THE ATLAS OF SOCIAL COMPLEXITY

The Atlas of Social Complexity

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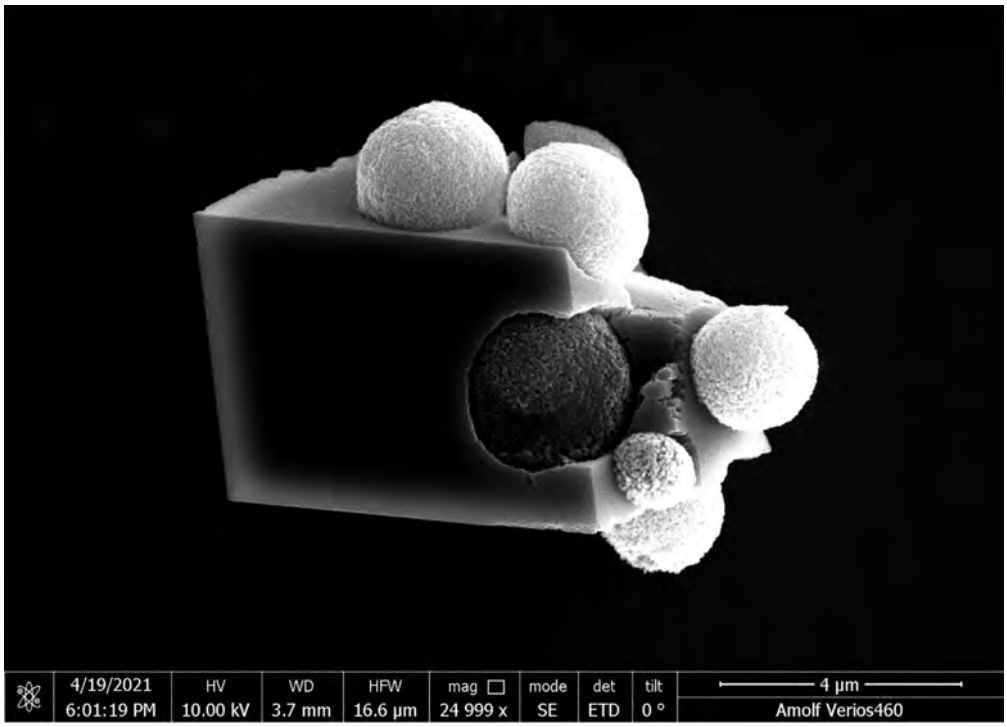

Source: Microscopic photography by Esmee Geerken (2022).

Figure 32.1 Experiments in permeability: Calcite and blood cells (No. 3)

York and Rotterdam, 2023 C.E. – The summer rain coming down on both sides of the North Sea provides a perfect excuse to hole up in our workspaces for a final push to finish this Atlas. The end destination seems perpetually located beyond the horizon. Worse, still, is how strong we are primed in bringing every voyage to a final destination, the place from which no further travel is possible or even necessary. This is silly. One of the main attractions of the complexity sciences is its open-ended, inconclusive nature; the nagging feeling that there are more lands beyond the lands we already know. Final grandstands may be theatrical but unnecessary. Instead of forcing and squeezing the wide variety of ideas discussed in the Atlas into one conclusive statement, we make the inconclusiveness the main attraction. And so, rain ticking, cups of tea steaming, and music playing in the background, we get to it.

The purpose of the Atlas is to pick back up earlier maps developed for the study of social complexity and, looking toward the future, detail the terrain beyond the current horizons to discover, and in some instances rediscover, what a transdisciplinary study of social complexity looks like. To this end, we first needed to define what transdisciplinarity entails and then the need to outline the social complexity imagination we believe vital for such an adventure to succeed. Next, we retrieved a few complexity science maps. Charting a course into new terrain

is a risky endeavour, particularly if one is not using recognized maps. One starts the trip from a known area before venturing into unknown lands. This was what the second chapter was about. We then identified 13 difficult situations in which the complexity science has manoeuvred itself, which we outlined in Chapter 3. As a final step to our first theme, we explained how we developed the Atlas. The map is not the terrain! So, we tried to come up with what we considered the 'best bet' to venture into such a new and incomplete territory. The maps in the Atlas may not be for everyone. But, as in the days of the first cartographers, it is enticing and of value to those daring travellers who choose, at the beginning of their journey, to let go of the known centres of their intellectual realm – to murder the sun, as we put it. For such travellers, uncertainty is needed, embraced and sought, as one navigates an uncharted horizon devoid of a predictable sunrise and sunset. There will be no waiting for Godot for such artisans.

We encountered a variety of people on our tour, all inhibiting different areas of the social complexity landscape. Our interviews with them were crucial to our journey's success. We spent just as much time listening to those new to the field and to those pushing the boundaries of the terrain in a disruptive transdisciplinary fashion as we did some of the more established figures in the field. What stood out for us across these interviews with newer scholars was how the *complexity turn* in social science has come to an end and is being replaced by a new movement, the *social science turn* in complexity.

The Atlas may answer questions, but crossing the terrain also means we discovered (and we hope readers did too) new questions – we are as much explorers as we are narrators. We observed the relations between objects in the realm of social complexity; what our interviewees had to say; and what directions their work appeared to be moving. We connected our observations and experiences to draw connecting lines or vectors through such an amorphous and complex space. In the process we identified four major themes – cognition, emotion and consciousness, the dynamics of human psychology, living in social systems, and methodological innovation.

It is key to remember that the Atlas represents a complex topography, a document that is in-between and influx, which attempts to capture and connect a non-traditional space. The resulting assemblage is not a grand theory or comprehensive synthesis. It is a rhizome that invites readers to be inspired to take any chapter as a starting point, and to decide on bifurcations in the narrative whenever that felt justified – to assemble one's own multilevel research agenda, and perhaps even as a team! We purposely organized the book to facilitate this form of reading and engagement. While our first five themes provided broad surveys, each chapter stands on its own, ready to be connected to whatever the reader imagined interesting or useful, relative to the work they do. A short summary of the terrains we crossed is useful for the current chapter.

The terrain we covered is rather extensive. We started with autopoiesis and cellular cognition, only to move on to the social behaviours of bacteria and their influence on the complex communication amongst our guts, immune systems and brains. Let us also not forget our relationship with the non-conscious digital machines we have created and the posthumanist world our actor-networks are creating. From there we moved on to our embodied brains. We again found the recurring themes of networks and multi-level analysis key to understanding that, contrary to a unified self, we are a universe of cognition, consciousness and emotion. Yes, let us not forget emotions, and also dreams, altered states of consciousness, creativity, imagination, and mindfulness. Let us also not forget complexity theory's triangle of structure, organization and process. Structure being the components of a system, organization being its

self-organizing and emergent outcomes, and process being the drivers of such outcomes. From such a framing, the mind-brain dualism is uninteresting.

The dualism between person and social world is another dualism that holds us back analytically. We travelled the terrains of psychopathology and the symptom network approach to mental disorders, as well as the dynamics of therapy and the value of dynamical systems theory for clinical psychology and social psychology. With the latter we encountered two key distinctions: first the complexity of psychology versus the psychology of social complexity. While the former has received considerable attention, the latter is new, seeking to understand how our human psychology impacts the complex social systems in which we live. The other distinction is between a psychological social psychology and a sociological social psychology. The first keeps us locked in the reductionist path of biology; while the latter frees us to move to the mesoscopic and macroscopic levels of human social existence, as well as embrace a much-needed critical social complexity – which open the horizon to our next theme: living in social systems.

