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Aggregation Dynamics: From problems and solutions to a generalized ecology

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Abstract

Aggregation Dynamics is a generalisation of ecology where organisms are replaced by aggregations. This totalises the notion of the ecology of living things to the ecology of all things. Aggregations are defined recursively: a thing is an aggregation if an already recognised aggregation acts on it accordingly.

The argument begins by problematising human notions of problem and solution. Reflection on this results in hypotheses such as the Innovation Illusion and the Control Illusion. Aggregation Dynamics suggests that behaviour and organisation of aggregations is emergent and largely information-driven. From that basis, the illusions seem plausible.

1 Introduction

In this paper, Aggregation Dynamics is presented. This is a total system in the sense of *Transmathematica* [34]. It is intended as a unified description for all interacting clusters of matter involved in a process of complexity growth. This includes: people and their related products such as organisations and commodities. Admittedly, this is quite an ambition and whether it leads anywhere remains to be seen. The reason for formulating this theory is my amazement at how people deal with problems and solutions.

I observe that solutions are rarely final. Usually a solution gives rise to new problems, or to the insight that there was something forgotten that also needs to be addressed. Nor can I escape the impression that people repeat themselves. With some hyperbole: we always solve the same problems with the same solutions, regardless of domain and scale. And because we permanently make mistakes, solutions generate new problems. However, we think we are working inventively and creatively. I call this situation the Innovation Illusion.

The Innovation Illusion may strike the reader as absurd: I hear you thinking. 'Ho, Ho. What about the drinking water supply, medical care, the European Union, the Mars Rover, the proof of Fermat's last theorem? Amazing human achievements. Could these be the result of some kind of problem-solving Lego? With a fixed set of one-size-fits-all building blocks?' I think so, and I will argue why and how. The modern world is not to our credit, although we certainly play a role in it. Rather, we are the involved witnesses to a natural phenomenon of complexity growth. To keep the article contained, it makes many assumptions that I only partially elaborate on. This article unfolds a search space, in other words, a project.

The argument begins by looking more carefully at our activities and introducing some terms (Section 2). This allows me to discuss in a systematic way a number of case studies in which problems and solutions appear to be instantiations of types (Section 3).

The observations from the case studies are generalised into a hypothesis: the Innovation Illusion (Section 4). The hypothesis arouses curiosity, but naive inventory of problem situations, however, encounters two kinds of complications: the meaning of things is context-dependent (Hammer Paradox); people have no idea of the real complexity of problem situations (Game Paradox, both Section 5).

The hypothesis and the paradoxes lead to a logical inconsistency: on the one hand, the Innovation Illusion and the two paradoxes, and on the other, the strong belief that we know exactly what we are doing and that we have control. If I assume the latter is not true then there is another illusion: the Control Illusion. Results from various disciplines support this idea, including psychology.

So how can the finely tuned organisation and complexity we see around us arise? Evolutionary theory and ecology provide clues for an explanatory model, assuming our appreciation of that organisation and complexity is not also an illusion.

Ecology is defined in Michael Begon and Colin Townsend's textbook [2] as: "*the scientific study of the distribution and abundance of organisms and the interactions that determine distribution and abundance*". By 'organisms' everyone can imagine something: plants, animals, fungi, bacteria.

In my view, 'organisms' constitute a limitation for modelling interactions in general. I propose a much broader category of beings: aggregations. The essential point: a collection of matter, possibly empty or void, is an aggregation if an already recognised aggregation assigns unity and meaning to it, takes it into account and acts upon it. With this, valid aggregations can corellate with our familiar DNA-generated phenotypes but also break right through these familiar divisions of time and space as well as be imagined beings. Aggregation Dynamics emancipates all constellations that we attribute a function to, including purely mental ones. A mathematical theory is an example of this.

Suppose you pay EUR 13.50 for a product that is discounted by 10% and on which 21% VAT is deducted. You are given a free sample of a new product. People do not dwell on it, but the notion of zero, of negative numbers and of fractions are each inventions, with flaws. The textbook

example of an arithmetical flaw is division by zero [3]. Anderson *et alia* think division by zero should result in a number and make good arguments for this in several articles. They show how division by zero works better with the alternative arithmetic of the *transreals* [1]. Herein, $1/0 = +\infty$ and $(+\infty) + (-\infty) = 0/0 = \Phi$. From the point of view of Aggregation Dynamics, it does not matter whether the intervention with Φ is 'good', that there is an intervention, is what matters, as discussed in Section 2.

Developing the earlier definition, I then get: *Aggregation Dynamics is the scientific study of the distribution and abundance of aggregations and the interactions that determine distribution and abundance.*

I describe an evolutionary complexity-generating process in Section 6. This necessitates several auxiliary concepts and other hypotheses, including encapsulated evolution and the Cybernetic Ladder. Finally, the Innovation Illusion and the Control Illusion can be understood on this basis. The section concludes with some conjectures.

