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Thinking Complexity

Sayfan G. Borghini

Humans are an aggressively and impressively transformative force and thinking itself is by all means a part of this continuous performance, a stage in the transformation of matter and life, interlaced with the forces at play. What follows is an improbable story and a serious attempt, drawing on current scientific views, to lay the grounds for repositioning the way we perceive complexity – from a disturbance in the linearity of our understanding and agency to a main actor in the story. It highlights in a few strokes the roles embodied by complex phenomena in the development of the very possibility for an evolved organism, such as the human, to comprehend the universe around itself, and act upon it in a significant fashion. The frameworks aggregated on the journey provide a perspective to reconsider current challenges at the level of social complexity.

1. Introduction

In our interaction with the world around us, we uphold the central belief that the human mind is able to comprehend the universe. This thought and collective enterprise of knowledge extraction and composition, which pictures the human as a cogent agent, has accompanied humanity since the birth of natural philosophy and possibly long before then. At the basis of this ability to rationally understand and describe the universe lies the abstraction of causality, namely the ability to determine how one event or process contributes to the production of another. Through the lens of causality, we are endowed with explanatory powers in regard to the processes around us. The effort to abstract general rules and underlying principles supports our ability to predict future events on the basis of past readings and adapt our behaviours accordingly. Thus, causality, whether implicitly or explicitly, holds a central place in our perception of how the world progresses, and of our place in it. Across the centuries the explicit formulation of causal perception has repeatedly morphed between the two extremes of necessity and chance, of determinism and uncertainty, of design and chaos, between a strictly knowable yet pre-determined future, and an uncertain yet open future.

With the unfoldment of the scientific method, the principle of causality has been explicitly formulated into the foundation of the scientific endeavour of knowledge production. It has provided the foundation for the initial aim of the scientific paradigm, that of developing a unified theory of everything. The synthesis of Newtonian mechanics, around 300 hundred years ago, completing a full century and a half of scientific revolution, provided the first materialisation to the human capacity to significantly capture and predict the world around us.

The description of the unperturbed observer as its main reliable witness was instated, while its language was deemed mathematics. Newton's synthesis provided a first explicit formulation of causality as universal physical forces in the language of mathematics, by actually establishing mathematics as the most efficient knowledge generation system, which from then reigned supreme (Glattfelder, 2019) bringing our scientific endeavour in explaining the physical world close to a complete culmination towards the end of the twentieth century. The achievements it yielded need no superlatives, they are at the basis of our civilization might.

The formulation of causality inherited from Newtonian mechanics is centred on universality, causal reducibility and deterministic development of initial conditions, or in other words it is centred upon predictability and repeatability. The particular conception of Newtonian mechanics in science has evidently been further expanded, complemented and challenged across the last two centuries, to begin with, by the introduction of statistical causes and probability logics, which limit knowledge at the level of macroscopic observations, and more recently, by the introduction of inherent uncertainty as to what can be measured at the microscopic quantum scale. Yet its image of clear machinic workings has been absorbed in our language as a synonym of the possibility of control, of planning and designing outcomes. It has become part of how we experience our influence, and the influence of others in the world. Knowing the cause of something, beyond endowing us with explanatory powers, allows and justifies effective intervention. Causality is deeply correlated to the way we perceive our agency in the world, and, specifically in all areas that involve planned interventions, linearity has been strongly emphasised and favoured in our communication, by the belief in efficient explanations.

Yet, the overall concept of linear causality, and the consequent reduction to primal causes together with the search for simplicity, are not compatible with fundamental aspects of life. All expressions of organised complexity, such as biological life and social dynamics, and the way they are characterised by interdependence, contingency, self-organisation and emergence – thus inherent uncertainty and novelty – are not accommodated by this formal structure. Our main milieu of existence, life and its collective dynamics escapes simple explanations. Today the understanding is growing that while complexity is everywhere in our world, from the way our brains operate to the dynamics regulating the development of our cities, 'formal thought systems exclude the complexity surrounding us and contained within us' (Wigner, 1960).

This apparent inconsistency begs the question: is complexity a recent phenomenon in our lives? Surely its impact and relevance became more undeniable with the recent development of humanity into a global civilization. The increasing complexity of our societies can be read in terms of growing connectivity and interdependence, reinforced by the continuous development of technology. (Bar Yam, 1997). Today we see that even systems that were designed to be fully controlled, such as planned urban settlements, energy production processes and communication systems, have grown excessively complex and show unexpected consequences we could not possibly predict, nor would we have chosen (i.e. social injustice, health hazards, misinformation, radicalisation to mention a few). These are instances of catastrophic failures that illustrate our loss of direct control in the face of emergent aspects in complexity.