While social systems can be studied from the outside – a hallmark of old-school systems science – the new emphasis is on understanding complex social systems from the inside, following in the tradition of sociocybernetics. This shift in focus involves a rather diverse set of research agendas focused on the complexities of *life within social systems*. It also involves interrogating social systems. Such a critical approach is grounded in concerns about power, and its manifestation across various configurations and intersections of inequality, domination and oppression. Such an embrace took us on a journey of collective/mass psychology, social networks, and the configurations of power relations and institutional arrangements in which we are situated. It also took us to various aspects of socio-technical systems, issues of governance and policy and the complexities of economics and the global economy.

From there we moved on to research methods and modelling. The study of social complexity is methods-heavy, to such an extent that technicalities threaten to dominate the field. We explored adjacent terrains by questioning the need for modelling and the ways in which models may be put to good use. We also discussed in what alternative ways one can conceive of complex causality. There are many reasons why one should put configurational methods front and centre in addition to net-additive methods. We are convinced that the dichotomy between qualitative and quantitative approaches or data is not helpful when uncovering social complexity. Instead, it is time to fully embrace multi-methods approaches, and to follow a nested, case-based tactic.

The recurring theme throughout the Atlas is our call for a *social science turn in complexity*: the need for complexity scientists to start incorporating theoretical, methodological and empirical innovations from other social sciences. The Atlas is a broad sweeping tour, but by no means exhaustive or complete. There is much more terrain to discover.[1] The remainder of this chapter is about how one can get there.

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[1] Here be dragons, still.

THE ART OF INCOMPLETENESS

The further we ventured into the new territories on our tour, the more we realized that the stretch of terrain crossed still pales in comparison to the horizon of 'needed knowledge' that sits on the edge of our understanding. The vastness of this horizon instils a distinct sense of modesty, even for those who embrace the study of social complexity explicitly. There is always more to learn and to understand. The Atlas will always be incomplete.

A traveller in ancient times may have found the type of incompleteness our maps render easy to accept. For such a traveller, any map, no matter how lacking, would have been better than no map. They would encounter enough fellow travellers and other people knowing places to get to their intended destination. Uncertain, yes, but it would have worked.

How readily do we accept the map we made today, in a time and age of near-instant and seemingly endless information? In an age in which we can monitor traffic flows in real-time, predict the exact travel time to our destination, and take stock of the restaurants and sights we definitely must visit? And yet, with all this information, an age where we still struggle to manage global pandemics or a global economy with the same impressiveness. Incompleteness may have something to offer.

In our discussions with the many people we interviewed for this book, as well as the workshops we attended and the papers and books we read, we realized that, while they appreciated a mapping of the complexity sciences, as its numerous roads and pathways helped lead them, in part, to their present standpoint, they were searching for maps of the future and the adjacent possibles that existed. Most map makers create historical maps or maps of the present; they wanted maps of the future, imbued with incompleteness and uncertainty. For them, to be an omniscient sun god was not the solution, as the true need for the journey, to find new answers, was lost. As Foucault said, there is a difference between knowledgeableness and knowing, the former being the accumulation of what is known, while the latter being about getting free of oneself to venture into new territory, to find new answers, new visions, new solutions, which, one day, will require others to break free of to find the next set of answers.

For daring navigators of the adjacent possible, the rough sketch, the blank canvas, the coding errors, the unfinished sentence, the unmoving, blinking cursor, and the unfurnished room are invitations for something new. They are the forms of incompleteness that hold the generative power to open up new trajectories within the otherwise binary-oppressed chaos of the disciplines. It is this incompleteness that kindles their transdisciplinary *social c*omplexity imagination; it is this incompleteness that invites them to move further; and it is through this incompleteness that they see new opportunities.

Still, we understand those choosing to turn away from such a project, to venture back into the known territories by which they came to such an Atlas as ours. It is only natural for social scientists to seek to lift the veil of ignorance by embracing the knowledgeableness – it affirms its standing and power. Still, for the travellers highlighted in this book, it remains equally essential that we appreciate the power and beauty of unfinished spaces. The study of social complexity, vast as it is in scope and depth, will remain unfinished business, which many of its artisans learned a long time ago. To the bewilderment of conventional map makers, the world of social knowledge is not stable, as the destinations continually shift their coordinates.

It is with this realization that we encountered a crucial paradox that those we interviewed for the Atlas have tried to solve: while the study of social complexity is in a constant unfinished flux, there is an equal desire to finish it, to set up boundaries and border checks. There

is a tendency to declare the territory finite and closed; and to demarcate between what one is allowed to do and what is considered 'outside' the study of social complexity. This is rather unfortunate because it kills the imagination that is enshrined in this scientific realm. This is an area of inquiry that, on the one hand, has wondered about such amazing things as the value of swarming behaviours for studying human cities; or exploring biomimicry to examine the similarities between plants and machines. At first sight, such questions may seem bizarre, but they are precisely the kind of inquiry that has driven us into new territories. On the other hand, however, the study of social complexity has slowly contracted inward, becoming somewhat of a normative science. In an attempt to get past this paradox, our interviewees have purposely fostered and embraced incompleteness, so that the spaces in which they work remain open and unfinished projects.

Next, we will analyze why the study of social complexity is boxed-in. Most of the chapter, however, will highlight the voices of the many people we interviewed. They talk about the ways in which they have driven themselves into unknown territories in this field. As our fellow travellers, we thought it only fitting to give them the last word, to ensure that our Atlas likewise ends as an open-ended and incomplete project.

UNEASE AND COMFORT

If the unfinished nature of the study of social complexity possesses a generative quality, it follows that a finished domain or realm is potentially debilitating to its study. Why is it, then, that the study of social complexity is subjected to so many attempts to box it in with definable borders and normative expectations? Such attempts are visible for all to see – from editorial policies and funding decisions to methodological dogmas and technological standards, and at conferences and in workshops. We suspect that many readers have experienced them first-hand.

Having said that, we are fascinated by the observation that, while most individuals do not enjoy such limits, they are collectively producing them in their day-to-day lives, and in great abundance, only to step back and watch these limits self-organize into the same type of prescriptive system they turned to the complexity sciences to otherwise escape. What drives this problem? As C. Wright Mills would say, why do people experience public problems as personal traps?

For our interviewees, many of the causes are commonplace in science and not exclusive to the study of social complexity.[2] They apply to almost any community. Luhmann demonstrated how social systems will veer towards self-referentiality over time. Incentives from outside of the system or community are felt as prompts to reinforce the existing logics, routines and reasonings.[3] Eventually, a social system will fail to see and appreciate alternatives.[4] And while

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[2] Bill Readings, *The University in Ruins* (Harvard: Harvard University Press, 1997); Andrew Abbott, *Time Matters. On Theory and Method* (Chicago: University of Chicago Press, 2001).

[3] Niklas Luhmann, *Social Systems* (Stanford University Press, 1995).

[4] Niklas Luhmann and Niklas Luhmann, *Soziale Systeme: Grundriß einer allgemeinen Theorie*, 17. Auflage, Theorie der Gesellschaft, Niklas Luhmann[…] (Frankfurt am Main: Suhrkamp, 2018). Rudi Laermans, 'Theorizing Culture, or Reading Luhmann against Luhmann', *Cybernetics & Human Knowing* 14, no. 2–3 (2007): 67–83.

they may be proficient at articulating such a process, there is no reason to assume that scientists are somehow immune to it themselves.[5] Indeed, it is through this self-referential nature and self-reproduction of (scientific) communities that differentiation into separate strands becomes real. Effectively, they become islands of lesser complexity where unstructured complexity is converted to structured complexity. Why? People are inclined to maintain themselves under uncertain and complex conditions. The social systems they form constitute selection processes that filter information for the members within the system while at the same time establishing themselves through that selection process. Selection is driven by different intersecting mechanisms: boundary judgments, communication, reproduction and semiotics.