Section 7, the Conclusion, summarises the article and reflects on its assertions.

2 Problems and solutions

Problems and solutions are central notions in human activities, anyone can easily determine for themselves. The reader's ordinary intuition of these notions suffices. I merely add some structure.

How to tackle problems intelligently and efficiently is the subject of a vast amount of engineering and management literature. What the philosopher calls critique is missing from it as far as I can see. I briefly discuss two works that do look beyond the issues of the day.

Dutch chemist Hans Peters called the phenomenon that solutions lead to problems *The Law of Conservation of Misery* (my translation of 'De wet van behoud van ellende'). In 1973 this was, in a book motivated by the release of the Report for the Club of Rome entitled *The limits to growth* [20]. In it, Peters explains how many solutions are merely symptom control and thus do not help or lead to new problems. Moreover, he shows that more rigorous interventions also run into complications because we do not actually have a good understanding of what we are doing [22]. American thinker Edward Tenner, in *Why things bite back*, lifts problem preservation into a subject in its own right [29]. He gives nice examples and introduces useful terms, such as *revenge effect*, for unforeseen side-effects or ill-understood but intended effects, and *chronic problem* for problems that behave like a chronic disease. I discuss examples of chronic problems in the case studies in Section 3.

People learn from mistakes and miscalculations. As a result, procedures, practices, methods and techniques, products, organisations and services are constantly changing. We do all kinds of things differently from before, and current practices are also under pressure from yet new ones. I argue that learning is also part of the same phenomena. Revising practices provides a higher level of abstraction at which the same phenomena reappear. But it is too early to dwell on that now.

Problems and solutions often involve multiple parties. The generalisation of party is aggregation. I use these terms interchangeably, party in more mundane situations and aggregation in more abstract claims.

The word solution has three meanings here: 1. a proposal for a concrete intervention, 2. a specification of effects of and conditions to an intervention if it is to pass as a solution (also called service specification), 3. an identifiable realised solution. Time for an example.

Suppose you have a cat. You do not like the fact that a neighbour's cat keeps coming in and eating your own cat's food. This is a problem for you. One solution, as a suggestion, is to replace the existing cat flap with a 'smart' cat flap that lets only specific electronically tagged cats through. The service specification might read 'an intervention such that neighbouring cats no longer eat from my cat's bowl'. So it says 'what' you want to achieve, not 'how'. If you install a 'smart cat flap', and like it, then that intervention is a solution in the third meaning.

I use the term 'problem' in two variants: *threat* and *chance* or *opportunity*. In a threat, a party directly experiences a situation as unwelcome. 'That annoying neighbour's cat!' is an example, albeit that 'threat' comes across a bit heavy in this case. But, I don't distinguish between minor and major problems.

In an opportunity, the better is the enemy of the good. In this, a party imagines a different situation and considers it preferable to the existing situation, and not only conceivable but also potentially achievable. There, an opportunity glimmers. The absence of the preferable situation is now the problem.

There are often several parties involved in a problem. To continue the example. You have a particular perspective on the cat bowl issue. You are a party. You read about smart cat flaps. Maybe you want to buy a smart cat flap? Your neighbour, with the cheating cat, has been asked if their cat eats at home; they now also have knowledge of the issue, and probably a view on it. A shopkeeper has been asked for advice on smart cat flaps. This person may see an opportunity to sell off an old model. A threat to someone is often an opportunity for someone else. The cats are also parties, so are the old and new cat flaps. Some seven parties, at least. Each party has its own view of the problem. I call that view the party's *problem position* or *position* for short.

A problem position may include a proposal for a solution or it may merely expose an impasse. In any case, in a problem position a solution has not yet been implemented. Sometimes the proposal is concrete, such as 'assemble a smart cat flap', sometimes a solution is a methodical answer to the question 'how to proceed?'. Then the proposal is, for example, a method for arriving at a solution or a choice chart with a number of scenarios.

A party's position may partly overlap with that of another party; they then partly share the same view of the problem. I use the term *problem situation*, or *situation* for short, to denote the merging of the problem positions of the parties involved in it. A problem position is embedded in a problem situation. The parties involved in a situation sometimes have an opinion about each other's position, but sometimes they do not know of each other's existence, let alone the private considerations that

another party drags into it. To continue the example once more. Another neighbour followed the cat bowl issue from a distance. This neighbour is rather handy and already sees that you are probably going ask for help to fit the smart cat flap. Such a request forms a threat to the few hours free for this busy neighbour, but at the same time it offers an opportunity as this neighbour has a request for you too: to go along with a plan for a hedgehog passage in the communal fence. Will the neighbour suggest that now or later? You may not yet know what a hedgehog passage is, let alone that your neighbour could attach importance to it.

As indicated in the introduction, solutions often give rise to new problems. To stay with the cat flap: the cat is the cause of the original cat flap. That cat flap is partly the reason for unwanted visits. That is solved with a smart cat flap. Of this, the battery dies after some time. As a result, the cat with access rights is accidentally locked out for a weekend. From problem to solution to problem. I call this a *problem-solution chain*, or a *chain* for short. A problem that is directly related to a certain solution I call a *follow-up problem*.

