Case-Based Visual Complexity

Entangling Science and the Humanities as Method

Brian Castellani, PhD. FAcSS
Professor, Environmental and Public Health

Director, Research Methods Centre
Co-Director, Wolfson Research Institute for Health & Wellbeing, Durham University, United Kingdom

Visting Professor, Nelson Mandela University, South Africa

Adjunct Professor of Psychiatry Northeastern Ohio Medical University, United States

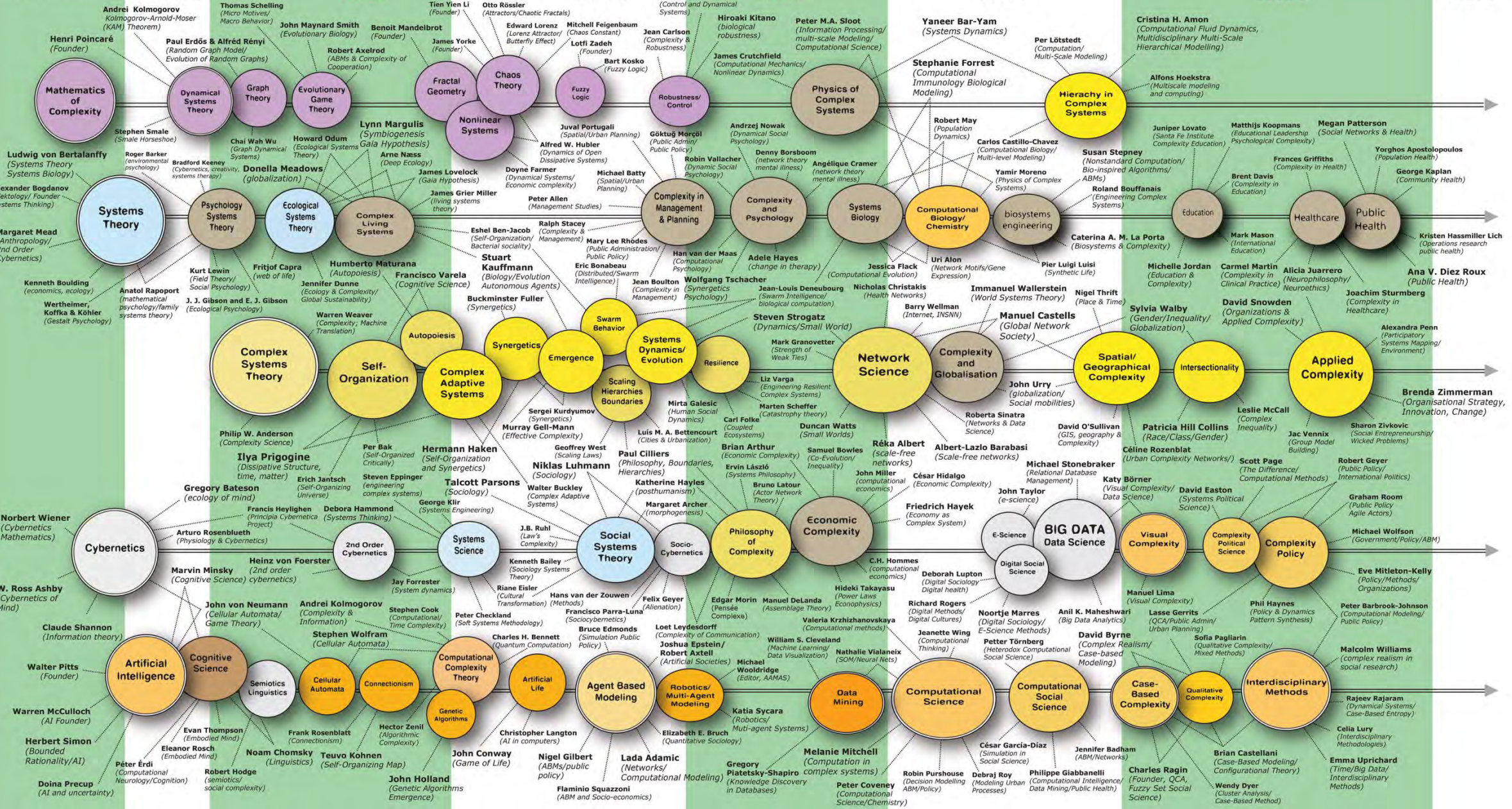Andrei Kolmogorov *(Kolmogorov-Arnold-Moser (KAM) Theorem)*

Thomas Schelling *(Micro Motives/ Macro Behavior)*

Henri Poincaré *(Founder)*

Paul Erdős & Alfréd Rényi *(Random Graph Model/ Evolution of Random Graphs)*

John Maynard Smith *(Evolutionary Biology)*

Benoit Mandelbrot *(Founder)*

Tien Yien Li *(Founder)*

Otto Rössler *(Attractors/Chaotic Fractals)*

Edward Lorenz *(Lorenz Attractor/ Butterfly Effect)*

Mitchell Feigenbaum *(Chaos Constant)*

John Doyle *(Control and Dynamical Systems)*

Hiroaki Kitano *(biological robustness)*

Peter M.A. Sloot *(Information Processing/ multi-scale Modeling/ Computational Science)*

Yaneer Bar-Yam *(Systems Dynamics)*

Per Lötstedt *(Computation/ Multi-Scale Modeling)*

Cristina H. Amon *(Computational Fluid Dynamics, Multidisciplinary Multi-Scale Hierarchical Modelling)*