The inability of our formal descriptive tools to accommodate complexity is an important reason as to why it was kept till now at the periphery of our knowledge in almost all areas of research

(Weinbaum, 2015; Mitchel, 2009; Morin, 2005). Advancing studies of complex systems across numerous disciplines are bringing forward updates, new tools and paradigms to model complexity, yet the integration of new thinking frameworks into our cultural paradigms is still in the making. The updating of thinking to our current best understandings, though seemingly abstract, is a fundamental requirement for survival. We are constantly forming our models of the world and act upon them both as individuals and as societies. We shape our lives, craft policies and build strategic plans based on them. This is valid at multiple levels, from the mathematical models we interrogate for policymaking to the mental models we used to predict and decide our next moves, to the metaphors we daily employ in our languages to communicate and make sense of the world we share.

What follows is an improbable story and a serious attempt, drawing on current scientific views, to lay the grounds for rethinking the way we perceive complexity – from a disturbance in the linearity of our understanding and agency to a main actor in the story. The story highlights in a few strokes some of the roles embodied by complex phenomena in the development of the very possibility for an evolved organism, such as the human, to comprehend the universe around it and act upon it in a significant fashion, a position that demands a reformulation of the way we perceive causality and its link to control and agency.

2. Yet, it flows

Raising our eyes to the sky and attempting to comprise them as a canopy for our understanding, is probably a first daring act describing humans' aspirations across nearly all ancient societies, a daring act that is still quietly lingering in the telescopes of today. Yet, where Newton and his contemporaries saw the marvellous similarity of the universe to a perfectly designed clock, constructed of bodies in repetitive motion on a frame, today we see immense scales of flows and change, bringing about an increasing level of organisation and complexity. An increase in order, which comes with complexity rather than simplicity.

Observations probing ever deeper and further in space and time show we are part in an expanding universe. Most importantly, from the standpoint of current cosmic models, existence in a universe in expansion means the existence in a universe that is not homogeneously in equilibrium. Differences in energy emerge and are amplified with expansion in the cosmic landscape, and it is these differences that drive immense flows of energy and matter, and ignite transformative processes (Chaisson, 2001). From a hypothesised, totally unstructured beginning, the universe is slowly evolving into a higher level of order, which becomes manifest over immense spans of time, specifically in the form of galaxies, stars, planets and eventually, life (Chaisson, 2001). What is being reconstructed today from observations far beyond our galaxy is a huge network of flows of intergalactic gas, spanning the immense distances of galactic super-clusters (Tylly, 2014). Upon such a network matter flows and transforms at high energy. Dynamic patterns, easily recognizable, such as galaxies, emerged in critical sites within the flows marking earlier stages of self-organisation. They are dynamic structures that organised to dissipate the huge concentrations of energy, while allowing its passage, and that are still drifting with the flows connecting them. Rather than the fixed points of reference, and mechanic perfection summoned by the idea of a deterministic sky, our gaze is diving into slow and incommensurable rivers shaping the very organisation of the matter we are made of. This view demands to look further into the question of how the increasing level of organisation and order comes about.

3. Powering complexity in the physical world

Everything in the universe has energy. Molecules in the cup of coffee on my table are jiggling around, bumping into each other, dissipating heat – their activity is not cohesive. The random motion will not organise by itself to push the molecules flowing out of the cup in a defined direction. Yet, if a gradient is accessed – for example by tilting the cup in the presence of gravity – the overall game changes and coffee will rush downward along the gradient. A gradient describes a field of differences, the rate of change that is generated and maintained by a variable quantity – i.e. energy, temperature, or even smell, sound. A landscape of peaks and valleys in the presence of gravity can be described by a gradient, differences in height upon which water flows from higher points to lower ones. In the presence of differences, the energy that was initially non-cohesively jiggling around and could not power any process becomes 'free', powering particles to flow over the gradient. Intense flows can indeed destroy and erode formations, but also, in a non-intuitive way, they can power organisation, increasing order.