Looking back, the occurrence of a certain problem in a chain is often inimitable. The world is unpredictable. But also often follow-up problems are already lurking in previous solutions and you know the risks. A broad category of known problems has to do with wear and maintenance. If there is a battery in something, it is potentially the cause of a follow-up problem.

The chain from the cat example is short. Longer chains can easily be constructed by readers from their own experience and environment. If one does so, it quickly becomes clear that chains are a simplification. There appear to be branching, cyclical, interwoven causal relationships, a network. I call such a network a *problem propagation*. A chain is a path in a problem propagation. Both are conceptual structures, abstractions. Because, exactly how it happened can only be reconstructed approximately. I also use the term problem propagation for the actual process in which problems branch off into solutions and those again into problems et cetera. Where solutions are realised, in actuality, I speak of the *problem front*.

3 Three cases

The treatment per case is always the following: I type a problem situation in the past and select solutions that typically seem to belong to it. I then identify these types again, later in time and ideally in a different domain.

3.1 Discord

The cities in Los Angeles county had been familiar with air pollution for some time. But, in July 1943, the 'fumes' took such forms that thousands panicked and called the police because of painful airways and burning eyes. The fumes turned from 'nuisance' into a major problem called smog. Soon the link was made between smog and human activity such as industrial processes, road traffic and private waste burning.

Within the county, cities, villages and rural communities had their own legislation on air pollution. Those laws differed and smog problems were also perceived differently. Conflicts arose between the administrative units, for instance, over the source of pollution and who was responsible for it. These were settled in 1947 with the enactment of Assembly Bill No. 1, which allowed a county in the State of California, after plebiscite, to enact air pollution control legislation applicable to all administrative units. Los Angeles county seized that opportunity right away that year [7, 12].

I call this problem type *discord*: a number of parties have shared interests, face related problems but experience and treat them differently, and this leads to conflicts between them. One solution is to *unify* the rules on the issues involved within a new structure with local interpretation and embedding. I call that an *umbrella*. A kind of conceptual roof under which the parties are equal on specific aspects and apply the same rules. The umbrella unifies.

I think an umbrella is a typical solution, but as indicated, there are other solutions to discord, for example ignoring it or hard fighting. I don't deal with those solutions here.

In the case study, a number of follow-up problems can be identified, there glimmer problem-solution chains. For example, an umbrella creates distance, namely a new administrative layer, and that leads to some autonomy loss for those under it. For example, mistrust and interpretation issues about the law reared their heads in Los Angeles county [32, 31]. These I suggest are typical of an umbrella, but I do not discuss them further here. A follow-up problem that I want to explore in more depth is the return of the problem, and the solution.

The federal government introduced the Air Pollution Control Act in 1955. I see this as repeating the solution at a higher level in the organisation of government: an umbrella over states. This act grew into an international milestone in environmental legislation: the Clean Air Act of 1970. Locally, there was also repetition. Adjacent counties Los Angeles, Orange, Riverside and San Bernardino decided in the mid-1970s to work more closely together in the South Coast Air Quality Management District. I see a pattern in this: problems internal to a county were solved (1947) and shifted to problems between counties, and these were solved in the mid-1970s by applying the same solution type. Generalising, an umbrella can create the conditions for its own reapplication. By analogy with mathematical terminology, one can say: the umbrella is an *invariant*.

Invariance, I think, takes two forms. The first case is scaling up, like the conflicts within a county coming back as conflicts between counties. The second case is reimplementation: the 1955 federal law was replaced by the 1970 law (I simplify for the sake of the argument as there were intermediate changes). My suspicion is that invariants play a defining role in Edward Tenner's chronic problems [29].

Unification, is a common pattern. The IPCC agreements are an extension of the Clean Air Act. The EU is an umbrella. Many products are umbrellas: the Internet; the Compact disk standard from Philips and Sony; the DIN standard for bolts and screws. In 2018, the advocacy organisation Cyberveilig Nederland came into being, dedicated "to increase

quality and transparency in the cybersecurity sector" (my translation of "voor het vergroten van kwaliteit en transparantie in de cybersecurity-sector") [11]. This organisation is an umbrella par excellence. After its establishment, it started working on a seal of approval and a cybersecurity dictionary for the sector, typically an invariant re-implementation of the umbrella.

3.2 Congestion

Car traffic jams are something everyone is familiar with. Attempts to solve traffic jams have been going on for decades. It is interesting to compare two snapshots in terms of solutions posited.

Sociologist Hans van de Braak lists some 13 of them in *Down with the traffic jam: Sociology of driving* (my translation of 'Wèg met de file: Sociologie van het autorijden') from 1996 [5]: A. new roads; B. increase road capacity; C. limit mobility growth; D. better public transport; E. eliminate bottlenecks; F. ramp metering; G. road tolls; H. carpooling; I. parking policy to keep cars out; J. free lane for commercial freight transport; K. awareness; L. permit system; M. fewer accidents through better car maintenance.