When faced with potentially unlimited and unfinished spaces, most humans will attempt to create boundaries in an attempt not to lose themselves. Starting with the in-group/out-group mindset of humans and the campfire and extending to the castle wall and then onward to nation-states, it is all about survival. Binary situations are created: either one is within or outside of the system. Like Bourdieu's habitus,[6] membership is established by the extent to which one understands the codes, language and logics of the system. Science and its countless niches are as much subject to these dynamics as any other type of system. Although we may understand these processes, we cannot escape them.[7] Even the writing and reading of this very Atlas draws boundaries and creates dichotomies, inevitably, through the language, the symbols, and the very fact that it is a printed book[8] available via university libraries and specialized shops. Many of the people we interviewed spoke of the silos in which they found themselves, even if they considered themselves to be interdisciplinary or transdisciplinary. Silos are nothing but bounded islands of lesser complexity.

There are ample sociological and psychological reasons why humans are prone to create such islands or silos. As the world is infinitely more complex than can be processed, those proverbial islands are places that can be understood more readily. They introduce predictability because they promote repetition of the same (or similar), instead of introducing (too much) novelty. Arguably, science – like any other social system – allows for some novelty. Some of our interviewees presented it as a balancing act: stay too close to the established core and nothing exciting will happen; move too far and peers will not be able to follow you, or (worse) perceive you selling snake oil. Added to the mix is a form of risk-avoidance: positions, promotions and incomes relate to the extent to which peers perceive one as being part of the group. Not everyone can afford to stray too far from the common themes.

As illustration, let us consider academia. One of our interviewees, a philosopher of science, gave the classic 'natural science' example of the star researcher with a good idea, who builds a large and well-funded lab and receives strong institutional support and academic recognition. All of this brings new scholars to the theme, mainly because they see it as a good career move. They do their years at the institute, move on at some point and replicate its approach elsewhere. This approach to career development has a strong tendency towards maintaining the

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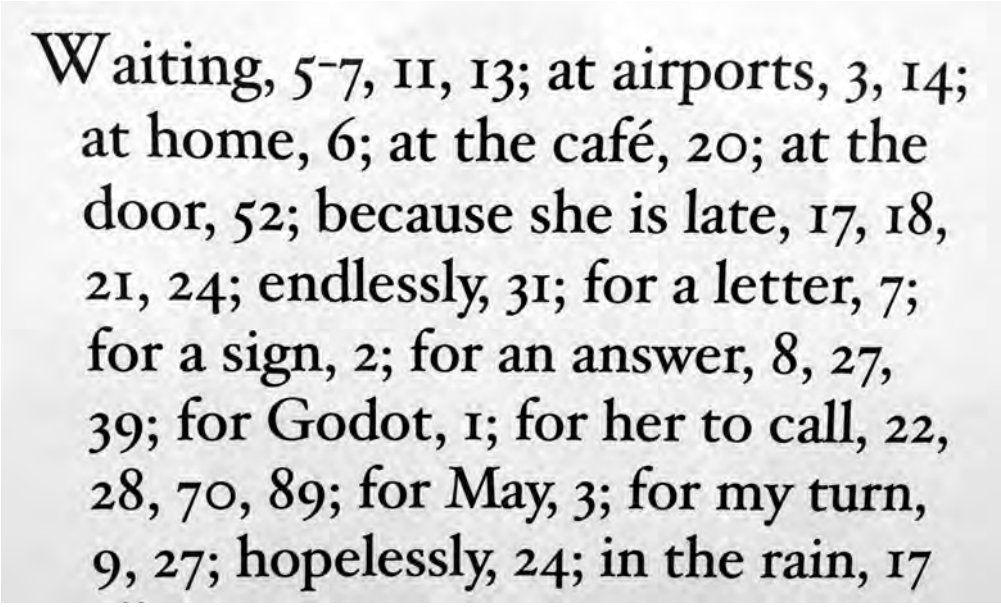
[5] Niklas Luhmann and Kerstin Behnke, 'The Modernity of Science', *New German Critique*, no. 61 (1994): 9–23.

[6] P. Bourdieu, *Outline of a Theory or Practice* Trans. Richard Nice (Cambridge University Press, 1989).

[7] Niklas Luhmann, Dirk Baecker and Peter Gilgen, *Introduction to Systems Theory* (Cambridge, UK; Malden, MA: Polity, 2013).

[8] And an expensive one at that, too. No, the sales won't make us rich.



Source: Lasse Gerrits (detail of the index photographed at an exhibition at Melly, Rotterdam – 2020).

Figure 32.2 *Alejandro Cesarco's 'Index' series (2000) consists of indexes of books not yet written and very likely never to be written by Cesarco himself. It invites the observer to imagine new storylines. This is an example of the generative power of unfinished*

status quo, as already pointed out by Abbott in *The Chaos of Disciplines*.[9] This self-referential and self-generating dynamic characterizes the relationship between individual career goals and desired institutional outcomes. It can be very hard to break away from, even if you know you are so disappointingly locked-in.

Such approaches to career and work life lead to a kind of academic speciation. It separates topics into containers – for example, agent-based modellers versus empiricists – that become increasingly constrained and closed-off and, subsequently, more difficult to interact with. Given such challenges, most people tend to veer back the moment you pull them away from their known, stable, state without providing the right kind of space for this. It is just too scary. The study of social complexity easily repels people, even those doing it, as it is too often perceived as theoretically messy, interdisciplinary, methodologically grey, hard to fund, difficult to publish, and intellectually challenging. Couple these challenges with the human need for boundaries, discipline and normative expectations and the institutional hierarchy of academic life and its baroque politics and medieval relations of power, and you have a recipe for convention. As one of our colleagues said, 'Everyone thinks academia is so open-ended and liberal, but then I remind them that we wear robes for graduation and begin ceremonies with a sceptre.'

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[9] Andrew Abbott, *Chaos of Disciplines* (University of Chicago Press, 2010).

In contrast are the artists we interviewed. They observed how academics seem to find it hard to go in directions other than the trajectory they are already on. Conventions rule. Scientific discussions regarding public health exemplify this.[10] The political and social aspects of epidemiology are highly complex and contested, also in the public space. As a result, many epidemiologists prefer to focus on conventional interventions, which they evaluate using accepted clinical or community trials, as opposed to examining complex configurations of social conditions that are place-based. Few epidemiologists dare to venture into that difficult space if they want to get funded. This is even so when using the latest advances in computational and complexity science, because it still means confronting the seemingly intractable social determinants that actually create the problem, including inequalities. However, it is exactly this kind of confrontation that is needed for the study of public health complexity and its policy and practice implications.

