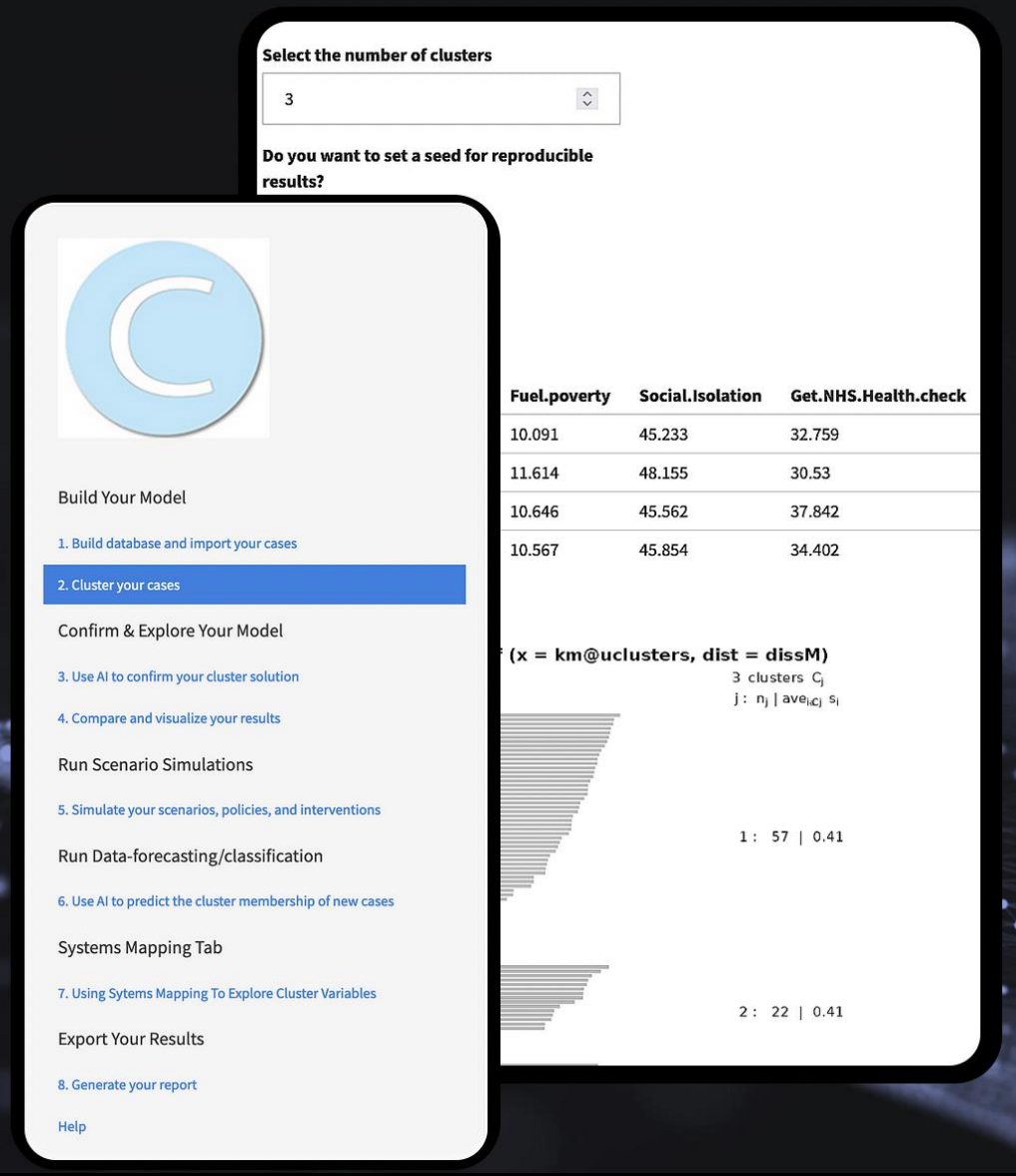

Case-based complexity

- **Configurational Problems**
  - Health workforce issues are shaped by intersecting social, institutional, and ecological factors—not single causes.
- **Nested Systems**
  - Workers operate within nested systems e.g., local hospitals, national policy, global labour markets, which are all interacting.
- **Emergent Systems**
  - Teams self-organize and evolve over time; workforce dynamics are adaptive and nonlinear.
- **Scalable Analysis**
  - Analysis moves across scales, from daily routines to global structures, revealing interconnected patterns.

Case-based complexity

- **Fluid Categories**
  - Job roles and workforce categories must be interrogated, as they shift with social and political change.
- **Nonlinear Causality – multifinality, equifinality, causal asymmetry**
  - **Multifinality**: Similar conditions lead to different outcomes.
  - **Equifinality**: Different conditions lead to similar outcomes
  - **Causal asymmetry**: what accounts for success does not necessarily account for failure.
- **Trajectory Clustering**
  - Workforce cases evolve along different paths, clustering into dominant trends and hidden counter-patterns.