The Royal Dutch Touring Club (ANWB) held a survey of 12,000 members that included voting on a top ten of solutions. The results were presented to the Dutch cabinet in 2016 [10]. The top ten consisted of: 1. give freight traffic its own lane; 2. improve public transportation; 3. reduce commuting; 4. expand the road network; 5. invest in smart technology; 6. reduce speed differentials; 7. encourage bicycle use; 8. more police on the highway; 9. learn from traffic accidents; 10. provide better travel information.

I can group the suggestions on four themes: *i.* raw capacity (A, B, 4) *ii.* exclusion (C, G, I, K, L, 3) *iii.* optimisation (E, F, H, J, M, 1, 5, 6, 8, 9, 10) *iv.* alternative modality (D, 2, 7).

Almost all solutions are invariants, that is, solutions that leave conditions for the problem to reappear. There is only one more rigorous solution, aimed at the source: Van de Braak's permit system. That these are invariants has been demonstrated because the problem has not gone away. The traffic jam problem is chronic.

An example in another domain comes from the *Haarlems Dagblad* of 9 July 2022, in it an article titled with the quote: 'Neighbours disadvantaged by panels on school roofs' (my translation of 'Omwonenden dupe van panelen op schooldaken') [4]. The panels mentioned are solar panels.

A primary school had received a subsidy from the state for a renovation and to make the building more sustainable. According to interviewed counselman Vermeulen, 300 solar panels would be put on the roof. He opined that local residents would then be disadvantaged, because, "during the day, the limited electricity grid cannot absorb the solar power and the solar panels of private individuals will be disconnected" (my translation of "overdag kan het beperkte elektriciteitsnet de zonnestroom niet opnemen en worden de zonnepanelen van particulieren losgekoppeld"). What is relevant for the reader to know and what the article does not mention is:

local residents earn from excess power they supply to the grid. Not being able to supply means their solar panel business case will fail.

The journalist also recounted the position of the City Counsel. This refuted the situation: the state would have ordered the grid operator to increase capacity; a capacity check would be carried out; besides, the school would use the generated power on weekdays and the local residents on weekends.

Abstraction of the solutions suggested here gives a list we already know from the traffic jam cases we just looked at: *i.* raw capacity (network weighting) *ii.* exclusion (Vermeulen's fears) *iii.* optimisation (school during the week, local residents on weekends). Not mentioned was *iv.* alternative modality. A resident or the school might reason: 'I'll just put a battery pack down, then I won't have to deal with you anymore'. That too is a well-known solution in this domain.

I see in the traffic jam story and the network story a type, a congestion problem. And the same types of solutions were put forward for it in both cases.

3.3 Proliferation

In my view, there is a large group of problems associated with curbing a certain development. There is hard-to-control growth in such a situation, and the measures are aimed at curbing it. What I seem to discern here is a cycle of research, standardisation and regulation followed by realignment and reorientation of those involved, followed by the reappearance of the problem, and then research, standardisation and regulation again. With each cycle, the next intervention gets harder, but it also gets harder to break free from.

To continue an earlier case study, uniform legislation in Los Angeles county in 1947 did not solve smog, it provided a basis for concerted action. The law required a department, the Air Pollution Control District (APCD). Its first director set up research projects and introduced a licensing system. The problem, smog, persisted. So there was more research, stricter and more precise standards, other permits. But the public and industry had just adjusted to the earlier regulation with adjusted behaviour, respectively adjusted business models and investments. In addition to technical problems, political sensitivities arose. Reese H. Taylor, president of the Western Oil and Gas Association, revealed that "The oil industry is fed up with being the whipping boy for every misinformed person claiming to be an expert on smog" [39].

To illustrate, I briefly recount a few excerpts from the cycle of research, standardisation and regulation. The geological and meteorological conditions of the Los Angeles area cause temperature inversion in the smog season, meteorologists James G. Edinger and Morris Neiburger established in 1946. A blanket of warm air then lies over a layer of relatively cool air and holds it in place [30]. In 1952, Dutch chemist Arie Haagen-Smit of the California Institute of Technology was able to unfold a complete theory: in Edinger and Neiburger's trapped layer of air, the sun had free rein to start and keep going a chain reaction that, via nitrogen dioxides and unsaturated hydrocarbons, leads to peroxides, ozone, aldehydes and

acids [8, 9]. Instrument makers were working overtime. They built flue-gas scrubbers and filters, for example to capture sulphur oxides, and much more. The Liston-Becker company developed equipment to analyse car exhaust gases. Industry took up the gauntlet. "Smog installations OK'd for 78 Plants" headlined the *Los Angeles Times* enthusiastically on 29 January 1949. The County Regional Planning commission thought about land use planning in relation to smog, the notion of *industrial zoning* came into focus to become part of a joint strategy some years later [6, 36]. In 1955 a monitoring network in the county for continuous monitoring of the concentration and distribution of various substances such as ozone, sulphur oxides and nitrogen oxides was set up. In 1958 the *Los Angeles Times* dropped the term *smog-emission standard* in relation to cars [33]. In 1970 California introduced its own car emission standards and started testing on them [12].