Contemporary conceptual art offers an alternative laboratory for exploring the utility of uncomfortable confrontations. Such art is often highly theoretical, abstract, and ambiguous in the messages it may convey. To some, a piece may look to be just a few stains on a canvas or an indistinct droning noise; their observations and reflections remaining at the surface. Others revel in the multiple ways in which art may be experienced and interpreted. The rough brush strokes leave space that one can fill with one's own imagination; atonal chords may conjure up additional melodies in the minds of the listener. What may look like random dots and lines to one person, may appear as an invitation for others to challenge their own existing repertoire. It is the ambiguity itself that has generative power. In his 1971 article, *Effects of Complexity and Prechoice Stimulation on Exploratory Choice*,[11] Berlyne floated this idea of a preference for ambiguity and incompleteness and, although later criticized via experiments,[12] we consistently found that our interviewees would often talk about how much they enjoyed working with under-defined questions under uncertain conditions. They expressed a desire to be exposed to new ideas, to be stimulated, to rethink what they were doing, and to be vigilant when repetition sets in. Some of them even mentioned boredom as the ultimate marker that a change of repertoire was in order. This may not be everyone's cup of tea. It can take years to become well-versed in a particular method or theory so the confrontation with alternative ways of doing research, which may imply that one should learn new methods and theories, can be daunting. At the same time, ambiguity and amorphous situations stimulate people to adapt their mental schemata to process new information.

The complexity sciences were always a program of imagination, as we wrote in the first two chapters. The imagination we speak to is a social complexity imagination, grounded in the insights we have outlined across the main themes. Science takes place in a living world and develops through provocation from that world. Naturally, science may be self-generating. We are certain every reader can name a few self-contained scientific niches that seem to thrive despite being insular – postmodernism is a good example, same with rational choice theory. Some of them will last longer than others, but none of them will last for a very long time.

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[10] See for example H. Rutter et al., 'The Need for a Complex Systems Model of Evidence for Public Health', *The Lancet* 390, no. 10112 (2017): 2602–2604.

[11] D. E. Berlyne and J. B. Crozier, 'Effects of Complexity and Prechoice Stimulation on Exploratory Choice', *Perception & Psychophysics* 10, no. 4 (1971): 242–246.

[12] Colin Martindale, Kathleen Moore and Jonathan Borkum, 'Aesthetic Preference: Anomalous Findings for Berlyne's Psychobiological Theory', *The American Journal of Psychology* (1990): 53–80.

Naturally, those niches also feature intense dialogues between facts and refuted causal claims, which generates new questions. However, those dialogues will grind to a halt when there is no external input.

Provocation is a necessary condition for scientific progress. Such provocation rarely comes from endless finetuning of models. It is generated through creativity and open boundaries. These are found outside of the computer desk or lab. The best moments in science may occur in galleries, on stages, in cinema's, on long walks, during discussions with people not working in academia, and whatever else that stimulates or inspires us to reinterpret the world and imagine new futures. Imagination is what separates us human beings from automatons. Humanity has dreamt of taking it to the skies. It took ages, and many failed experiments (and a few dead inventors) before a viable flying machine was created but then it was there. It was born out of a burning desire to fly, not born out of exact bookkeeping.

Of course, technological refinement progressed insights and inventions – today's planes are infinitely better than the fragile constructions built by the early pioneers. So many had a vague vision that lacked scientific underpinning in the strict modern sense of the word. Unrefined visions entice people to think of the world in different ways. Vagueness is not a problem, just as people can instantly rewire their thinking when seeing Wassily Kandinsky's abstract compositions or hearing Pierre Boulez's *Jakobsleiter*. It works for us exactly because of the fluidity, multiplicity and ambiguity of those compositions. Tinkering may follow the original vague or unrefined idea. Tinkering is important, too, in moving from imagination to reality. But technicalities are rarely the source of radical ideas. It is misguided to think that data alone can tell the story; it is misguided to think that models can fill empirical voids. It is imagination that does the work. Imagination is not a luxury or an afterthought; it is a necessary condition for science to move forward.

The complexity sciences have had the power of imagination infused into them. The field offers a novel way of seeing the social world. Our call is to rediscover that imagination, primarily by making the social science turn and grounding it in a sociological imagination. If done, anything is possible! It requires one to recast science as a broad movement of discovery using all kinds of techniques, methods and data sources: very personal experiences, paintings at an exhibition, music at earth-shattering volumes, the dance of people in crowded streets, or a final farewell kiss at the train station – whatever it takes for the reader to generate curiosity and insight.

Our interviewees did not need any prompt to talk about how the study of social complexity inspired them. It is useful to remember that the study of social complexity has the same self-selecting and self-referential properties as any other community, and it is not difficult to see that curiosity and the willingness to be challenged are psychologically core to the people attracted by the outer territories of the study of social complexity. Which takes us back to the paradox above: as individuals we are drawn to the study of social complexity because of its non-final status; as a community we put up borders and walls to delineate this territory from other territories that are, presumably, considered less relevant or applicable. Not everyone in the study of social complexity operates according to the principles so richly described in the literature. A social complexity imagination seems more challenging for some advocates than it needs to be. Is it not somewhat curious that one would write a single-authored text on the importance of swarm behaviour? It seems that the practice of enacting a transdisciplinary social complexity imagination has some intriguing gaps. How do our interviewees deal with all this?

RHIZOMES

> Let us summarize the principal characteristics of a rhizome: unlike trees or their roots, the rhizome connects any point to any other point, and its traits are not necessarily linked to traits of the same nature; it brings into play very different regimes of signs, and even nonsign states. […] It has neither beginning nor end, but always a middle (milieu) from which it grows and which it overspills.[13]

A moment of realization came when one of us was wandering through an Asian megalopolis, a sprawling and continuously evolving urban space that has come to mark the urban nature of the twenty-first century. Like some architecturally inspired Escher creation, the metro station morphed into an underground mall, with access to the hotel lobby cramped between the shops, a gaming hall, and a series of elevators that could take people to the restaurants and gym above, which then in turn gave access to a pedestrian bridge across the roads down below and into the apartment block, with its in-house convenience stores and bars. The built environment as a rhizome, a tensor forever extending in all directions and to be crossed in whatever order feels best. Every crossing taken; every door opened leads to new worlds and stories. Lucid urban dreaming, almost feverish. Those doors and elevators and hallways, streets and bridges, create pores into the urban fabric that invite the traveller to go in any direction.

The epiphany that these undirected and amorphous spaces can open and link in any random order transfers easily to the crossing of the known and unknown terrains of the study of social complexity. Multi-level thinking multiplies into *n*-dimensional tensor spaces to become a *rhizome*. The social complexity imagination and its networks, all layered and intersecting, one with the other, become rhizomatic. This is the nature of the study of social complexity many of our interviewees proposed going forward. As Deleuze and Guattari state:

> Unlike the graphic arts, drawing, or photography, unlike tracings, the rhizome pertains to a map that must be produced, constructed, a map that is always detachable, connectable, reversible, modifiable, and has multiple entryways and exits and its own lines of flight. It is tracings that must be put on the map, not the opposite. In contrast to centered (even polycentric) systems with hierarchical modes of communication and preestablished paths, the rhizome is an acentered, nonhierarchical, nonsignifying system without a General and without an organizing memory or central automaton, defined solely by a circulation of states.[14]

PERMEABILITY AND PORES

Embracing the rhizome map, our interviewees highlighted the need to become porous and to create permeability so that their work spaces, which are at risk of becoming delineated, could become unlimited again. This is not a kind of general handwaving that ‘we need to cut through silos’, or whatever other cliché there might be. It is about taking concrete cues on porousness from the people we interviewed, from the literature, and from our own experiences.

As a (unfinished) space, the complexity sciences appear to have created hard borders or walls. Those limitations are mental and social. These don’t need to be solid and impenetrable. They can be made porous, permeable. We can find our way around or through them. Structures

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[13] G. Deleuze and F. Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia* (Bloomsbury Publishing, 1988), 21.

[14] Ibid., p. 21.

Source: Lasse Gerrits (2018; 2010).