This is a different kind of order from the static image we may hold in our metaphors of well-arranged systems. We usually understand order as a result of static, low energy and equilibrium structures, whereas here we are in the middle of intense flows. The difference is visible for example in the appearance of a whirlpool at the bottom of an open bathtub. This is a recognisable and rather ubiquitous structure in turbulent flows, resulting from the gradient produced by removing the plug. It is a resilient structure (disrupt it with your finger and it will reappear) that we can easily differentiate from its environment and describe as more organised, yet we cannot physically grab and move around directly. These dynamic structures do have basic autonomy from perturbations in their environment, yet they exist only as long as flows of energy and matter are powering them. Prigogine was the first to describe and define such self-organising phenomena, taking place far from equilibrium, as dissipative structures, demonstrating how they present us with a process akin to order out of chaos (Prigogine, 1979, 1984). The ordered patterns emerging are dynamically steering flows of matter into structures that express overall higher efficiency in processing energy and material flows (Georgiev, 2013). They are the result of positive and negative feedback loops driving reciprocal adaptations among the particles and elements composing the emergent system, (Heylighen, 2001), for example adapting and modifying the trajectories of water molecules to minimise constraints to motion into vortex-like whirlpools. One can think of the whirlpool in water as a simple example of these dissipative structures, echoed by the more complex and unpredictable hurricane and by the vast spiralling galaxy. The way connected feedback loops amplify and inhibit behaviours in these systems can make causal reasoning extremely difficult and impossible to break down to individual causes. Examples abound in the physical world, and among them, notably, an abundant number of autocatalytic chemical reactions where chemical reagents, when fuelled by adequate flow of reactants, operate on one another to produce one another, self-maintaining the reaction in time. All such processes, in contrast to static equilibrium structures, which exist in isolation from the environment, are open systems; they are coupled with the environment because they need a continuous flow of energy and matter through them to continue to exist. They can even grow their complexity when pushed beyond particular thresholds, increasing further the possibility for unpredictable and unknown behaviours. Thus, one may say that landscapes of flows are underlying circumstances powering complexity.

4. Emergence and novelty

Most interestingly from the standpoint of this discussion, while growing in complexity, these structures present emergent properties. What this means is that novel behaviour emerges at the global level of the organised structure that seems much more complex than the behaviour of the parts (Holland, 200). The behaviour cannot be reduced to the properties of the components alone nor can it be predicted from their study. The wetness of water is novel in relation to the properties of its components, hydrogen and oxygen. The macroscopic patterns emerging in sand dunes or the climatic phenomena emerging on our planet cannot be predicted by observing the components alone. These global behaviours depend on the interactions among the components and together with the environment. They depend on how the components are organised and how they interact among them, rather than resulting from simply adding up linearly the properties of single elements. The universe acquires new qualities and properties via emergent evolution, as well as whole new levels of organisation displaying new behaviours.

A spontaneously occurring level of complexity binds the constituting elements in a new whole, a system, constraining their activities, while increasing the capacities of the system in relation to the environment. These constraining conditions select and refine in time the most relevant interactions for the maintenance of the emergent level and redefine the type of phenomena at play in relation to the environment. The new level characteristics cannot be derived by the lower-level characteristics. Articulated in other words, novel structures, rules and laws in systems emerge at new levels of organisation (Georgiev, 2016).

We must consider such far-from-equilibrium interactions as having generative properties – the ability to generate unanticipated and potentially open-ended behaviour – via the emergence of whole levels of increasing complexity. In this sense chemistry is not applied physics, and biology is not applied chemistry. Though the laws of physics remain generally valid, they are not significant to describe the ongoing dynamics in the new levels of organisation. One may say indeed that our body is made of atoms, this though, does not explain why our body is ageing nor why the one of a particular specie of jellyfish is immortal. To decipher this, we need to identify regularities that are relevant at the far more complex level of the organisation of life.