James Yorke *(Founder)*

Lofti Zadeh *(Founder)*

Bart Kosko *(Fuzzy Logic)*

Jean Carlson *(Complexity & Robustness)*

James Crutchfield *(Computational Mechanics/ Nonlinear Dynamics)*

Stephanie Forrest *(Computational Immunology Biological Modeling)*

Alfons Hoekstra *(Multiscale modeling and computing)*

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

Stephen Smale *(Smale Horseshoe)*

Lynn Margulis *(Symbiogenesis/ Gaia Hypothesis)*

Juval Portugali *(Spatial/Urban Planning)*

Göktuğ Morçöl *(Public Admin/ Public Policy)*

Robert May *(Population Dynamics)*

Carlos Castillo-Chavez *(Computational Biology/ Multi-level Modeling)*

Juniper Lovato *(Santa Fe Institute Complexity Education)*

Matthijs Koopmans *(Educational Leadership Psychological Complexity)*

Megan Patterson *(Social Networks & Health)*

Ludwig von Bertalanffy *(Systems Theory Systems Biology)*

Chai Wah Wu *(Graph Dynamical Systems)*

Howard Odum *(Ecological Systems Theory)*

Arne Næss *(Deep Ecology)*

Alfred W. Hubler *(Dynamics of Open Dissipative Systems)*

Andrzej Nowak *(Dynamical Social Psychology)*

Robert May *(Population Dynamics)*

Yamir Moreno *(Physics of Complex Systems)*

Susan Stepney *(Nonstandard Computation/ Bio-inspired Algorithms/ ABMs)*

Brent Davis *(Complexity in Education)*

Frances Griffiths *(Complexity in Health)*

Yorghos Apostolopoulos *(Population Health)*

Roger Barker *(environmental psychology)*

Bradford Keeney *(Cybernetics, creativity, systems therapy)*

Donella Meadows *(globalization)*

James Lovelock *(Gaia Hypothesis)*

Doyne Farmer *(Dynamical Systems/ Economic complexity)*

Michael Batty *(Spatial/Urban Planning)*

Denny Borsboom *(network theory mental illness)*

Angélique Cramer *(network theory mental illness)*

Roland Bouffanais *(Engineering Complex Systems)*

George Kaplan *(Community Health)*

Alexander Bogdanov *(Tektology/ Founder Systems Thinking)*

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

Margaret Mead *(Anthropology/ 2nd Order Cybernetics)*

James Grier Miller *(living systems theory)*

Peter Allen *(Management Studies)*

Han van der Maas *(Computational Psychology)*

Wolfgang Tschacher *(Synergetics Psychology)*

Uri Alon *(Network Motifs/Gene Expression)*

Caterina A. M. La Porta *(Biosystems & Complexity)*

Mark Mason *(International Education)*

Carmel Martin *(Complexity in Clinical Practice)*

Ana V. Diez Roux *(Public Health)*

Kenneth Boulding *(economics, ecology)*

Kurt Lewin *(Field Theory/ Social Psychology)*

Eshel Ben-Jacob *(Self-Organization/ Bacterial sociality)*

Ralph Stacey *(Complexity & Management)*

Mary Lee Rhodes *(Public Administration/ Public Policy)*

Eric Bonabeau *(Distributed/Swarm Intelligence)*

Adele Hayes *(change in therapy)*

Jessica Flack *(Computational Evolution)*

Pier Luigi Luisi *(Synthetic Life)*

Michelle Jordan *(Education & Complexity)*

Alicia Juarrero *(Neurophilosophy/ Neuroethics)*

Joachim Sturmberg *(Complexity in Healthcare)*

Wertheimer, Koffka & Köhler *(Gestalt Psychology)*

Anatol Rapoport *(mathematical psychology/family systems theory)*

Fritjof Capra *(web of life)*

Jennifer Dunne *(Ecology & Complexity/ Global Sustainability)*

Humberto Maturana *(Autopoiesis)*

Stuart Kauffmann *(Biology/Evolution Autonomous Agents)*

Jean Boulton *(Complexity in Management)*

Jean-Louis Deneubourg *(Swarm Intelligence/ biological computation)*

Nicholas Christakis *(Health Networks)*

Immanuel Wallerstein *(World Systems Theory)*

Nigel Thrift *(Place & Time)*

Sylvia Walby *(Gender/Inequality/ Globalization)*

David Snowden *(Organizations & Applied Complexity)*

Alexandra Penn *(Participatory Systems Mapping/ Environment)*

J. J. Gibson and E. J. Gibson *(Ecological Psychology)*

Francisco Varela *(Cognitive Science)*

Buckminster Fuller *(Synergetics)*

Swarm Behavior

Systems Dynamics/ Evolution

Barry Wellman *(Internet, INSNN)*

Manuel Castells *(Global Network Society)*

John Urry *(globalization/ Social mobilities)*

Self-Organization

Complex Adaptive Systems

Synergetics

Emergence

Scaling Hierarchies Boundaries

Resilience

Network Science

Complexity and Globalisation

Spatial/ Geographical Complexity

Intersectionality

Applied Complexity

Warren Weaver *(Complexity; Machine Translation)*

Autopoiesis

Sergei Kurdyumov *(Synergetics)*

Mirta Galesic *(Human Social Dynamics)*

Mark Granovetter *(Strength of Weak Ties)*

Roberta Sinatra *(Networks & Data Science)*

David O'Sullivan *(GIS, geography & Complexity)*

Patricia Hill Collins *(Race/Class/Gender)*

Leslie McCall *(Complex Inequality)*

Brenda Zimmerman *(Organisational Strategy, Innovation, Change)*

Complex Systems Theory

Murray Gell-Mann *(Effective Complexity)*

Geoffrey West *(Scaling Laws)*

Luís M. A. Bettencourt *(Cities & Urbanization)*

Carl Folke *(Coupled Ecosystems)*

Marten Scheffer *(Catastrophy theory)*

Duncan Watts *(Small Worlds)*

Réka Albert *(scale-free networks)*

Albert-Lazlo Barabasi *(Scale-free networks)*

Jac Vennix *(Group Model Building)*

Sharon Zivkovic *(Social Entrepreneurship/ Wicked Problems)*

Philip W. Anderson *(Complexity Science)*

Per Bak *(Self-Organized Critically)*

Hermann Haken *(Self-Organization and Synergetics)*

Steven Eppinger *(engineering complex systems)*

Paul Cilliers *(Philosophy, Boundaries, Hierarchies)*

Brian Arthur *(Economic Complexity)*

Samuel Bowles *(Co-Evolution/ Inequality)*

César Hidalgo *(Economic Complexity)*

Michael Stonebraker *(Relational Database Management)*

Katy Börner *(Visual Complexity/ Data Science)*

Scott Page *(The Difference/ Computational Methods)*

Robert Geyer *(Public Policy/ International Politics)*

Ilya Prigogine *(Dissipative Structure, time, matter)*

Erich Jantsch *(Self-Organizing Universe)*

Niklas Luhmann *(Sociology)*

Katherine Hayles *(posthumanism)*

Ervin László *(Systems Philosophy)*

Bruno Latour *(Actor Network Theory)*

John Miller *(computational economics)*

Friedrich Hayek *(Economy as Complex System)*

John Taylor *(e-science)*

David Easton *(Systems Political Science)*

Graham Room *(Public Policy Agile Actors)*

Gregory Bateson *(ecology of mind)*

Talcott Parsons *(Sociology)*

Walter Buckley *(Complex Adaptive Systems)*

Margaret Archer *(morphogenesis)*

Friedrich Hayek

Michael Wolfson *(Government/Policy/ABM)*

Norbert Wiener *(Cybernetics Mathematics)*

Francis Heylighen *(Principia Cybernetica Project)*

Debora Hammond *(Systems Thinking)*

George Klir *(Systems Engineering)*

J.B. Ruhl *(Law's Complexity)*

Economic Complexity

C.H. Hommes *(computational economics)*

Robert Geyer

Arturo Rosenblueth *(Physiology & Cybernetics)*

2nd Order Cybernetics

Systems Science

Social Systems Theory

Socio-Cybernetics

Philosophy of Complexity

E-Science

BIG DATA Data Science

Visual Complexity

Complexity Political Science

Complexity Policy

Marvin Minsky *(Cognitive Science)*

Heinz von Foerster *(2nd order cybernetics)*

Jay Forrester *(System dynamics)*