The strange thing is: knowledge grows, regulation refines, but the complexity of society and the industrial complex also grow, the (chronic) problem remains.

A topical example is the nitrogen file in the Dutch situation. Here 'nitrogen' refers to nitrous oxides, ammonia, and other nitrogenous pollutants. The precipitation of nitrogen compounds has led to loss of biodiversity for decades and this is not considered acceptable. Law followed law. For various reasons, which go too far here, the 2015 law was set aside by the highest court in the Netherlands in 2019 [25]. The current effort seems aimed at reaching a solution with once again modelling, innovation, optimisation and regulation: a national agricultural agreement. In my view, this moves in the direction of an invariant that will cost a lot of money and add complexity on balance through new agreements, bridging arrangements, more elaborate models, dependence on new technology and promises.

4 The Innovation Illusion

What the case studies try to illustrate is that problems and their solutions in a certain domain at a certain time can be seen mutatis mutandis in another domain, at a different time and scale. Solutions also have characteristics, e.g. invariance. There seem to be more, such as structural aspects (more on this in Section 6.1).

Hypothesis 1 (Innovation Illusion) *People have the idea that they approach problems resourcefully and creatively, that they come up with new solutions. That is an illusion.*

Our thinking pushes an unwelcome situation into a problem type. The collection of problem types is limited.

With each problem type comes a limited collection of solutions. I call that collection the repertoire *of the problem type.*

Problem types and their respective repertoire are scale-free and domain independent.

Would it work to organise problems and solutions systematically? For example, like a taxonomy of plants or like products in a catalogue. This

does not work nicely. I formulate the difficulties in two specification paradoxes in the next section.

5 The Hammer and the Game Paradoxes

The Hammer Paradox is about *das Ding an sich*, the discussion of it is old but has not lost relevance [14]. The observer might imagine filling a catalogue of solutions. In it are exact and structural descriptions of concrete things, neatly ordered, categorised and indexed. So, screws and bolts under connectors, wind turbines under power generators, refrigerators under refrigeration units. But this catalogue cannot be made. What are the essential difficulties?

The first difficulty is context dependence. A hammer is for driving nails, but you can also kill someone with it. A thing is what someone wants or does with it. Furthermore, solutions are not bounded in time or space. Suppose you are thirsty and fill a glass of water. When did the water in the glass become a solution? The exact moment when the tap should close cannot be specified. Once the tap is closed, the spatial position of the 'solution' is uncertain. Some water molecules settle in cavities in the glass, others dance away in gas form.

Interesting in this regard is the work of American physiologist J. Scott Turner. He describes the relationship between organisms and the structures built by them in *The Extended Organism* [35]. He describes, for example, the interaction between the soil forming the burrow of an earthworm and the earthworm and argues that they form a whole. There is no centre in this system that as a whole is particularly difficult to delimit. What grain of sand still participates?

Then the Game Paradox. Everyone knows the Socratic wisdom: 'the more you know the fuller the realisation that you know little' (my phrasing). Could I give this superficiality some numerical justification? A thought experiment.

Define the *community of conditions* of a party as the collection of terms, or conditions, under which a party can assume its problem position and its role in a problem situation. Each party depends for its functioning on, for example, the benevolence of others, the availability of certain resources, the stability of the situation. You name it. Each circumstance in such a community itself has a community of conditions and so on. A stopping criterion is needed. It does not come down to the millimetre in this thought experiment. A condition counts if famous film director Steven Spielberg could come up with a plausible plot for a thriller in which this condition plays a key role.

Call what someone knows about their problem position the *information content* of that position. In game terms: what pieces are on the 'board', how do they relate to each other and what are the rules of the game?

You determine the information content of a position of a party as follows: you ask that party to write a report on its problem position in which it lists assertions on all the assumptions, properties, conditions, relevant

parties and latent knowledge it considers important. The information content is the collection of these assertions. In its report, would the party have thoroughly considered the community of conditions too? Surely not. You determine the information content for the problem situation by the union of the respective sets of assertions of the parties involved.

Suppose the assertions from the information content of the position of some party P are about 10 things or concepts. In the cat flap example, we are already roughly at that number. How many assertions could P express at least about 10 things? A reasonable estimate seems to be $2^{10} = 1024$. That is the number of elements in the set of all combinations of 10 concepts. I call this indication of the order of magnitude the *indicative potential complexity of the information content* of P's problem position or problem situation or community of conditions, respectively. Would P make 1024 assertions in its report? Doubtful, presumably far fewer. Now, I would like to know too: how does the information content of a position relate to that of the indicative potential complexity of the information content of the problem situation and of its community of conditions?