Figure 32.3 *A thousand plateaus in the built environment: Kyoto (undirected, multi-entry and exit, rising above) and Rotterdam Blijdorp metro station (directed, singular entry and exit, subterranean)*

are only permanent if we declare them so. One of our interviewees, the Dutch artist and earth scientist, Esmee Geerken's work on permeability (see Figure 32.1) exemplifies how one can deal with the walls or borders that bracket the study of social complexity. Those walls are there for a reason: they create predictable spaces that many people are comfortable with, as discussed above. This desire for stable and predictable space must be honoured. For Geerken, the walls can stay. The key principle here, instead, is to foster permeability, to create pores: openings through which matter passes through a membrane. Any individual can try to set the conditions for such openings to be created. It is a task we may ask from others but must also pose to ourselves: to become pores or membranes between different worlds.

Being intellectually porous is highly useful, as it links to Latour's purposed tension between networks and spheres. In both instances, there needs to be an inside and an outside, but the walls do not need to be airtight or closed. Instead, they need to be an open-ended complex system. From the autopoiesis and eco-immune systems we discussed in this Atlas to symptom networks and psychopathology to globalization and social mobilities, porosity (be it operational or structural) is a key feature of how complex systems stay alive and healthy. Of course, it is not always discussed in such terms. If the study of social complexity is to remain alive and healthy, it requires that its artisan community continually work to keep it porous:

while working in our various arenas, and with the walls we create to do so, we have to ensure they remain permeable and leaky and spongy and absorbent to both the smaller and larger systems. Such porousness also requires regular critical inspection for the ways in which our pores become clogged or shut down, cutting us off from the vital oxygen needed to keep us intellectually alive. This can be our metaphor for transdisciplinary work, then – that which is done porously.

THE TERRAIN NOT YET GRASPED

The unfinished space is intimately connected with a fondness for the terrain not yet grasped. Our interviewees were univocal about their reasons for seeking out to explore the world of social complexity: a strong curiosity for the unknown lands behind the known terrain. To most, the study of social complexity offers a break away from the conventions that govern their own fields and institutions, as if the study of social complexity is simultaneously the new terrain and the gateway to that new terrain. These new terrains called to our respondents, as one interviewee stated, to 'a real engagement with the most basic stuff; the sources of structures, the sources of order', which 'comes as a relief in science'; as they 'can open the black box of actual causes and can help to solve it' and 'offer useful new tools to study social phenomena beyond their disciplinary framing'; and give access to 'the conceptual world beyond the primary expression'.

The study of social complexity also seems to have an aesthetic appeal, a beauty that seems inherent to theories and visualizations that can be found all across the literature. There is a willingness, a desire even, to move forward because there is the possibility of 'finding something mysterious, new', because it is 'an antidote to the deadlocks that societies keep themselves in' and because it 'feels right intuitively, even though it is hard to achieve in every-day practice'.

Access to this new terrain can be surprisingly hard, especially when one considers how driven the people we met are. There are the common barriers faced whenever one tries to do something different. In academia, these range from having to publish in a select group of monodisciplinary journals, to not having enough time to reflect on the world, to lacking an appreciative audience. In policy and practice it ranges from the politicization of almost everything to the intractability of the global issues of pressing concern. In the sacred halls of neoliberalism, such barriers include suggesting anything outside of growth. In the arts, barriers range from commercialism to fitting with the latest trends to placate galleries. Before even getting to the 13 situations, there are very real forms of structural barriers that make doing something different sometimes very difficult and with clear consequences for one's career. This is particularly so when intersectional factors such as ethnicity, gender, sexuality, political position, and socioeconomic status enter the picture. The people we interviewed were not pollyannish about any of this.

But that is only half of our interviewees' story. In terms of the *via positiva of the social complexity imagination*, the fact that the study of social complexity is thriving more than ever, and that it is no longer a minority interest, speaks volumes about the ability of people to somehow make it work. Never give up! Our interviewees felt it necessary to challenge the binary-enforcing narrative where we, as individuals, who seek to achieve something new or different, are somehow always the 'other' going against everyone else who is 'trying to stop us'. It is unproductive and reductive. Many of the people we met while developing the Atlas

demonstrated the same view: they were moving toward (as opposed to away from) what they sought to think. It all left us very optimistic about the future. Driving themselves into these unknown territories, they have created for themselves 'a productive struggle' (a term that was used many times) that challenges their own ideas. Indeed, it was deemed pivotal by many interviewees that one keeps challenging oneself. Instead of relying on the same idea time and again, people with a social complexity imagination seem able to challenge themselves, cast the world around them in novel ways, and to improve their own ways of working.

This social complexity imagination can be achieved in many ways – for example, it can be achieved through a willingness to engage with qualitative studies from a background of quantitative work because of an intuitive understanding that the countable world is a partial representation of social complexity; or through the understanding that the nature of the question determines the theories and tools to be used instead of reframing the question to match familiar tools. Progress is also achieved by thinking of things that do not exist yet, which is as much about creativity as it is about craft. The artists we interviewed all nonchalantly mentioned how often they would try out something and then discard it again. The creation of something – a sketch, a text, sound art, a performance, and all the other things they make – is part of the discovery, a steppingstone into the unknown territories. Their output is as much a process as it can be a product.

As with so many other aspects in life, there is no quick-fix or shortcut into social complexity imagination and the embrace of incompleteness. One cannot just sit down and expect such transdisciplinary creativity to emerge all of a sudden.[15] It takes persistence and the ability to adapt. We observed an important work habit similar to jazz artists in the practices of the people we interviewed. On the one hand, they advocated the need to reinvent oneself, to break-away from existing thoughts and routines. On the other hand, they talked about how they got better by continuously working on their craft: doodling, fiddling, scribbling, tinkering, observing, talking and listening, experimenting, writing, and programming. Indeed, it all 'starts with good craftmanship,' one interviewee said, so the ability to understand theories and operate the tools does not negate the ability to reinvent oneself. The Dutch physicist and complexity scientist Peter Sloot calls the people working in our terrain 'competent rebels': 'They know what they talk about, but they also fight against themselves to understand something better.'

Intuition is also often mentioned as important in understanding complexity. Intuition emerges. It cannot be forced, and it can only be trained in indirect ways – craftmanship and an intuitive understanding of social complexity are somehow related, we believe. But with enough space to breath, intuition may drive creativity.

What we are witnessing here is emergent science. People try to get the conditions such that novel insights can appear. The constant tension between the familiarity of known ways of working and thinking and the draw of new terrains moves people irreversibly forward. Something novel learnt cannot be unlearnt. Hysteresis ensues. As with any complex system, there might be tipping points toppling individuals from one state to the other. Irreversibly, yes, and expect resistance. We love showing how driven our explorers are, but we do not want to

[15] In very much the same way that buying an expensive guitar won't make you a good guitarist, or a switch from Windows to Linux doesn't make you a good programmer.

shy away from also discussing the personal crises that came along the way. The constant push into unknown territories comes with a price.[16]

Quite a few interviewees recalled moments of despair and stagnation. They would start projects without ever having the time to push them through. Few of them remained in the field in which they were trained. They moved into other disciplines – sometimes by design, sometimes more or less accidentally, as they took the only job on offer at that time. This speaks volumes about their adaptability, but the moves are often driven by a sense of alienation and lack of recognition in the original field. Similarly, quite a few of them regularly travelled between different worlds altogether: from science to consultancy or arts, from businesses back into academia, and many other such journeys very similar to the pedestrians crossing the horizontal and vertical planes of Osaka's city centre. They lamented to us about the closedness of a singular intellectual world and how they tried to find a solar system elsewhere. They talked about how it was key to establish new interdisciplinary partnerships, but also about knowing when to stop working with people who were closing down their social complexity imagination. Yet they were not unrealistic: several discussed how they have had to leave behind complexity projects they loved working on because they needed a job, or there were families to raise and mortgages to pay – again, issues of gender, ethnicity, sexual identity, ageing and location were key factors.