5. Life and the ascent of autonomy

Going back to the example of water flowing on a gravity gradient, and focusing our attention on the unique case of a stream, provides us with a way to emphasise the leaps in organisation and complexity. A flowing stream allows different substances to dissolve into the water and interact among them, creating a chemical environment that is rich in complex molecules, depending upon circumstances. In this environment on our planet, we find a radically new type of highly organised phenomena, unicellular life. Such microorganisms are still mostly made of the same water and macromolecules, but the water now is confined within a defined boundary – a membrane – where chemistry can be regulated, thus embodying a whole new spectrum of possible behaviours. By selecting a particular type of chemistry, along billions of years, these microorganisms have mastered a number of metabolic routes. These are dedicated channels of energy flows that power the organism's own subsistence, mainly channelling chemical energy. Internal fine-tuned circumstances are maintained, so that these metabolic pathways can take place, and organisms can regenerate their internal organisation against fluctuations, at least to a point. What we are observing is not only self-organisation but self-construction, the honing of a complex dynamic of autonomy that is unique to living systems (Maturana, 1980). Such systems are able to pursue increasingly more autonomous purposeful activities. They are able to manipulate structure (both spatial and temporal) to increase local order and reduce environmental uncertainty. The system is clearly constrained by the environment, yet not defined by it; it can produce different responses to the constraints it encounters.

In the same river we meet a diversity of multicellular organisms. They belong to a further level of organised phenomena. A fish is still partly made of the same water and minerals present in the river, and it is also a community of a multitude of cells. Yet these cells are now fully coordinated, differentiated and integrated, around internal energy flows, and they are associated into uniquely dedicated organs and bound into a greater autonomous organism with even more formidable capacities. The fish is less bound by the direction of the stream, for example, and it can actively pursue its source of energy in the water (possibly another fish). Moving our attention to the shore of the river, a lizard exemplifies how this same water and minerals, and these corporated cells, can wonder outside of the stream, on land, away from flowing water. A full new daring level of autonomy. Growing along the banks of the river multiple networks of roots and branches are extracting water, partly transforming it into biomass and elevating the rest toward the sun radiation and the resulting temperature gradient, where it evaporates in great amounts. By so doing the river contributes to wide cycles (circular flows) of water in different phases, which at the widest scale of full ecosystems and planetary cycles takes part in perpetuating flows. Water does not only flow down the gradient on the landscape, it also circulates back up to replenish the flow. Of course, the wide new level of organisation we are observing is not anymore water and minerals. The emergence of a global new level of organisation, coordinating multiple organisms with physical elements and dynamic structures in the environment, allows to redirect flows and to recirculate resources. Life, vast networks of organisms in relation with their environments, harvest and process resources, releasing them back to the environment in their available state, and maintaining material flows on physical gradients.

6. Evolution versus decay

To realise the power of such phenomena, we can look at the planet from a thermodynamic perspective. Earth is a physical system of finite resources (other than asteroids not much matter goes in and out), immersed in a continuous flow of energy – sun radiation. From the standpoint of the second law of thermodynamics, it could simply heat up and dry away till disintegration, and it would make perfect sense. Instead, what we see is how one source of energy – the sun – is being sucked up, transformed, recirculated and redirected, until it powers an enormous variety of organisms and ecosystems, nested one within the other, and finally radiates back as heat. These cycles take over the dynamics of a whole planet so that its finite resources (water and other chemical elements fundamental for life) might be continuously replenished along the flows. Our marble planet, under the energy-radiating bulb and its delicately organised flows, seems for a brief moment to break the universal tendency towards disorder. Life indeed feeds the opposite trend, the one of increasing organisation, initially delineated by the case of self-organising structures and here expressed by more and more complex organisms in interaction, and it feeds it with more distinct variety and growing autonomy – a grandiose escape, if momentary, from the inevitability of thermodynamic decay. Seen from this perspective, being (and remaining) a live organism on this planet, whether an amoeba or a human, demands wide amounts of life infrastructure. All scales of life are involved in the perpetuation of circumstances favourable for life. Any known living being, cannot exist but in the context of a global network of similar systems (Ruiz-Mirazo, 2011). Earth is at the moment the only locus of life that we know of in the universe.

The apparent conflict between structures that evolve and structures that decay introduces the big question of how the dynamics of life do control complexity, rather than succumbing to it (Pattee, 2000). To be clear, life is not in breach of thermodynamics, on the contrary, it can be described as an extremely efficient way to dissipate energy coherently (Chaisson, 2001), which is still in line with the second law on the universal timescale. Yet, at our scale this is once again a very general and loose-fitting description of life; it doesn't tell us anything about its diversity, the billions of species distributed from the micro to the macro and their unique rules of interactions. To better understand, we must look at life as a whole new event in the cosmic becoming, with its own logic and rules.