Kenneth Bailey *(Sociology Systems Theory)*

Deborah Lupton *(Digital Sociology/ Digital health)*

Eve Mitleton-Kelly *(Policy/Methods/ Organizations)*

Cybernetics

Digital Social Science

Cognitive Science

W. Ross Ashby *(Cybernetics of Mind)*

John von Neumann *(Cellular Automata/ Game Theory)*

Andrei Kolmogorov *(Complexity & Information)*

Riane Eisler *(Cultural Transformation)*

Hans van der Zouwen *(Methods)*

Felix Geyer *(Alienation)*

Edgar Morin *(Pensée Complexe)*

Manuel DeLanda *(Assemblage theory)*

Hideki Takayasu *(Power Laws Econophysics)*

Richard Rogers *(Digital Methods/ Digital Cultures)*

Noortje Marres *(Digital Sociology/ E-Science Methods)*

Anil K. Maheshwari *(Big Data Analytics)*

Manuel Lima *(Visual Complexity)*

Phil Haynes *(Policy & Dynamics Pattern Synthesis)*

Peter Barbrook-Johnson *(Computational Modeling/ Urban Planning)*

Stephen Cook *(Computational/ Time Complexity)*

Peter Checkland *(Soft Systems Methodology)*

Francisco Parra-Luna *(Sociocybernetics)*

Loet Leydesdorff *(Complexity of Communication)*

Valeria Krzhizhanovskaya *(Computational methods)*

Jeanette Wing *(Computational Thinking)*

Petter Törnberg *(Heterodox Computational Social Science)*

David Byrne *(Complex Realism/ Case-based Modeling)*

Lasse Gerrits *(QCA/Public Admin/ Urban Planning)*

Malcolm Williams *(complex realism in social research)*

Claude Shannon *(Information theory)*

Stephen Wolfram *(Cellular Automata)*

Charles H. Bennett *(Quantum Computation)*

Bruce Edmonds *(Simulation Public Policy)*

Joshua Epstein/ Robert Axtell *(Artificial Societies)*

Michael Wooldridge *(Editor, AAMAS)*

William S. Cleveland *(Machine Learning/ Data Visualization)*

Nathalie Vialaneix *(SOM/Neural Nets)*

Sofia Pagliarin *(Qualitative Complexity/ Mixed Methods)*

Artificial Intelligence

Semiotics Linguistics

Cellular Automata

Connectionism

Computational Complexity Theory

Artificial Life

Agent Based Modeling

Robotics/ Multi-Agent Modeling

Data Mining

Computational Science

Computational Social Science

Case-Based Complexity

Qualitative Complexity

Interdisciplinary Methods

Walter Pitts *(Founder)*

Evan Thompson *(Interdisciplined Mind)*

Frank Rosenblatt *(Connectionism)*

Hector Zenil *(Algorithmic Complexity)*

Christopher Langton *(AI in computers)*

Katia Sycara *(Robotics/ Muti-agent Systems)*

César García-Díaz *(Simulation in Social Science)*

Jennifer Badham *(ABM/Networks)*

Rajeev Rajaram *(Dynamical Systems/ Case-Based Entropy)*

Warren McCulloch *(AI Founder)*

Eleanor Rosch *(Embodied Mind)*

Elizabeth E. Bruch *(Quantitative Sociology)*

Melanie Mitchell *(Computation in complex systems)*

Celia Lury *(Interdisciplinary Methodologies)*

Herbert Simon *(Bounded Rationality/AI)*

Noam Chomsky *(Linguistics)*

Teuvo Kohnen *(Self-Organizing Map)*

John Conway *(Game of Life)*

Nigel Gilbert *(ABMs/public policy)*

Lada Adamic *(Networks/ Computational Modeling)*

Gregory Piatetsky-Shapiro *(Knowledge Discovery in Databases)*

Robin Purshouse *(Decision Modelling ABM/Policy)*

Philippe Giabbanelli *(Computational Intelligence/ Data Mining/Public Health)*

Charles Ragin *(Founder, QCA, Fuzzy Set Social Science)*

Brian Castellani *(Case-Based Modeling/ Configurational Theory)*

Emma Uprichard *(Time/Big Data/ Interdisciplinary Methods)*

Péter Érdi *(Computational Neurology/Cognition)*

Robert Hodge *(semiotics/ social complexity)*

John Holland *(Genetic Algorithms Emergence)*

Flaminio Squazzoni *(ABM and Socio-economics)*

Peter Coveney *(Computational Science/Chemistry)*

Debraj Roy *(Modeling Urban Processes)*

Wendy Dyer *(Cluster Analysis/ Case-Based Method)*

Doina Precup *(AI and uncertainty)*

Robert Axelrod *(ABMs & Complexity of Cooperation)*

Genetic Algorithms

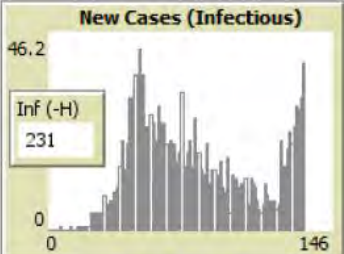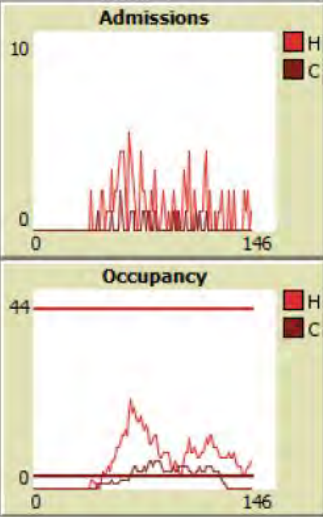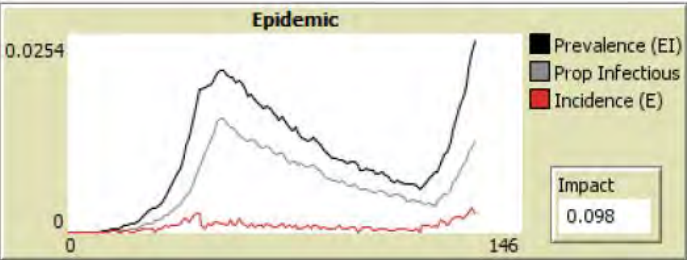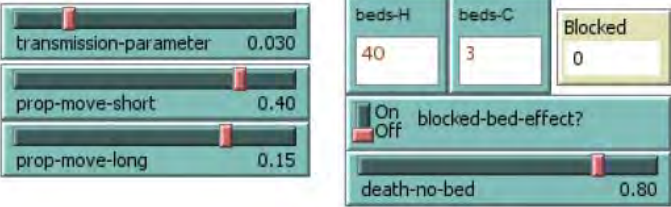Chaos Theory

Emergence

Resilience

The Challenge

- The transdisciplinary nature of the complexity sciences reminds us that knowledge is entangled across disciplines, practices, and methods
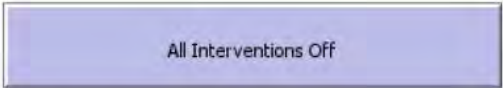- However, complexity science models, while powerful, create discipline-specific, visually flat outputs

LEGEND

INFRASTRUCTURE

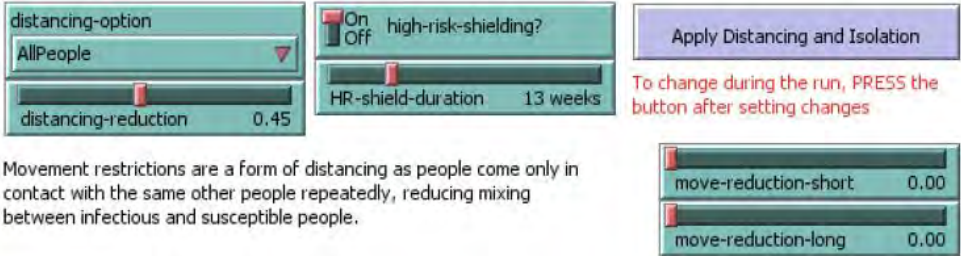MUSTARD SQUARES = Existing Wolfson Infrastructure
PURPLE BOXES = DRMC
OLIVE BOXES = International Linkages
BLACK BOXES = Potential Barriers to Change
GREEN BOXES = RIS
BLUE BOX = IMH
RED BOXES = Local Council and Trust

BLUE CIRCLES = Key individuals who link things together
YELLOW SQUARE = FUSE/Newcastle

ARROWS = Key linkages
DASHED ARROWS = Key action linkages

RESEARCH

Star = Health at Durham Strategy
YELLOW CIRCLES = Existing Research Programmes
GREEN CIRCLES = Research Priorities 2024
BLUE CIRCLE = ARC Research Grant
PINK CIRCLE = Child of the North

Epidemic Progression

transmission-parameter   0.030
prop-move-short   0.40
prop-move-long   0.15

beds-H   40
beds-C   3
Blocked   0

On / Off   blocked-bed-effect?
death-no-bed   0.80

Epidemic

0.0254

- Prevalence (EI)
- Prop Infectious
- Incidence (E)

0

0   146

Impact   0.098

Admissions
H
C
10
0
0   146

New Cases (Infectious)
46.2
Inf (-H)   231
0
0   146

Occupancy
H
C
44
0
0   146

Daily Deaths
10
Dead   67
0
0   146

setup
day
week
go

People   20172
Mix R0   2.68
R   1.16
isolation-efficacy   0.90
E days   5.4
I days   9.16
HC LoS   9.21

Interventions

All Interventions Off

Social Distancing

Select what is meant by social distancing and how strongly the distancing works.
(1) ByContact: the probability of a tranmitting contact is reduced by the specified proportion.
(2) AllPeople: everyone reduces their activity (attempted contacts) by the specified proportion.
(3) AllOrNone: the given proportion of people isolate (includes high risk if isolation also selected), but others make no reduction.

distancing-option
AllPeople
distancing-reduction   0.45

On / Off   high-risk-shielding?
HR-shield-duration   13 weeks

Apply Distancing and Isolation

To change during the run, PRESS the button after setting changes

Movement restrictions are a form of distancing as people come only in contact with the same other people repeatedly, reducing mixing between infectious and susceptible people.

move-reduction-short   0.00
move-reduction-long   0.00

Social Distancing Timing

When does the social distancing policy start (and stop)?

trigger-type
hospital
trigger-level   4
intervention-duration   10 weeks

Time Based
> interactive - operates throughout
> days - after given number of days
Epidemic Based
> hospital - people in hospital
> cases - people infectious

On?   no
Triggered at   42

Response to Symptoms

On / Off   isolate-inform?
mild-asymptomatic   0.45
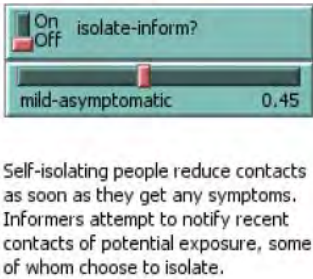
Self-isolation and informing contacts (if switched on) apply regardless of whether distancing interventions have been triggered.