Adventurous people can get into interesting places but the ability to travel around, mentally and physically, comes with the need for some very hard decisions. Creation and destruction go hand in hand. Irreversibly moving forward. That is why, for us, we adopt the *Anselm Strauss one-third principle*. Strauss was an American sociologist, known for creating the grounded theory method with Barney Glaser and for his work on symbolic interactionism, negotiated (processual) ordering and the sociology of health. Like so many of the people we interviewed, Strauss' adventurousness meant that he spent the majority of his career outside his primary discipline, working instead in the School of Nursing at the University of California, San Francisco, where he founded the Department of Social and Behavioral Sciences. In an essay he wrote to honour Strauss, Glaser (1991) outlined the things his friend and colleague had taught him about collaboration and, more important, the intellectual life. One of these lessons Glaser called the *one-third principle*. When we go to share our work with the world, Glaser notes, 'One third will read our work and love it. One-third will dislike it and criticize it according to their own canons. And one-third will simply ignore it. But one-third favorability among colleagues is ample for career and recognition and for attracting students and friends all over the world'.[17] It is this dictum, we believe, our interviewees seemed to embrace, and one we feel worth suggesting to everyone.

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[16] To this we would like to add: academic work is hard and can be soul-crushing. Over the years, we learnt that this must be discussed instead of being glossed over. The scientific endeavour is not helped by people saying, 'you'll get used to it', or 'it is part of the deal'.

[17] See Glaser's chapter (p. 21) in A. L. Strauss and D. R. Maines (Eds.), *Social Organization and Social Process: Essays in Honor of Anselm Strauss* (Transaction Publishers, 1991).

ORGANIZING EMERGENCE

As much fun as it is to read about individual geniuses changing science single-handedly, the reality is that all of us operate in large ecosystems that, we hope, will be conducive to our own practices. (Team reading this book, as an example.) A very small number of cases notwithstanding, most of us operate within contexts that have a marked influence on how we perform as individuals. Emergence and entropy are as much a matter of organizing that context as they are about an individual's personal approach, that is: emergence can be fostered within an individual but also in groups and within networks of groups. Naturally, the same complexity principles of organization apply here as much as they do in any other social phenomenon.

It is again instructive to draw on arts. To understand how jazz music is created, Sawyer[18] analyzed the ways in which performers interact to allow the music to emerge. Jazz has building blocks that are known. They are the basis for improvisations that give rise to genuine musical novelty, a form of collaborative emergence.[19] The important bit here are those basic building blocks that, while known, are combined and re-elaborated to create this novelty. This is a few steps removed from 'anything goes', even if it sounds like that. Musicians know those building blocks and skilfully play with them during the performance. Sawyer also points out that a knowledgeable audience can play a role in the performance because they can follow the emergent music and appreciate its novelty. An audience without that knowledge can still enjoy the music, of course, but the receptiveness is enhanced when one understands the processes driving the creation. This is the same with other forms of art.

What we have here is a group of skilled people, that use those skills and knowledge to put known things into different sequences and into different configurations to create new terrains in conjunction with an audience that understand what is going on. We deliberately phrase it in generic terms because we believe that there are no essential differences between emergence fostered in the arts such as jazz, and in science. The expressions differ in form, of course, but the mechanisms driving this emergence are just the same. The obvious question is, How and to what extent emergence and entropy can be organized in terms of collaboration within our wider, all-encompassing systems?

Many innovation studies demonstrate that novelty does not come out of thin air but instead is driven by the ability to recombine existing elements such as routines, organizational structures, technological artefacts, and many more. This is something observed everywhere: in the urban, in technology, in organization and administration, and, well, everywhere else. Here we wade back into the territory of Actor-Network Theory: the networks that are being reshuffled encompass human and non-human actors and elements. But while necessary, a recombination of those existing elements is not sufficient for novelty to emerge. Stacking a lot of similar items together creates a warehouse instead of a laboratory. The key principle is to develop transdisciplinary configurations of heterogenous elements that can create novelty. Groups are more likely to be creatively successful when the members work together with members

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[18] R. Keith Sawyer, 'Emergence in Creativity and Development', *Creativity and Development* (2003): 12–60.

[19] R. Keith Sawyer, 'An interdisciplinary study of group creativity', *The Nature of Human Creativity* 280 (2018).

that are not like them.[20] As some of our interviewees pointed out, creative contests between different ideas are good and even necessary. Homophily, while perhaps efficient in production of output, rarely leads to genuine novelty. From this angle, the complexity sciences are a great avenue because of how its theories and methods travel from one field to the other.

Of the people we interviewed, Peter Sloot has the most immediate experience with organizing a place that fosters emergence. He headed the Institute for Advanced Study (IAS) at the University of Amsterdam. As fellows of the institute, we experienced first-hand how important it is to enter a new space of possibilities.

The reasons why IAS has become an intellectual refuge are many. For starters, it brings people from very *different backgrounds together*. It demands from them to be open-minded and to be willing to listen to other viewpoints. It doesn't demand immediate returns, be it publications or grants or practical solutions. Nice if that happens but it is not the goal. It provides a free space where seemingly impossible questions may be asked, without pressure, and experimentation is encouraged. It takes time. Sloot knows that having different people in one physical space is only the beginning. They will not understand each other at first. It is only through repeated meetings over a long period of time that they start to see in what ways they can complement each other. Most academics tend to dig into (technical) details while the purpose of the conversation disappears in the fog. IAS was set up to first ask for the goals to be achieved, and then to work backwards towards what is needed to get to the goals. In Peter Sloot's own words: 'The willingness of disciplines to work together is always there but one needs to start with the final picture. Discussions about details can be done later. I don't start with details because people get lost. The depth of thinking of all disciplines is actually really good so that [the final picture] is what I want to focus on.'

The *setting* is important, too. IAS offers an informal, accessible space. Peter Sloot was clear that this space should be delineated and porous and should encourage people to admit that they do not know things; and even the things they do know they do not know. No posturing, no showing-off: all members hold small pieces of the answers to the complex questions and the challenge is to put those pieces together in a sensible way. There is ample time for people to develop and express ideas, and to experiment with what they had found in their collaborations.

Another important aspect of such places is *the space to listen*. Most people, not just academics, are notoriously poor listeners. If they listen, it is to find an opportunity to interject and wedge their own opinion into the discussion.[21] Listening is a real skill that must be mastered for creative spaces to emerge. Peter Sloot believes that complexity is much more about asking the right questions than about coming up with final answers. One must understand why other people are asking their questions in the way they ask them.

Listening is obviously something that an individual can train to do, but it is also something that *must be fostered in collectives*. It can be organized. One of the IAS fellows, resident artist, Orion Maxted argues that academics should invest more time in collective thinking as a practice, to see conversations as performances with others. Moments of breakthroughs come from listening and observing a situation intensely and for long periods of time. It is important that the listener tries to collect as many vantage points as necessary. Everyone has a mental map of the situation, but it is important to distance oneself from initial assumptions. In his own

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[20] Mathijs De Vaan, David Stark and Balazs Vedres, 'Game Changer: The Topology of Creativity', *American Journal of Sociology* 120, no. 4 (2015): 1144–1194.