Consider that typical projects, the kind of projects and problem situations that many people work on every day, soon involve dozens of things and these are related to dozens more via the community of conditions. Without effort, you come up with 100 things, concepts or aspects. The indicative potential complexity of the information content of this (2^{100}) is astronomical. The probability of someone overlooking something important is 100%.

It is a ridiculous calculation, I readily admit. But in my opinion, the conclusion is inescapable that our perception of a problem is rather superficial compared to the potential complexity of the adjacent situation in which that problem arises. It is obvious that solutions will fail. How is it that we are often so sure of our case? I call this the *Game Paradox*. We only see a fraction of the pieces on the board and we don't know the rules very well.

Results from different disciplines support the paradoxes. Biologist Humberto R. Maturana and cognitive scientist and epistemologist Francisco J. Varela examine in *The tree of knowledge: The biological roots of human understanding*, how living beings perceive their environment, build understanding about it and act accordingly [19]. They argue at length that these creatures, and so do humans, live in a projection. We imagine our world and think that is the real world. But it is not. Our senses probe the world and the brain builds a worldview with it, which is what you 'perceive'.

Daniel Kahneman, psychologist and Nobel laureate, and his colleagues created a body of empirical evidence that people are not as rational as they think they are. People have a strong tendency to dredge up a biased and palatable narrative based on the scant information they gather from the outside world. There, they contentedly attach the stamp of 'That's the way it is!' In *Thinking Fast and Slow*, Kahneman formulates the principle of *what you see is all there is*. That is, the projective narrative is forcibly put together with elements that happen to be at hand. Rapid suggestive comprehension is the result of brain processes referred to as

system 1, by him and in the literature. Kahneman also shows that people are capable of better imaging by tapping into other faculties in their brains (called system 2), but this takes time and effort. People prefer to rely on system 1 [13].

Of biased projections, philosophers Herman de Regt and Hans Dooremalen of Tilburg University (The Netherlands) make a great theme in *The bingo feeling: how the illusion of understanding holds our thinking hostage* (my translation of 'Het snapgevoel: Hoe de illusie van begrip ons denken gijzelt'). In the context of the discussion of the two earlier books, this third title needs no further explanation [24]. The paradoxes are indeed apparent contradictions.

5.1 Control Illusion

The hypothesis of the Innovation Illusion and the paradoxes lead to a logical inconsistency. The Innovation Illusion and the two paradoxes say we repeat ourselves, we don't really know the things we manipulate, and we don't have the faintest idea of the complexity of the situations we're in. This clashes with the strong belief and feeling that we know exactly what we are doing and that we have control. If I assume the latter is not true then there is another illusion: the Control Illusion.

Hypothesis 2 (Control Illusion) *People think they have the initiative in shaping their environment, that they are the architect of it and that they direct change in a top down fashion based on sound knowledge and rational considerations. This is an illusion. People are there so they play a role, but being able to respond to problems in a relatively sophisticated and comprehensive way is not the same as having the initiative and control.*

The notion appears to have been coined by U.S. psychologist Ellen Langer in an article titled *The Illusion of Control* in 1975 [15]. The illusion was defined 'as an expectancy of a personal success probability inappropriately higher than the objective probability would warrant'. In six experiments she showed that 'people assume a skill orientation in chance situations'.

6 Aggregation Dynamics

Aggregation Dynamics aims at insight into the two illusions as formulated in Section 4 and 5.1.

6.1 Complexity growth model

Aggregation Dynamics assumes that life is a spontaneous natural phenomenon that can arise in quite cold conditions, with sufficient chemical elements and supply of energy. Life is an effect of the thermodynamic decay of the universe [27, 23]. That sounds far away but Dutch philosopher Th.C.W. Oudemans shows that thermodynamics is nowhere far away in our lives [21]. I examine some aspects of living structures that I think are relevant to their organisation and so for my argument.

The decay is an apparently chaotic sloshing of matter and energy as living processes keep creating new imbalances. They play free energy and matter and deploy these for their own creations, or better, orderings. In the process, they produce non-recoverable losses, residuals and side effects. The latter grow into new imbalances because living structures tend to proliferate, they continue until their operation fails. A new imbalance is a potential opportunity for an adapted living structure. But, it must be there in time and manage to seize the opportunity. Replication and its mistakes lead to new structures. In the absence of these new structures or their success, life dies out while there is still potential energy available. Life is not a thermodynamic goal, has no higher purpose, and certainly is not perfect, smart or efficient.

It is on cybernetic grounds that I think living structures have an inherently limited field of vision and understanding (see Section 6.3 below). This means that with steady supply of energy, life tends to form a network of symbiotic relationships. For a process that converts all potential energy into unusable residual heat in one go is unthinkable. We find such a symbiotic network on Earth. A network with relationships from crude predation to civilised cooperation. The activity within it is hyper parallel: everywhere it collides and bubbles. But it is not chaotic, as anyone observing nature or following the cars circling the Arc de Triomphe in Paris can see. It flows. There is, I think, something to be said about causality in a general sense. Three clusters of facts, considerations and suggestions form the starting point.