7. Bio-logic worlds

Looking at biological life, in its vast and flabbergasting variety, Darwin realised a new law of interaction becoming evident at this level of organisation, which he called natural selection. Organisms, and humans among them, are not exactly free to do as they please with energy; they need to survive in an environment of finite resources, and any new change they introduce in their dynamic organisation needs to be well adapted to the environment and the overall network of organisms that co-inhabit it, or perish. The resulting complex dynamics of evolution describes the process by which the variety of living organisms develops and diversifies from earlier forms, increasing overall complexity along history.

When we look at the universe from this newly earned standpoint, we still see of course the interaction of energy and matter and the increasingly complex dynamics of self-organisation. Living systems build and actively maintain most of their own boundary conditions (regulating input and output of energy and matter), making possible a robust far-from-equilibrium dynamic behaviour. Yet, information, its transfer and processing, singular and collective, are paramount here, being foundational to life and its control of complexity. Any organism needs to incorporate in the way it is organised the information gained from interacting with the environment, from which it depends and to which it needs to adapt. This aggregated information is partly embedded in the dynamic organization of the components – in a distributed, self-organizing way – yet not only. In living organisms, we find that some information is embodied in a completely new fashion, life employs memory, based on the development of a coded symbolic description, to store evolved useful information (Pattee, 1972). This begins with molecular memory encoded in nucleic-acid messengers and genes. Encoded information allows living organisms a supra level of self-regulation (this is often referred to as semiotic control, where symbolically encoded information is used to control a physical process), which goes beyond feedback dynamic and can generate new local rules (constraints) to govern dynamic behaviour (Pattee, 1972). Such information can be transferred among elements and individuals and inherited across generations of organisms. This provides the means to retain relevant changes and provides over time and networks a remarkably efficient collective search process for advancing the discovery of new adaptive and emergent structures in the face of natural selection (Pattee, 2012). Evolution has been mostly emphasised in terms of selective and competitive dynamics, leading to selfish entities (Dawkins, 1976), yet not less crucially, evolution weaves a collective network of increasingly complex and entangled cooperative relations among a multiplicity of entities at different levels (Dupre', 2009).

8. Inventors of worlds

The result is the proliferation of multiple forms of increasingly autonomous organisation – from chemical to unicellular, multicellular, developmental, cognitive and rational autonomy (Ruiz-Mirazo, 2011). Importantly many of these scales interact among them, meaning for example that the individual organism level can have an impact on the collective level and vice versa (Krakauer, 2011). Thus, once the collective and historic aspects of life are sufficiently emphasised, it is fundamental to come back for a moment to the individual organism and characterise it, however briefly. The individual organism is the organisational core whose capacities are at the basis of autonomy. Live organisms are able to auto-produce, maintain and self-regulate themselves; in the words of Maturana, they are autopoietic (Maturana, 1980). The reality of the individual is fundamental to be able to speak of metabolism, of genetic memory and selection, or of behaviour and goals. As we have seen, individual organisms are constrained, yet not defined by the environment – they are adaptive – they can generate new responses to their environment. They are agents, in the sense of pursuing functional actions serving their autonomy (that can be represented as goals). It follows that their perceived environment is full of significant differences (perceived gradients). A bat chasing a bug across the evening sky by echolocation and a dog navigating smells in the field underneath, perceive and respond to widely different landscapes of signals. This difference, which might variate even from organism to organism, allows each of them greater probability to hone upon successful solutions within their environments – individual organisms are inventors of worlds with meaning (Hoffmeyer, 1996). In this sense they may be understood as well as 'informational individuals', resilient wholes that are able to propagate information from their past to their future and maintain a temporal integrity (Krakauer, 2020). Such adaptive systems, in their paradoxical tension between autonomy and dependency, are able to generate completely new degrees of freedom, new possibilities of dynamic behaviour, which were inexistent until that moment (Ruiz-Mirazo, 2008) and thus introduce novelty.

8. Social complexity

The appearance of humans in the biological realm epitomises the development of a whole new stage of social complexity. We are not the first organisms to evolve sociality, from bacterial colonies to mammals' hierarchical packs, social complexity arises multiple times in life history. However, with humans a further level of organisation emerges, which is spanning today planetary scales. This level we can first characterise in terms of two main drivers of change that we have followed up to now and that grow paramount with humans. The first is a new way to organise information: language – information is now accessible by word and transmissible across space and time. Language is the new symbolic description regulating both self-imposed constraints and social order. Providing new grounds for increasing organisation and complexity. The second is a new way to organise matter and energy: technology – with it, the ability to modify the environment, to serve the process of autonomisation of humans, grows exponentially (in relation to anything else alive). Planet-wide flows of energy and matter, as well as information, can be re-organised to serve human development. This allows new and spectacular things, the translation and transformation of information and matter across different domains – biological, chemical, physical, abstract, technological – and into new complex forms of organisation. And with it the further carving of new degrees of freedom.