[21] The infamous conference evergreen 'This is more of a comment than a question.'

words: 'Stay open enough to let your inner network build up these different vantage points, this kind of priming on a subconscious level. Don't grasp for the first thing that comes into your mind because that is something you already know. You need to see beyond what you already have, to move beyond the local optimum. Be open. It takes time and trust to go into what feels nonsense or what feels uncomfortable or what feels like something that you do just for the sake of doing it. The mind is very good self-organizing mechanism, it can create all kinds of new things.'

It is important to leave unfinished spaces. People try to speak in complete sentences. Orion Maxted: 'There is no need to be complete right from the start. Unfinished sentences give room for others to add, change it – in a very emergent kind of way. Rhythm is important, too, being on time, on the beat. If you are, it doesn't matter what you say – the rhythm preserves the collective more than that people worry about their own contribution. A shared mental accordance state for collective intelligence can invoke an almost hypnotic state that opens up to new ideas.'

These examples from Maxted demonstrate that the complexity sciences have strong performative aspects in that they require the continuous creation of unfinished spaces. In practical terms, it requires longevity, and mental and physical space. It asks for judgment to be postponed and for intuition to come to the fore. It calls for experimentation for the sake of experimenting. In other words, it asks for slow science.

Spaces that allow for this, such as IAS, are rare but not unique. Another example within the complexity sciences is the famous Santa Fe Institute, which some of the interviewees also attended. Such places offer a refuge from the treadmill life of academia. As heavenly, almost unreal, as those places may seem, they are just as contested as any other intellectual place. They need to prove themselves and are subject to external pressures. As so much literature emphasizes: institutions come into being, adapt to changing circumstances, morph and perhaps dissolve at some point in time.[22] The Santa Fe Institute, for all the impact it has, also needs to develop and sell commissioned knowledge to sponsors. Likewise, the Institute for Advanced Study must continuously prove its utility to the University of Amsterdam. If all spaces are contested, it follows that the space of permanent unfinishedness is the one that is created through transdisciplinary interaction amongst people. Bricks and mortar help, but it is even more important to develop listening, intuition, curiosity and reflexivity as group capacity. Indeed, the *social science turn in complexity* requires engagement with other fields.

BECOMING TRANSDISCIPLINARY

Calls for non-disciplinary research are plenty – it is almost established rhetoric by now[23] – but it is challenging to achieve when one gets down into the details of actually doing the work. It is as much an individual stance and skill as it is an organizational question. The key might be in understanding that it is more about *becoming* transdisciplinary than about *being* transdisciplinary. It requires one to not only combine and integrate different theories and concepts and

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[22] R. Nelson and S. Winter, *An Evolutionary Theory of Economic Change*, digitally reprinted (Cambridge, Mass.: The Belknap Press of Harvard University Press, 2004).

[23] Thomas Jahn, Matthias Bergmann and Florian Keil 'Transdisciplinarity: Between Mainstreaming and Marginalization', *Ecological Economics* 79 (2012): 1–10.

methods, but it also requires an engagement with the wider societal environment. This is challenging. Any system has a degree of closure that determines the difference between being-in-it or being-out-of-it. The social sciences, with their impenetrable jargon, confusion of tongues, methodological tribes, and unwritten rules about whom to pay tribute to, can come across as a mighty fortress – even to other scientists. Those things also characterize the world that is not science. Policymakers, for example, also indulge themselves in lingo and are just as sensitive to hierarchies as are scientists. Likewise, consultants. Is it genuine? Is it snake oil? Who can tell? Theoretical notions aside, how is transdisciplinary research enacted?

As we saw above, many of the interviewees travel between different domains. While somewhat anecdotal, we seem to note a persistent pattern of self-selection: intellectual travellers feel at home in the complexity sciences in general, and the study of social complexity in particular. They are drawn to the complexity sciences because it is a space for travellers. One of the interviewees mentioned how he was trained in physics but moved into sociology as he grew critical of how social complexity is approached from physics. Another interviewee moved back and forth between philosophy and psychology, while yet another one went from art school to a master's and PhD in palaeontology, and back to fine arts. Quite a few travelled back and forth between academia and practice. With very few exceptions they weren't originally educated in the complexity sciences but came across it accidentally. Unplanned encounters at workshops, conferences, in lectures or in advisory practices with people using the complexity sciences created bifurcation points in their careers. One interviewee recalled how he had joined a small discussion club when at the university where he did his PhD research. The main topic was self-organization. Naturally, they started discussing the works of Luhmann, and Maturana and Varela on autopoiesis. At the same time, there was a mathematical discussion about synergetics. One member recommended him to talk to Herman Haken. He was hesitant at first, not directly seeing how synergetics could be useful for psychology, but he went anyway. This was a breakthrough in his understanding of the mind.

In many examples, the complexity sciences helped our interviewees to articulate their unease with the fields in which they were trained – from heterodox economics to urban and spatial planning to social theory, among the many examples. The textbook explanation for the draw of the complexity sciences holds that they offer a unifying language that allows people from different backgrounds to communicate and develop otherwise unrecognized ideas. The current Atlas shows that this is indeed a promise that brings people to this space but that this unification is an unwanted distant pipe dream, given the importance of incompleteness, porousness and difference.

Transdisciplinary research is hard. More than knowledge of the complexity sciences, it requires a willingness to deal with questions to which there are no straightforward answers.[24] Many of our respondents said that it is pivotal to start working from the logic of the phenomenon instead of framing things first in terms of a particular method, technique or theory. Understanding urban complexity, for example, requires knowledge from (among many) sociology, planning studies, political science, geography. Other interviewees found out that their questions required methods and theories from other fields, so they taught themselves to work with those. As one interviewee said: 'I look at the substantive research questions first, and then

[24] For example, most of the social sciences.

I use whatever I need to answer that question. Could be DNA sequencing or anthropological observations, anything that helps me getting closer to understanding what is going on.'

Contemporary science is so specialized and complicated that no one can master all techniques and theories. More than doing it all by oneself, our interviewees pointed at the importance of collaboration. Here we can close the loop in this chapter: cooperation between disciplines to achieve transdisciplinary work requires listening, first and foremost, which is facilitated in unpressurized and unfinished spaces (and, by definition, generates such spaces). It confirms findings elsewhere about the conditions that foster transdisciplinary research.[25] It is hard, but it can put together different pieces of the puzzle: physicists with a good theory in search of data, and social scientists with data looking for a good theory, and data scientists with computational tools searching for targeted explanations, and advisors that know how complexity plays out in the unpolished, muddy reality of day-to-day practices.

BECOMING EDUCATED

What about education? There is a near-universal desire to see the complexity sciences and transdisciplinary thinking being taught broadly at universities. Some of the interviewees are doing that already or have managed to smuggle some complexity stuff in existing courses. There is a strong argument that one should teach complexity at a much earlier age, as exemplified, for example, in the Center for Ecoliteracy, Berkely, California.[26] Children can have an intuitive understanding of complexity, but contemporary teaching is not always helpful in fostering a social complexity imagination. Naturally, it would start with observations of the world in which children move, not with mathematics or complicated jargon. This is not (just) intellectual indulgence. It is of pivotal importance that people grow up with an immediate, intuitive understanding of complexity so that they do not fool themselves into thinking that society's hard questions can be solved through easy solutions.