First, U.S. biologist Lynn Margulis demonstrated and fully developed a longer standing suggestion: the organelles in cells have bacterial origins. Examples include mitochondria, the power plants of cells. Her work had a major impact on cell biology and taxonomy [17, 18]. Aggregation Dynamics generalises this idea of bacterial trapping. I call it *structural composition* or *structural aggregation*. Basic forms are: absorption, autoabsorption, separation, fusion, clumping, monitoring, simulation and replacement. I think these are scale-free universal forms: 'man + glasses', a long list could be made. In my view, structures have an *aggregation order*, a measure that expresses stratification of a structure.

Second, Aggregation Dynamics generalises the idea of DNA: coding. Every structure has coding in Aggregation Dynamics. Coding is the existence of a correlation, however weak, between the state of certain internal structures and the state of other internal and external structures such that it affects the behaviour of the overall structure. DNA is just one example of coding. I assume that if two structures have coding, so do their structural compositions. How might this work? No idea. Composition does not necessarily lead to more complex coding and hence behaviour. Aggregation Dynamics assumes that coding can be understood in familiar terms like information, language and semantics. Indeed, that it is no exaggeration to say that each structure has an image and a theory of itself and its environment.

Aggregations are the projected structures that I assume play a central role in the image and theory of a structure. Aggregations are about the composition, state and operation and intentions of structures that the structure believes it must take into account. The material structures that

correlate with aggregations are called aggregations as well. Aggregations can correlate with organisms as in classical ecology but they need not.

Third, Aggregation Dynamics generalises evolutionary effects into a multidimensional phenomenon. The dimensions here are understood freely. They include the manner of structural composition and the conceptualisation in image and theory of aggregations by aggregations. Structural composition makes evolution recursive in two ways. A truncated sub-environment can form the basis for a local evolutionary process. Earth is such an environment, but so are the islands to which the ancestors of the Darwin finches had wandered. Much smaller is the fatty membrane of the first cell. I call this phenomenon *encapsulated evolution*. And, the results of structural compositions form larger units that engage in interactions amenable to evolutionary forces: *emergent evolution*.

I claim that with a reasoning similar to induction to the construction of terms from logic and algebra one could prove properties of causal chains with an induction to the construction of living structures. Namely, that: causal chains can start anywhere but on balance the initiative is bottom-up.

With image and theory formation, fantasy was born and presumably a huge series of evolutionary accidents. These abstractions underlie a new type of interactions in which chemistry becomes linked to postulated states. That is a step away from basic imbalances in the direct supply of matter and energy, or food. Therefore, I propose a more abstract term for 'food': *potential*. A potential is a situation for which a change process can be imagined that, possibly through a whole series of intermediate outcomes, releases energy and matter flows. Hence I speak of a *potential network*, which is more general than a food pyramid or network. Sulphur compounds are a potential, but so are movements of stock prices.

6.2 Control Illusion revisited

I believe that based on the model of complexity growth I described above (Section 6.1), the sense of control people experience, although thus misplaced, is explicable. The point is that causal chains run upwards in the aggregation stratification. So, the initiative usually lies outside the human body or deep within it. Of course, the exact role and functioning of aggregations high up in this stratification, like humans, is far from being described with that. Nevertheless, the shaping of the situation we are in follows universal thermodynamic laws that are out of our reach.

Measurements of brain activity by Libet et alia in the 1980s showed that consciousness runs behind events [16]. The current view is more nuanced. The Belgian philosopher and neuroscientist Jan Verplaetse distinguishes between free will and conscious free will and the denial of both [37]. The Control Illusion resembles such a negation, but the exact position of Aggregation Dynamics in the free will debate needs to be further defined. This is one reason why I choose to articulate the Control Illusion in my own way. Another reason is that Aggregation Dynamics has a different starting point. It does not start with the division of labour within

the brain or the role of consciousness but seeks general principles behind complexity growth through evolution.

6.3 Cybernetic Ladder

What can an aggregation know about its situation in a potential network? I claim that the picture an aggregation has and the theory it adopts is always an abstraction that just suffices to survive. On thermodynamic grounds, it can be seen to be an abstraction.

Suppose A maintains an image and theory about B. A extracts material and energy from B, and among other things A maintains its image and theory with it. In turn, B exists by the grace of C. The more detailed the image and theory the more material and energy A has to extract from B. Suppose A would include a complete simulation of B. Then it is reasonable to think A would then extract at least as much material and energy from B as B extracts from C to exist. A can't do this as it would need to extract so much from B that B would succumb. The refinement of the modelling by A stops well before the model of B is complete.