Optimization and Demand Models

- **Case-Based Complexity as the Grammar of Workforce Diversity**
- Health systems do not follow one script.
- They are **ensembles of cases,** each a unique constellation of social, economic, institutional, and ecological factors.
- Case-based complexity approaches reject the search for universal laws.
- Instead, they trace
  - **equifinality:** many paths to similar outcomes
  - **multifinality**: similar starting points diverging
  - **causal asymmetry:** the same variable helps in one setting, harms in another
- For workforce demand models, this means dropping the illusion of one-size-fits-all projections.
- Treat each workforce ecosystem as a situated case, where solutions must be assembled, not imposed.

Complexity is not a complication; it is a place-based contextual truth.

Optimization and Demand Models

- **From Forecast to Foresight: Emergence over Prediction**
  - Traditional workforce models treat the future as a statistical extension of the past. Complexity tells us otherwise: the future is emergent.
  - By shifting from linear forecasting to case-based modelling and scenario exploration, we acknowledge that healthcare systems are historically contingent, non-linear, and riddled with tipping points.
  - This allows us to simulate alternative futures to prepare for them.

- **Embed co-production and reflexivity into modelling**
  - Models should not just describe the system; they should *become part of it*.
  - That means involving healthcare staff, patients, and planners in *co-constructing demand and optimization models* that reflect their realities.
  - Reflexive modelling, aware of its assumptions, ethics, and use, supports *better decisions and deeper trust*.

Leadership workforce management and policy making

- **Complexity Without Structure is Managerial Mysticism**
  - Complexity is not a metaphor. It is an ontological reality.
  - Too often, in workforce leadership and management, “complexity” is invoked to romanticize ambiguity, celebrate agility, or cloak decision-making in systems-speak.
  - Organisations are imbued with power and hierarchies that often resist bottom-up self-organisation.
  - True social complexity demands grappling with feedback loops, causal asymmetries, path dependencies, and emergent structures.

- **Leadership is the property of the group**
  - Leadership is a property of the system, not the individual. It is something that the group creates.
  - Putting all those aspects on the doorstep of an individual is impossible - no human being can pull that off alone.
  - This also avoids the consultancy-speak of leaders as heroes.

Leadership workforce management and policy making

- **The complexities of policy**
  - Policy cannot be treated as a linear intervention and evaluation cannot remain a post-hoc audit of outcomes.

  - **Even seemingly simple policy actions take place in complex systems** – which can trigger feedback loops, resistance, and unintended effects that ripple across levels and domains.
    - METHODS: Use developmental evaluation, real-time learning loops, and participatory systems mapping, sensemaking to stay responsive.

  - **Causality is Configurational, Not Universal:** Ask: *what works, for whom, in which context, and in what combination?*
    - METHODS: Use QCA, case-based approaches, and realist methods to unpack causal complexity.

Leadership workforce management and policy making

- ## The complexities of policy

  - **Values Clash, So Learn From It:** Policy is conflicted. Different stakeholders define success differently.
    - METHODS: Embrace deliberative methods, multi-criteria analysis, and negotiation frameworks to surface these tensions constructively.

  - **The Method Is the Intervention:** How you evaluate shapes the system itself.
    - METHODS: Use methods that promote reflexivity, empower communities, and build adaptive capacity, not just accountability.

Justice and Equity: Power, Inequality, Discrimination

- **See the workforce through an intersectional lens**
  - Healthcare workers do not experience the system equally.
  - Racism, sexism, ableism, classism, homophobia intersect to shape their working lives, often invisibly.
  - Social complexity theory calls for models and strategies that *surface these patterned inequalities*, showing how they are embedded across institutions, roles, and geographies.

- **Reframe discrimination as a structural feature**
  - Gender violence, pay gaps, role segregation, and professional silencing are not accidental; they are *reproducible outputs* of systemic dynamics.
  - Modelling justice means tracing how such harms emerge from feedback loops, incentive structures, and institutional norms.
  - Complexity helps us name these mechanisms and identify points of ethical intervention.

Justice and Equity: Power, Inequality, Discrimination

- **Treat equity as an emergent property of system design**
  - Equity is not just an outcome to be measured; it is *a dynamic result of how systems are designed and governed*.
  - That includes who sets policy agendas, whose knowledge is valued, and how accountability is structured.
  - Social complexity theory shows how just systems emerge from distributed power, inclusive participation, and adaptive governance.

- **Embed intersectional co-design into planning and modelling**
  - Strategic workforce planning must include those most affected by inequity.
  - Complexity-based modelling becomes a tool for *co-enquiry*, where lived experience, frontline expertise, and community knowledge reshape what is seen, valued, and prioritised.
  - Inclusion here is not consultation; it is co-authorship.

Thank you

Hopefully, some of these ideas will inspire or disrupt discussion across the events of the conference

Looking forward to the conference