The people we interviewed working on practical applications recount how much effort it takes them to get policy makers and advisors to understand some of the core concepts of the complexity sciences because they first encounter them in their professional life. Many people often have an intuitive feeling for complexity but need to cut through the conventions they learnt themselves (and through the jargon of the complexity sciences) first before they can rediscover that intuition.

It might have become somewhat easier to teach complexity in higher education, as more and more of complexity's core concepts and methods are absorbed in mainstream literature. In a global survey, Ivanovic and Gerrits[27] identified 108 programs worldwide teaching the complexity sciences in the realm of political science and public policy and administration. Most, but not all of them, were taught at the master's level. While the survey was limited in many ways, it is indicative that complexity can be taught at university programs and that students find it attractive enough to sign up for it.

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[25] Scott E. Page, *Diversity and Complexity* (Princeton University Press, 2010).

[26] https://www.ecoliteracy.org/about.

[27] Nevena Ivanovic and Lasse Gerrits, 'Teaching Complexity in Public Administration across the Globe: An Overview', *Complexity, Governance & Networks* 4, no. 1 (2018): 10–18.

Yes, they find it attractive but challenging and bewilderingly complicated at times. Courses must be designed such that they are coherent and consistent, and offering a cumulative learning experience. Complexity's universe is too large to be covered in full in a course and offers too many entry points to warrant a singular narrative to be taught in classrooms. Students desire to understand the utility of something they must learn. Complexity is hard to grasp if people don't know what to do with it.

In our own teaching, we like to start our courses with practical examples, usually counter-intuitive observations that demonstrate to the students that alternative answers need to be sought. Alternatively, we sometimes start with a success story, an application of some of the central concepts and methods from the complexity sciences that demonstrate the added value of thinking and working with those concepts and methods. The examples must travel well across the classroom. This is especially important if the courses are attended by students from various backgrounds. In courses on urban planning, we noticed how a certain example worked well for students who had already followed introductory courses in planning theory, while other students (e.g., from urban sociology) couldn't relate to those examples. Of course, these differences are nothing unusual in classrooms. Much teaching is about bridging different understandings in one room. The point here is that the complexity sciences may offer something of a unifying language, but that this is not obvious when someone walks into a course on the topic for the first time. Examples that cover multiple perspectives into one narrative are therefore very much needed. This grounds the narrative of the course. Next, one can ask: 'What is your domain? How are things done in your domain?'

In general terms, the study of social complexity focuses on the intersection of human issues. In the context of higher education, this means that students need to be 'un-disciplined'. In turn, that requires students are well-versed in a discipline first before entering a course on social complexity. Many of our interviewees pointed out that the study of social complexity requires some craftmanship as a foundation to build on. This resonates with our own experiences in classrooms. The value of complexity thinking shines in contrast to other theories and methods.

Inevitably, unlearning comes with the anxiety and uncertainty that we described elsewhere in this chapter. This uncertainty may be compounded by the fact that students also need to graduate and move on in their professional lives. Complexity's unfinished state might be fascinating to many people, but students still must get their grades and diplomas so they may be less captivated by this constant work in progress. We can't fault them for that, so we engage in a delicate dance that, on the one hand, celebrates this unfinished state, while still rewarding students with reasonable grades on the other hand. The classroom can be a place for creative struggles and tensions but always needs a form of resolution to avoid turning students nihilistic. Of course, there are not many clear-cut answers in the complexity sciences, but we have experienced how even discussing some of the core principles – such as self-organization, emergence, path-dependence, hysteresis – can already lead to insights and the feeling that one has made gains. For example, we may not be able to tell (yet) under what conditions certain forms of self-organization give rise to certain spatio-temporal urban structures, but we can discuss how the principles of self-organization work. A full solution to urban problems it might not be, but it will deliver the satisfaction of having achieved a deeper understanding.

Given the vastness of the complexity sciences, the study of social complexity cannot be taught in one course. It requires a careful set-up of subsequent courses or modules that slowly,

step-by-step, build an arc from abstract concepts to applications.[28] A single, stand-alone course might appear as an interesting niche topic, but a sustained learning experience requires courses (note the plural) to be related and properly anchored in the wider curriculum.[29] It also requires a mix of different teaching forms. With a topic as complex as this one, there is no substitute for classical teaching ex-cathedra to get students to a common basic understanding of the core concepts. From there, one can experiment with different teaching techniques. As real-world applications resonate strongly with students, the focus should be on such applications. 'The risk is that complexity remains on an abstract, theoretical, and conceptual level, which significantly hinders learning. Using different kinds of exercises, such as simulation gaming and deliberative forums, students not only begin to grasp complexity better, but they actually *get to operate within complexity*.'[30] Workshops, in various forms, are often mentioned as a technique supplementary to lectures, for example using dialogues, case studies and visualizations.[31] We have experimented with reverse classrooms and Problem-Based Learning (PBL). PBL was introduced in the curriculum of the medical school at Maastricht University in 1976. At its core, it presents a small team of students with a real-world problem that they then need to diagnose and develop solutions for.[32] As a teaching method, it performs very well in bridging the gap between theories from the complexity sciences and practice.[33] It requires a targeted effort, of course. The technique alone is not enough. Whatever the setting, the teacher should act as a bridge, a mediator,[34] between abstract theory and real-life phenomena.

Teaching complexity means being open about the blanks in the landscape, such as its silence on values, ethics, power and inequality, to name but a few.[35] This does not always sit easily within the heavily optimized curriculums of higher education, and also doesn't look great to students expecting quick and easy manuals that contribute to their employability. We understand. And yet, it is the incompleteness that one must celebrate. We remain adamant that the study of social complexity remains an open, unfinished space, but we also understand people working in practice when they ask for clear guidance, easy to read books and websites. As one of our interviewees said, there is a massive gap between formalized complexity and what happens on the ground. She experiences this as almost impossible to bridge in practice. Books and other guides can definitely be useful but we should also invest in tools that foster imagination and intuition. While the study of social complexity may be hard to comprehend at

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[28] For example, Wolf (2018); Jazy (2018) {Citation}.

[29] Harri Raisio et al., 'Teaching Public Administrators and Leaders to Handle Complexity', *Complexity, Governance & Networks* 4, no. 1 (2018): 80–91.

[30] Harri Raisio et al., 'Teaching Public Administrators and Leaders to Handle Complexity', *Complexity, Governance & Networks* 4, no. 1 (2018): 88.

[31] For example, P. Cingel, 'How to Educate Navigators in a Complex World: Making a Case in Higher Professional Education in The Netherlands', *Complexity, Governance & Networks* 4, no. 1 (2018): 19–31.

[32] H. Maurer and C. Neuhold, 'Problem-Based Learning in European Studies.' In S. Baroncelli, R. Farneti, I. Horga and S. Vanhoonacker (Eds.), *Teaching and Learning the European Union* (Dordrecht: Springer Netherlands, 2014) 199–215.

[33] L. M. Gerrits and M. Wirtz, 'Teaching Complexity by means of Problem-Based Learning: Potential, Practice, and Pitfalls', *Complexity, Governance & Networks* 4, no. 1 (2018): 32–45.

[34] H. Raisio, A. Puustinen, P. Vartiainen, J. Lindell and S. Ollila, 'Teaching Public Administrators and Leaders to Handle Complexity', *Complexity, Governance & Networks* 4, no. 1 (2018): 80–91.

[35] K. Morrison, 'Educational Philosophy and the Challenge of Complexity Theory', *Educational Philosophy and Theory* 40, no. 1 (2008): 19–34.

first, thus asking for structure and clear guidelines, we should be cautious that we don't force people to only colour inside the lines.