Imagine the following script. One day a human wakes up and raises their eyes to the sky with a thought about flight and wings, s/he is the first to envision a winged human, a 'hybrid' with superior capacity. The imagined creation is communicated and lives on in a new space – an abstract space of meaning, shared by groups of humans, propagated across generations and spaces via language and shared experiences. This is a space whose gradients are moulded by ideas, communications and coordinated interactions, rather than physical laws. More humans wake up across time with the renewed longing and image of flight. It becomes visions, shared gods, mythologies, until it is the study of wings and of flight, of gravity and engineering, the fever of actuation, coordination of resources, materials, technology, shared dreams and the conception of the first 'metal bird' – today humans can actually fly. We fly with wings that are not personal but rather a product of the new socio-technological level of organisation feeding the flows: flying routes, fuel, knowledge and technology, and the people and communication. This example illustrates the impressive new capacities and levels of autonomy brought to might across mere centuries of social complexity, based on the individual human as its core organisational structure, within social and technological networks of collective coordination.

On a much faster track than biological evolution, social complexity enacts the evolution of culture. It brings about a high level of information exchange and memory building among individuals over collective-historical networks. Culture allows to aggregate thousands if not millions of adaptations with every generation. Thus, one may describe it as a process of collective learning. A form of collective search process for discovering adaptive and emergent structures.

On the very wide scale, our socio-technological civilization is growing in complexity, with some placing it among the most complex phenomena known in the universe (Chaisson, 2011). Growth in complexity entails that our expenditure of energy is currently intensifying, with flows of matter and energy feeding increasingly complex forms of organisation. The curves of exponential growth spanning the last two centuries, both in goods produced and in the exploitation of resources and environment, seem to run into an impossible acceleration. The energy needed for maintaining the current level of social organisation is challenging human collective enterprise into generating innovation in terms of the development of less harmful ways of producing and maintaining flows of energy, matter and information.

With it, while the unrelenting growth of organisation echoes as a story of progress at the scale of the universe, it deeply differs from it at the scales that are relevant for our existence. At these more immediate scales, an increase in meta-structures is not an orderly phenomenon – it comes with dependencies, growth in uncertainty and potential catastrophic failures. New local and global challenges are emerging. While the human population almost quadrupled over less than two centuries, sustainability of the process of growth has become a planetary question for the first time in history, menacing meta-systems such as the climate and biodiversity (Smith, 2014) and igniting wide and unstable processes of social transformation and reorganisation such as wide waves of migration (Castles, 2010). Vast socio-technological systems are emerging that, at least in some respects, self-organise outside our control (i.e. the economy, social networks, media). These systems are part in the new mechanisms controlling flows of resources and partly operate beyond current individual or collective understanding. For all practical purposes they are a new level of organisation presenting novel laws and regularities in the process of being deciphered.

The selective pressure upon which the human process of social evolution is taking place, though governed by survival – if not adaptive in terms of life on this planet, it will eventually encounter failure – is not necessarily directed by it. The field of differences upon which we operate, singularly and socially, has grown in dimensionality and complexity. Drivers of possible convergence for individual and collective strategies are in a process of change due to the exponential alterations in the landscape – whether ecological, cultural, technological or social. As part of the challenges, our strong dependence on formalised knowledge is involuntarily driving all that which is 'too complex to be formalised', or which is simply unanticipated, to the fringe of our attention.

More than ever, we need to seriously reconsider and adapt the models we use to make sense of our world, beginning from the metaphors we share in our language, to the stories we use for context and the conceptual assumptions informing our idealisations.