On evolutionary grounds, it can be seen that the model is only just adequate. For, a more elaborate model that offers no advantage is competed away. This is a commonplace phenomenon. Scientific insights (broad model) condense into professions (just enough). Aggregations are thus always incomplete and partly erroneous abstractions, but they feel complete to the possessor: *what you see is all there is*.

There will be differences between the image-forming and theory-forming qualities of aggregations. One difference is speed of adaptation. Compare a stock market trader during a stock market crash to a thermophilic bacteria at a smoker on the ocean floor. For the latter, conditions hardly change, even over millions of years. The former struggles with a chaos of conflicting messages and interests that can change within seconds. Aggregations that depend on many other aggregations and face highly variable conditions must have relatively powerful images and theories, as well as powerful methods to adapt both.

Suppose we were to capture the capacity for image and theory in a metric of flexibility. Suppose we thereby order the aggregations around us into a series. I call that hypothetical sequence the *Cybernetic Ladder*. The higher an aggregation sits on this ladder the more flexible. Humans are eminently adaptable.

6.4 Innovation Illusion revisited

However flexible, relatively then, the Innovation Illusion expresses that people think in a limited set of schemes. Why is thinking not free?

As I have argued, every living structure has only a limited theory at its disposal, a theory that is just adequate. That theory will be tailored to survive in a world of aggregations in which it is always a matter of devising and maintaining schemes that convert potentials into other potentials suitable for realising survival. I call such a scheme a *potential reduction scheme*; you could also call it a business model. That theory is not tailored to poetic conversations with the life forms on any planet in

any universe from the multiverse. It seems reasonable to think that the 'grammar' of potential reduction schemes matches the behaviour of the aggregations that the schemes deal with. These aggregations too operate encoded, not completely free in other words.

I think based on the above considerations that the Innovation Illusion is plausible.

Two well-known facts and an observation are nice to recall in this regard. Someone can get by in a foreign country in a language that this person has a poor command of. A current example is the billionaire Van der Wallen who made his fortune with savings campaigns at chain shops. BrandLoyalty began operations in Hong Kong in the mid-1990s. "Although his English was so bad they could hardly understand him, they often gave him a chance. Customers liked him, he had a favour factor" (my translation of "Hoewel zijn Engels zo slecht was dat ze hem nauwelijks konden verstaan, gaven ze hem vaak toch de kans. Klanten vonden hem leuk, hij had een gunfactor") [26]. Also interestingly, people can only have a limited number of concepts in their working memory at a time, around 10. Finally, why are aliens in the movies so often depicted anthropomorphically?

6.5 Conjectures

First, the line of research initiated with the cases can indeed be continued successfully.

Second, I suspect that interference of solution types leads to patterns in problem propagations such as chains and tree structures.

Third, certain characteristics of solutions can be looked at further. The conjecture is that invariance and structural composition are examples of such characteristics.

Fourth, the work on *small world models* raises the question of whether potential networks and problem propagations understood as graphs show special clustering [38].

Fifth, the Jevons paradox [28]. This is the phenomenon that efficient use of a resource to counter shortages leads to a fall in its price. This drives demand for it, which in turn leads to new shortages. What effects do solutions have on the thermodynamics of situations? This seems a relevant question in the context of the high expectations around the energy transition.

7 Conclusion

This article is an introduction to Aggregation Dynamics. This theory is a generalisation of ecology: in it, organisms are replaced by aggregations. The latter form a much broader category of 'beings'. Something is an aggregation if an already recognised aggregation thinks so and acts accordingly. Aggregations do not respect our familiar boundaries in space and time. Aggregation Dynamics totalises and emancipates all beings, including virtual ones. It is a *total system*.

Aggregations do not literally exist but can correlate with structures usually referred to as things, products, organisations or organisms. The notion of aggregation emancipates information as a player alongside matter and energy. It takes the verb 'to inform' literally: to bring into form.

The argument examines several cases. On this basis, the Innovation Illusion hypothesis is formulated. This expresses that people do not innovate: they change the world through repeated application of a fixed repertoire of interventions. The hypothesis clashes with our self-image that says we are creative and know perfectly well what we are doing. But two paradoxes make that self-image untenable too. Rather, in addition to an Innovation Illusion, we also live in a Control Illusion. This raises the acute question of how the complex and yet largely well-functioning society and its products can then come about? To explain this, the organisation of living structures is examined. Based on the postulated and argued properties of that organisation, the Innovation Illusion and the Control Illusion seem plausible indeed. The modern world is not to our credit, although we certainly play a role in it. We are the involved witnesses to a natural phenomenon: complexity growth.

This all sounds cool. But, applying Aggregation Dynamics to itself, I have to conclude that this whole argument is a type and a complexity increasing addition to the world. This article is as suspect as almost any human activity. It is almost certainly not correct. A small reassurance, perhaps, is that it does not purport to offer a solution.

So as not to undermine the main thrust of this presentation, I have made limited reference to related work and left many assumptions for what they are. This is not to say that I already know all that related work and the necessary arguments under assumptions. Far from it, there is much work ahead.

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