Only some of mildly infected may show symptoms (plus all in hospital).

Self-isolating people reduce contacts as soon as they get any symptoms. Informers attempt to notify recent contacts of potential exposure, some of whom choose to isolate.

Self-Isolate
self-isolators   0.00
SI-isolation-duration   14 days

Inform Contacts
informers   0.00
found-and-isolate   0.20
IC-isolation-duration   14 days
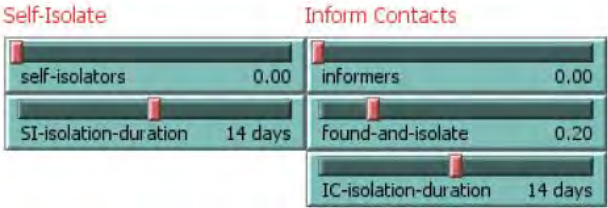
Response

- Case-Based Visual Complexity (CBVC): visual method → lived, embodied, conflicted, affective
- CBVC is part of the field of case-based complexity (CBC)
- CBVC is also situated within a wider field of artists-scientists addressing the tangled nature of knowledge and complexity
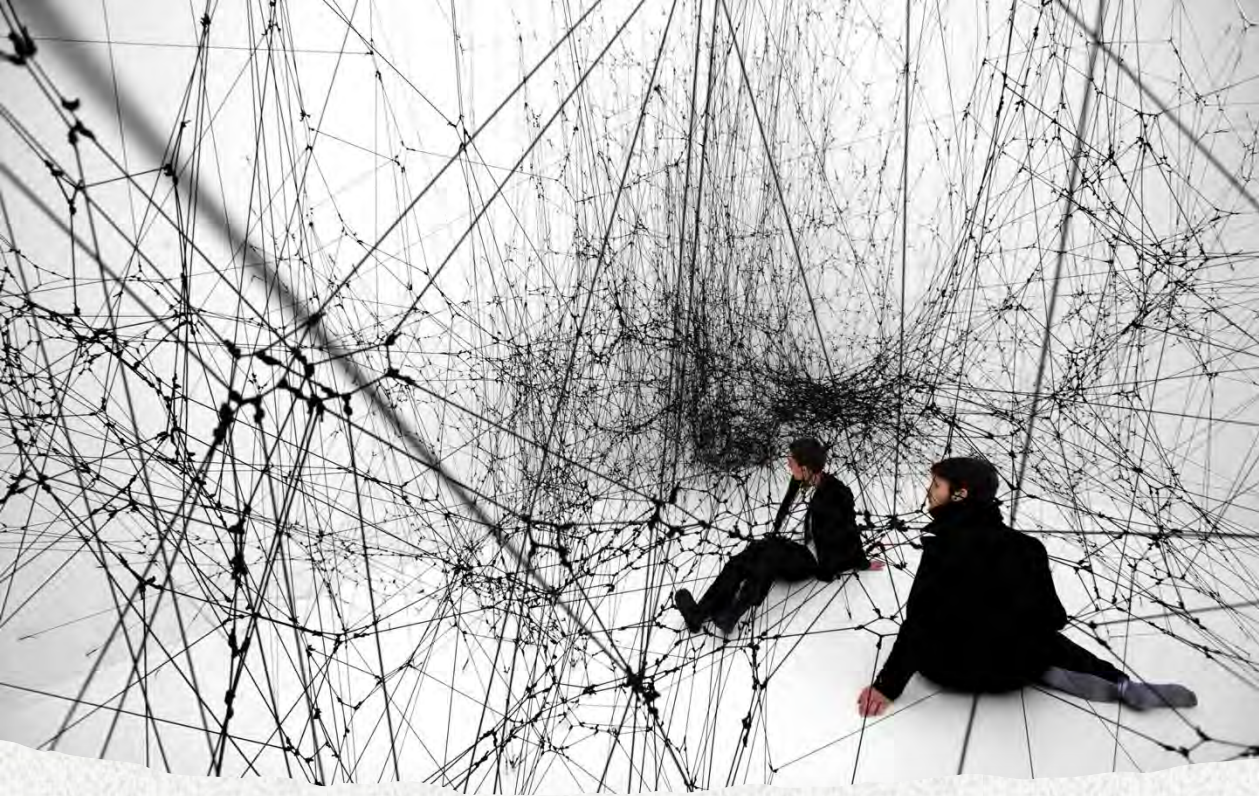
Artist–Scientist Networks

- Tomás Saraceno: webs, aerosolar structures
- Julie Mehretu: layered cartographies

Artist–Scientist Networks

- Neri Oxman: material ecology
- Chiharu Shiota: immersive webs, memory

Philosophical Foundations

- Complex Realism = middle ground (realism ↔ relativism)
- Social life is ontologically complex and systems
- Entanglement as ontologically real
- Avoids traps of naïve realism & relativism
- Visual practices as epistemology and method

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*.

The SAGE Handbook of
Case-Based Methods

Edited by
David Byrne
and Charles C. Ragin
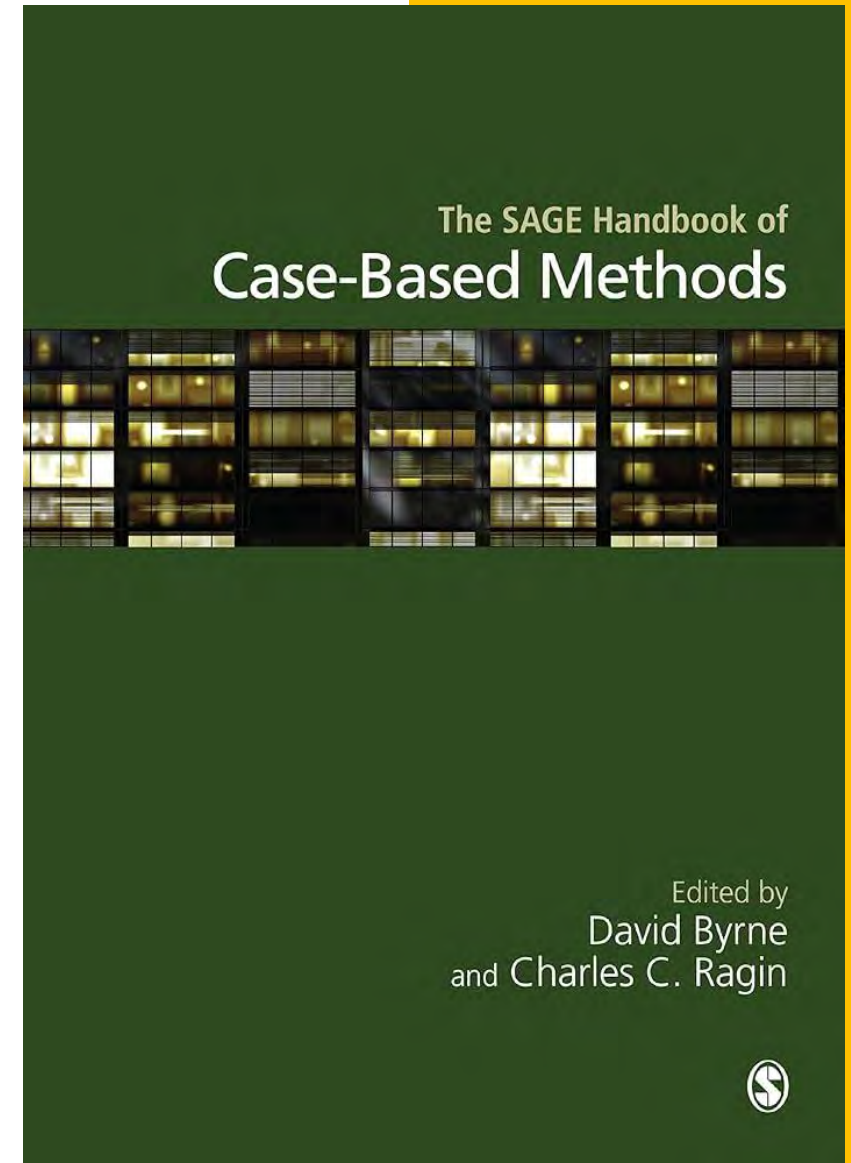
The Field of Case-Based Complexity