9. Simplicity in complexity

Conceptual models, such as the abstraction of causality discussed in the introduction, as well as their tangible implications – such a rules, laws and forms of social organisation – can be understood as valid approximations, coarse-grained depictions of the world, which, when fit, allow to reduce complexity in behaviour, provide strategies to align to for decision-making and organisation, and effectively reduce environmental uncertainty about the future. Uncertainty reduction produces positive pay-offs freeing resources at the level of the individual and of the society, in turn expanding possible actions and behaviours and, thus, ultimately allowing further increases in complexity (Flack, 2013). Despite how successful, models are nonetheless temporary approximations. One may expect that such approximations and simplifications are emerging only at the cognitive level of humans, yet recent theories viewing life as a computational process – with organisms constantly processing and manipulating information – elaborate how coarse-grained encodings of macroscopic slow variables that reduce uncertainty, are typical of life, and emerge at each new level of organisation – changing and adapting along time (Flack, 2014; Krakauer, 2020).

Models and other forms of simplification in this sense cannot be removed from the way we operate cognitively or socially, and should be used to the extent of their power of simplification, but they must be frequently reviewed and adjusted, and must include a diversity of strategies while remembering that nature organises itself in a plurality of ways and our approaches must reflect such diversity. The understanding of linear causality is fundamental in describing a physical, mechanical world, yet the predict-and-act model that it furnishes us with, assuming certainty of information and finality of action, is a terrible approximation while approaching areas of inherent uncertainty, multiple interacting causes, partial information and context dependency (Mitchell, 2009). Current global challenges, requiring operating in front of the future of the likes of climate change, migration, social injustice or genetic engineering are all confronting highly complex, feedback rich and contextually contingent processes. And more local challenges such as confronting new social realities or adapting education are no different. In each of these cases universally planned actions counteracting a supposed main cause are likely to ignite unforeseen consequences rather than steering the system in the wished direction.

This does not mean that we are left at a loss, not at all, complexity is not entirely beyond our understanding – yet it demands from us to establish different conceptual maps and coordination strategies. The literature is rich with examples and strategies. from the more theoretical work (Mitchel, 2009; Morin 2008; Kauffman 2008, Haken, 2006; Heylighen, 2006; West & Brown 2005; Holland 1995, 1998; Cilliers 1998; Prigogine 1984) to the more pragmatic and applied (Portugali, 2011; Ostrom, 2009; Gershenson, 2005; Latour, 1996). They vary in contexts, approaches and methodologies, yet all share an emphasis on a number of broad lines: the seeking of coarse-grained patterns and working with information that is 'good enough', rather than using only what is universally certain; including a plurality of explanations and strategies rather than the one golden rule; operating iteratively with recurring cycles (for ex. of prediction, action, setting metrics for success, monitoring consequences, and again adjusting prediction), rather than once-and-for-all decisions and interventions; building best way to integrate the local inputs at the system level, whether participatory methodologies, multiple scenarios or computer simulations. Last but not least working with the individual's cognitive complexity, creating circumstances for continuous flows of knowledge, instances of reformulation, and the periodic challenging of implicit assumptions. It is the individual, in its rational and reflective autonomy, that embodies the organizational core of social complexity and the driver of cultural evolution.

10. Conclusions

The world we inhabit is growing more complex, escalating how connected and interdependent we all are, driven by the intensification of energy and resource use, by rapid demographics, multi-varied ways of collective coordination and by exponentially advancing technology. Yet, with it, our world is more complex predominantly because we are learning to see and recognise complexity. The story introduced in this article sketches some of these newly emerging perspectives, and argues that while recognising complexity, we are beginning to recognise ourselves as part of wide, immensely complex and incredibly generative networks and processes of recirculation and recreation of energy and matter. Where Newton saw the perfection of a watchmaker mind, we see a relentless cosmic evolution, gradually, if surprisingly, carving new forms and degrees of freedom and restrictions. This realisation on one side forces us to mature. We are not the perfect outcome on top of an evolutionary tree, nor are we the ruthless product of some competitive rat race. We are part in a becoming 'between possible and impossible', which presents a multiplicity of metastable paths and niche opportunities at all scales. And on the other hand, it better equips us in front of incoming challenges. Complexity offers a more nuanced understanding of the multiple systems of which we are part and of the way they regenerate and sustain the spaces we exist in. We need to reconsider our underlying metaphors and rules of how the world works to allow a shift in attitude and goals, to bring forth an appropriate participation in these systems as co-creative agents. And with it, while reframing our mindset we gain transformative and creative forces that increase degrees of freedom for action, towards new phases of coordination and idea generation. We earn leverage points for introducing change. We discover the pleasure to re-understand ourselves in a greater context, while embracing greater processes in the coagulation of thinking.

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