- QCA, TJ-QCA, CBDM, Systems Mapping, COMPLEX-IT

- Cases not variables → configurational, systemic, entangled wholes

- Problem of flatness → schematic outputs

- Latour's 'flat networks' critique

"Networks, Societies, Spheres: Reflections of an Actor-network Theorist"[*]

Keynote speech for the INTERNATIONAL SEMINAR ON NETWORK THEORY: NETWORK MULTIDIMENSIONALITY IN THE DIGITAL AGE
19th February 2010
Annenberg School for Communication and Journalism
Los Angeles

Bruno Latour, Sciences Po

Case-Based Visual Complexity

- Not illustration or 'making results visually compelling'
- Visual–epistemic practice in its own right
- **Aesthetics as method: perception, sensation, affect**
  - Psychological, emotional, existential, ecological grounding
  - Complementary to case-based complexity

Areas of visual research into entanglement

- Assemblage / Material Experiment (wire tangles, mixed media)

- Embodied Complexity (portraits, tangle faces)

- Comic & Critical (OneBigMob satire)

- Speculative Futures (Entangled film, Gallery Cluster, architectural tangles)
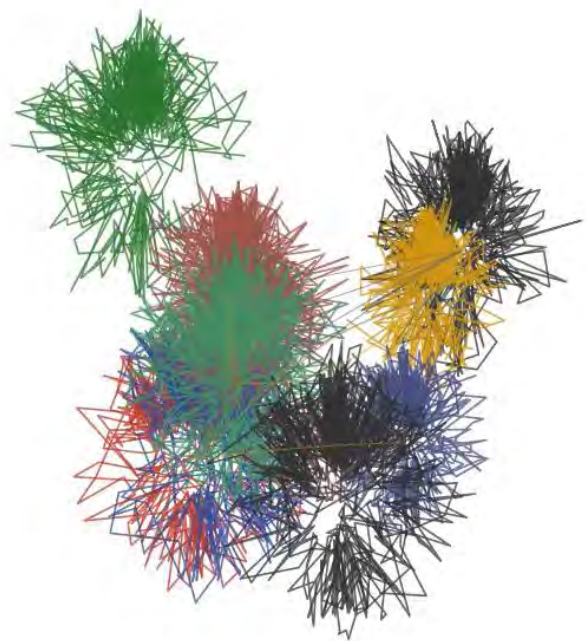
Entanglement
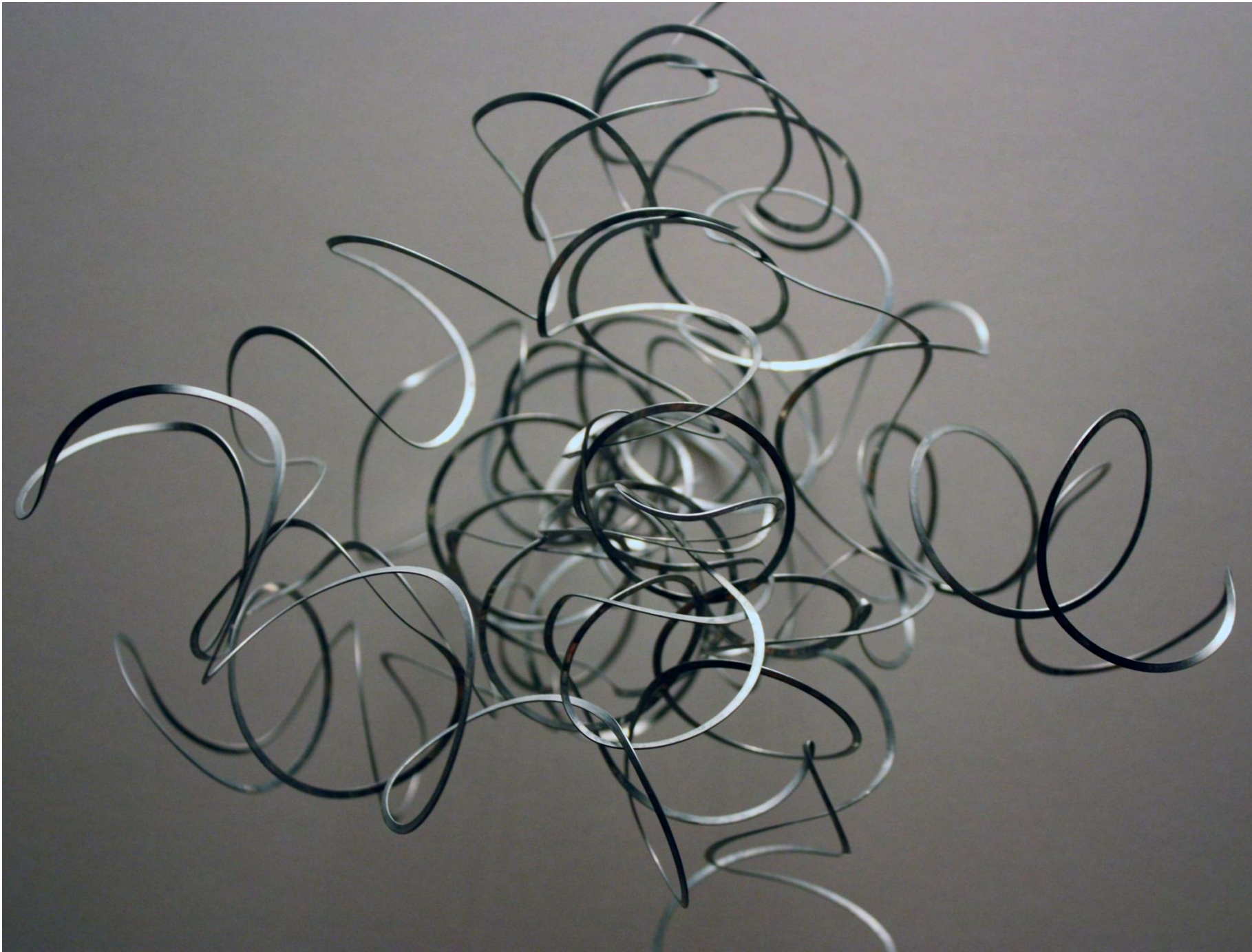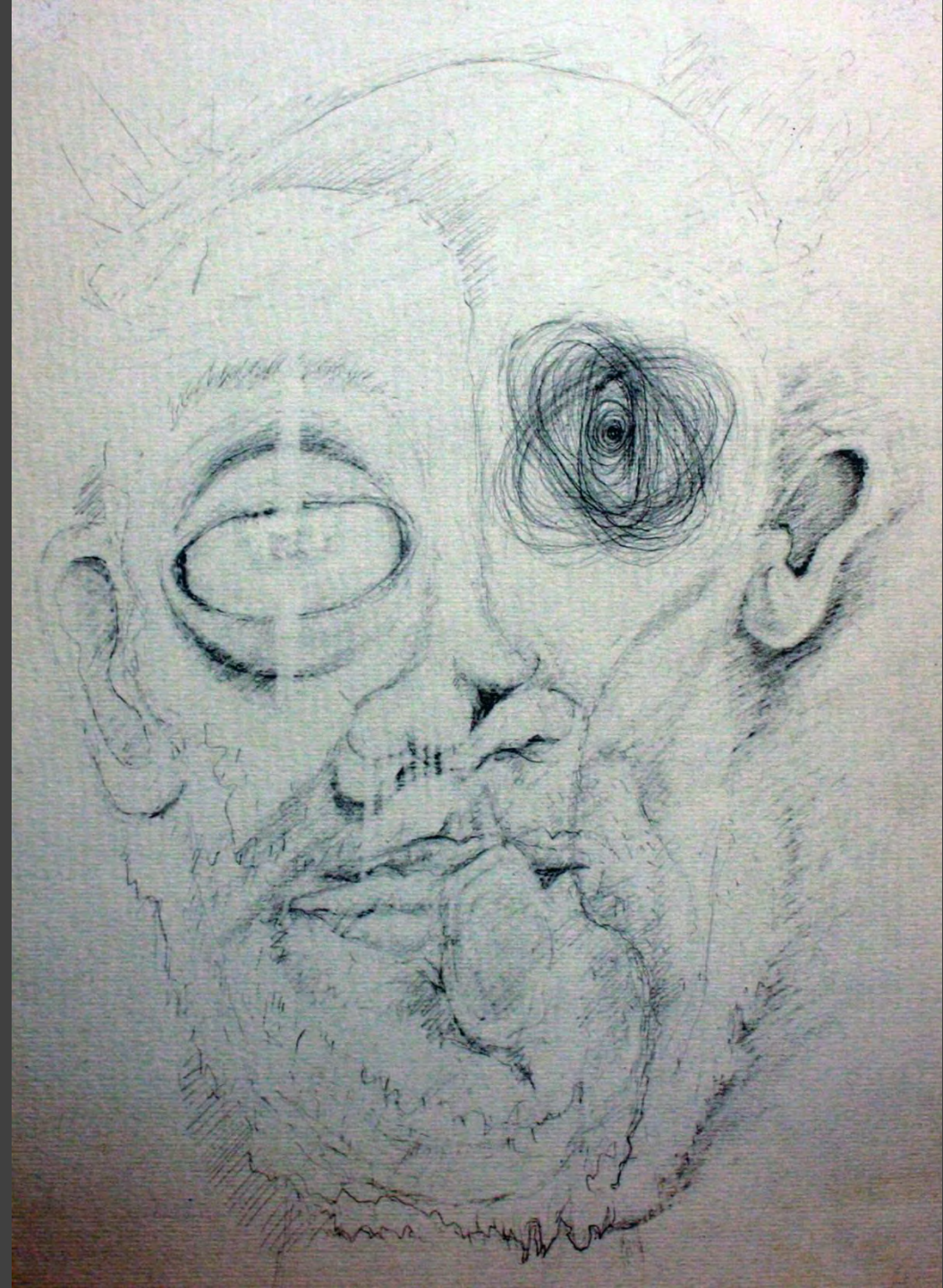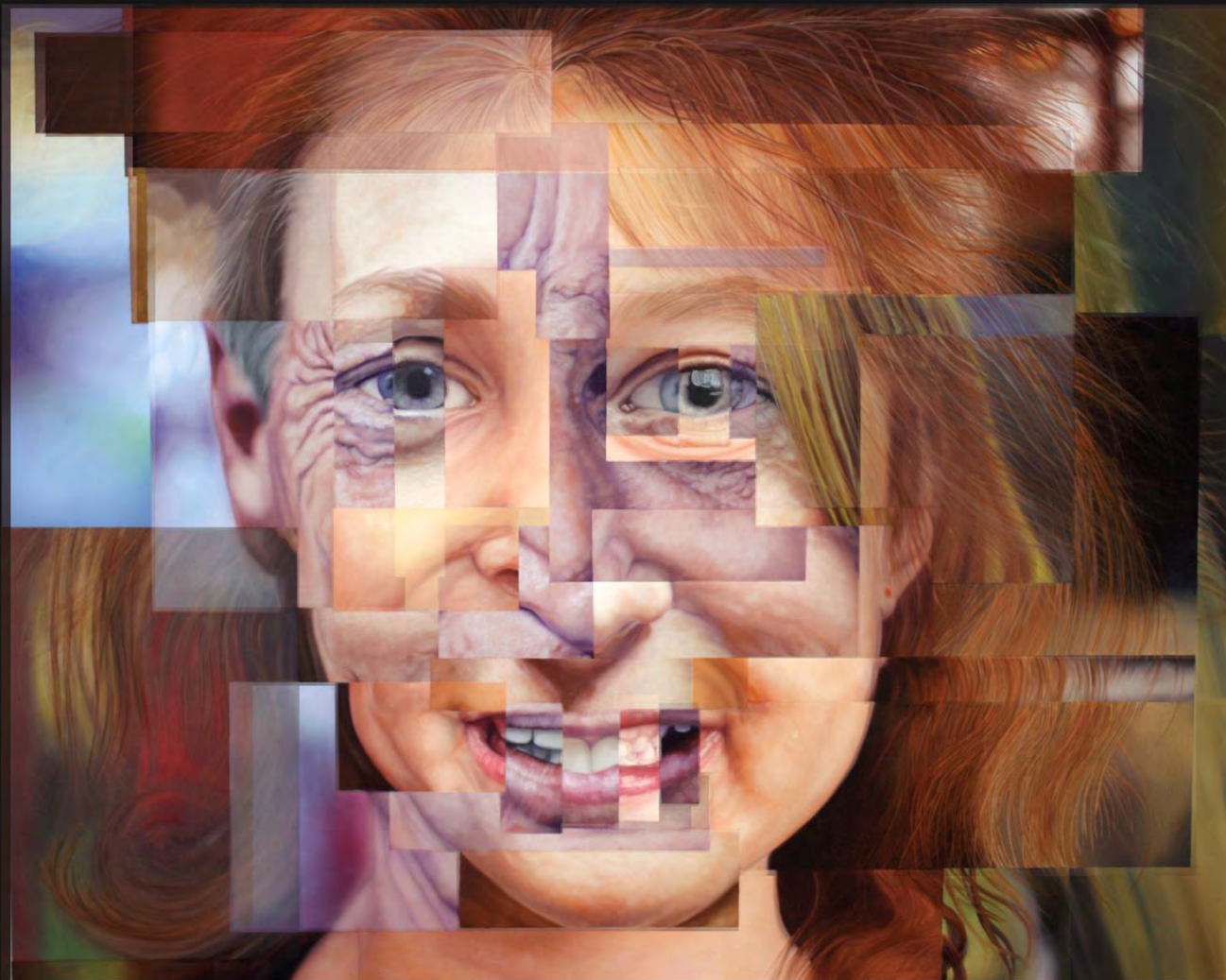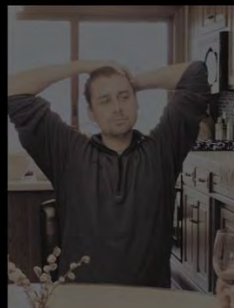
Complex Systems as k-dimensional Vectors/Cases
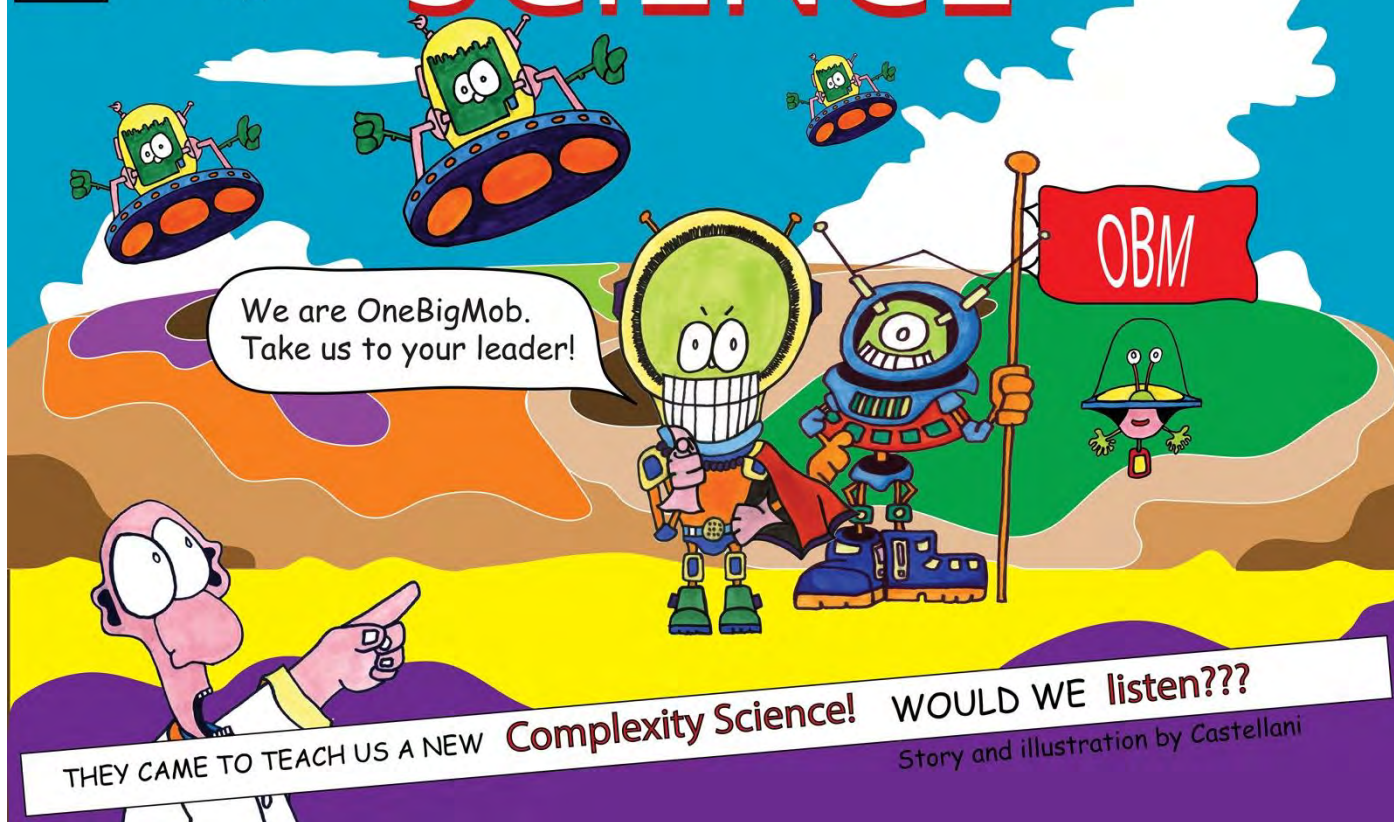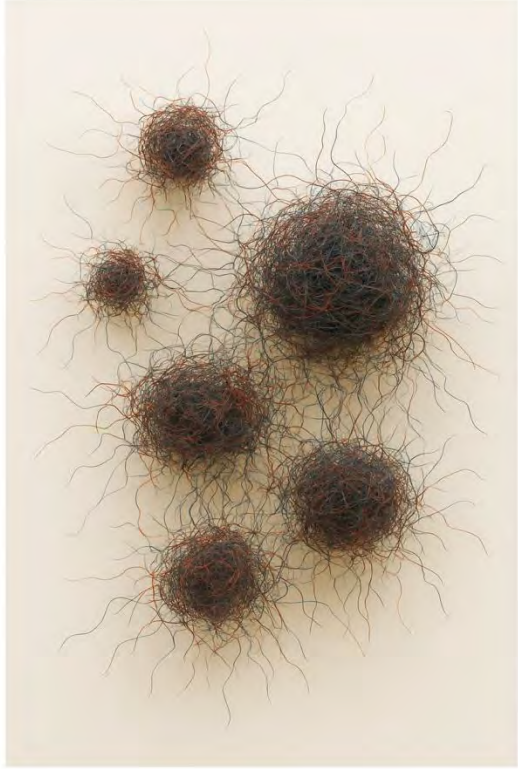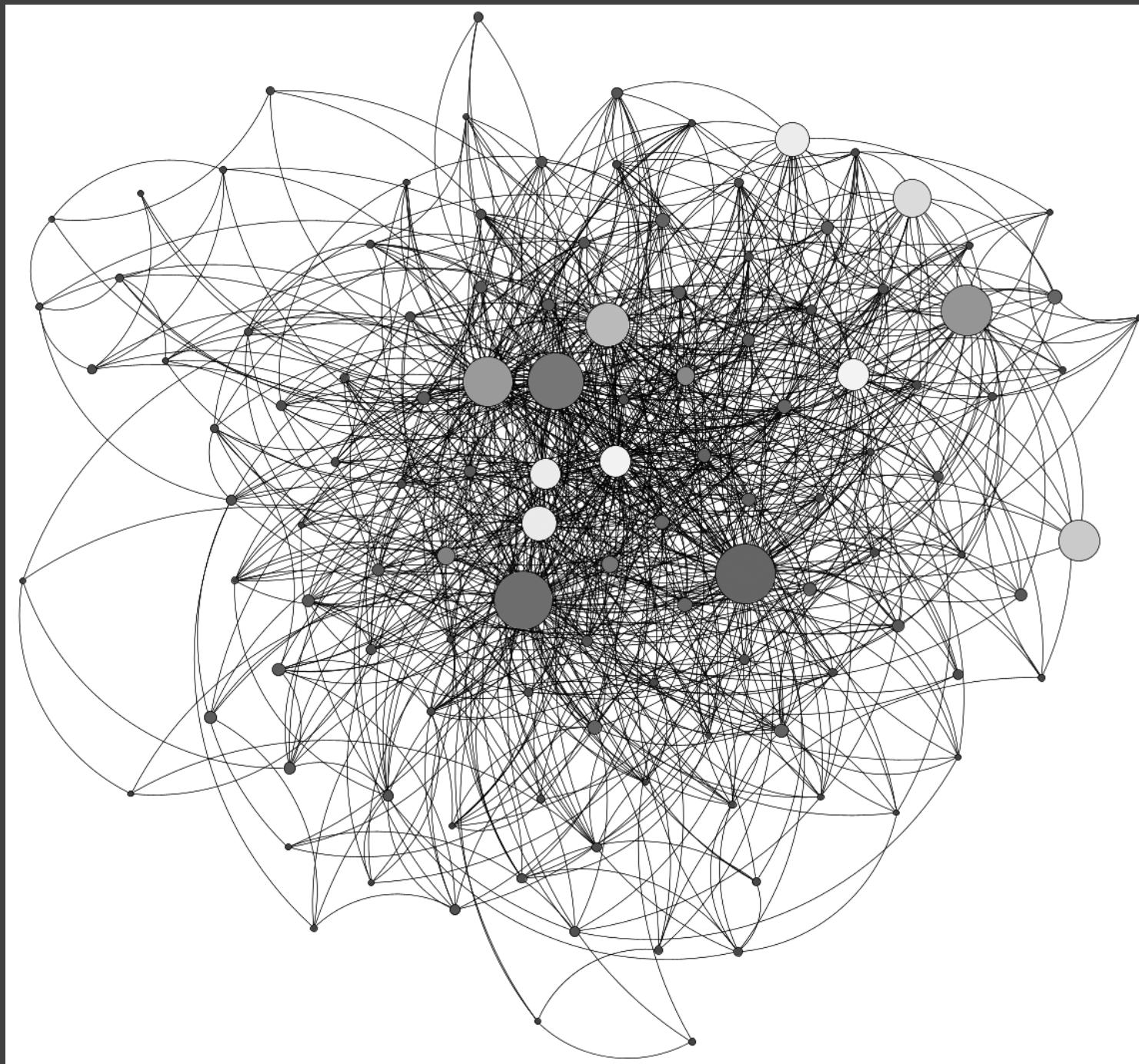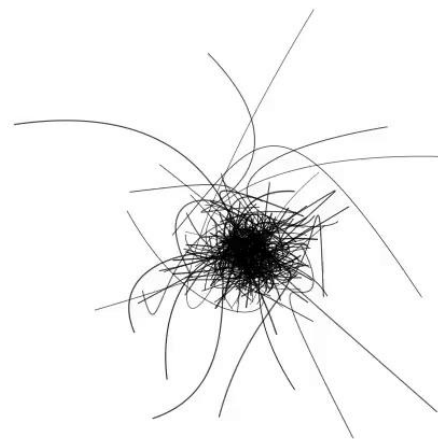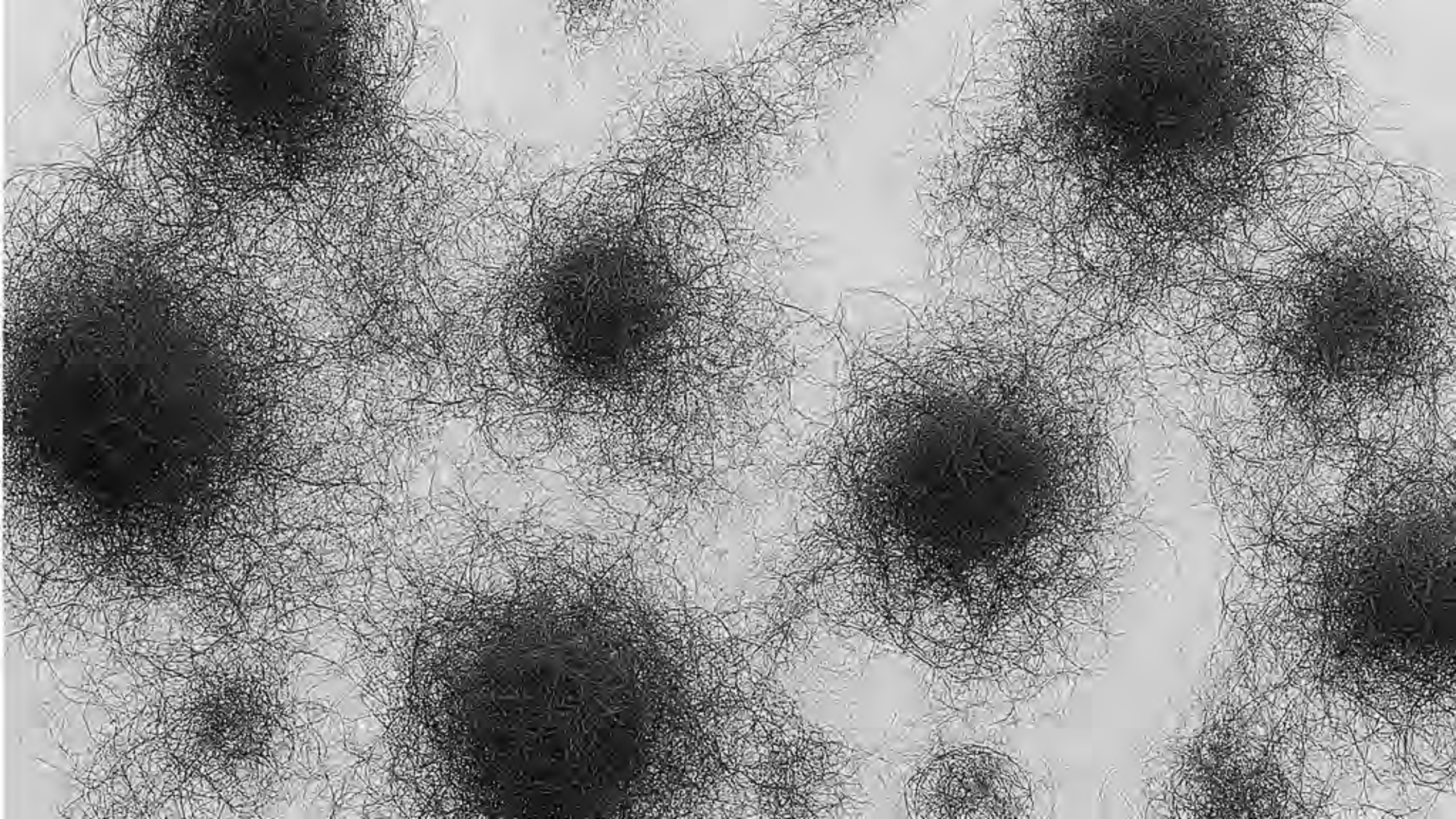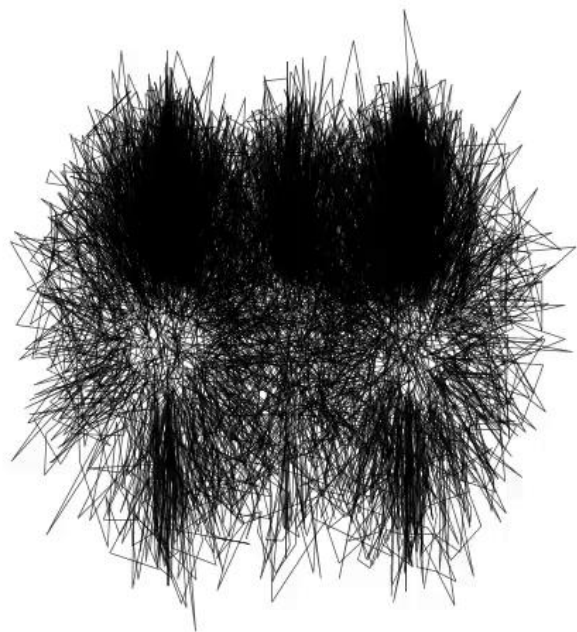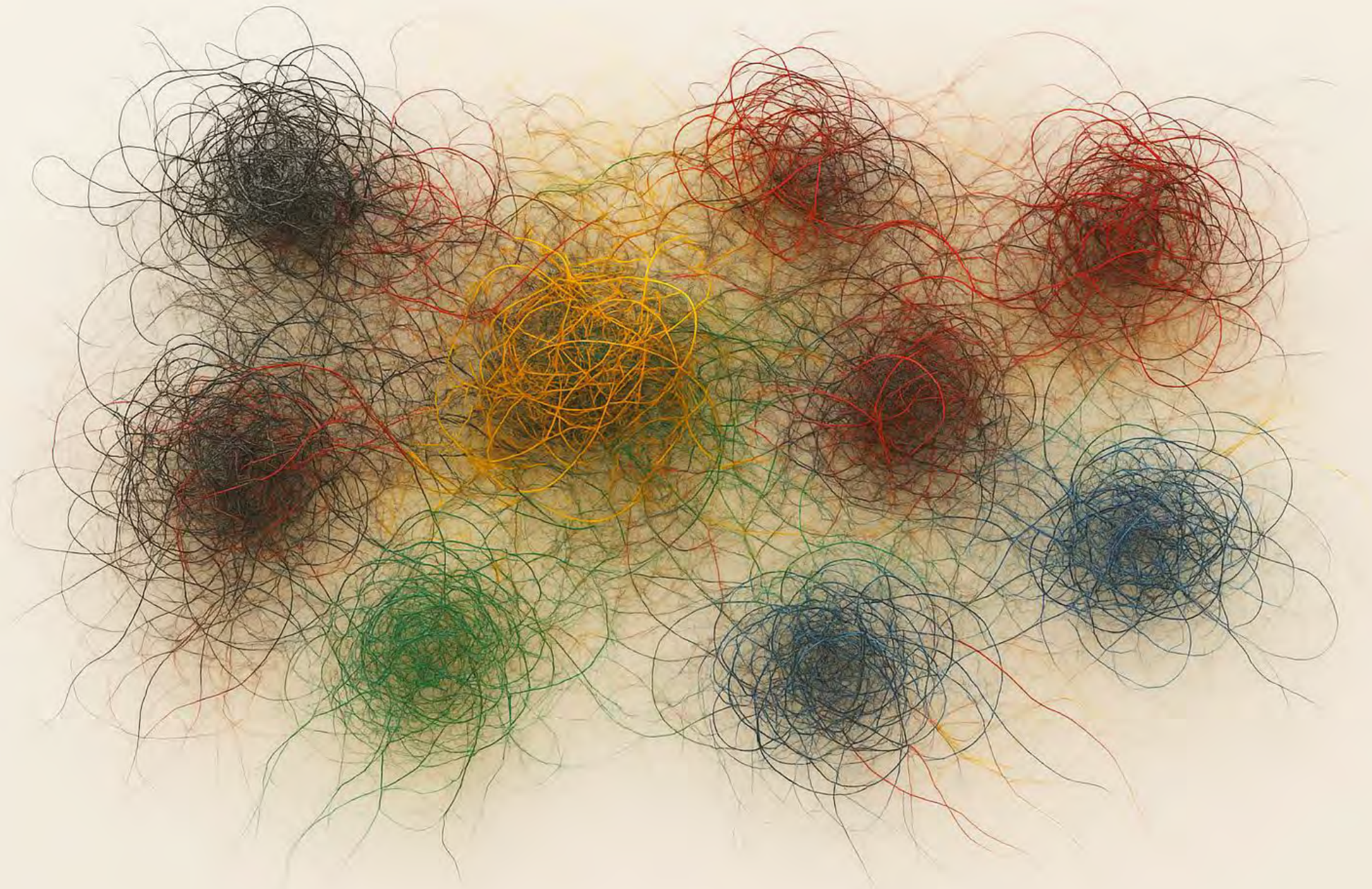
Political & Ethical Stakes

- Representation = power (Foucault)
- Flatness → analytic shortcoming & political risk
- CBVC restores conflict, inequality, embodiment
- Grounds complexity science in the humanities
- Helps to cultivate ethical imagination

Conclusion

- Sciences + humanities need not be separate
- CBVC complements CBC: analytic clarity + lived resonance
- Families of practice illustrate entanglement
- Political & ethical stakes: why representation matters
- Hybrid, participatory, pedagogical, policy uses