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Let's interplay! Does co-evolution enable or constrain?

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ABSTRACT

In various domains, there is an interplay at work: elements form and influence a structure, but this structure in turn influences the elements. By time, rigidity often turns in: the structure start to have its own goals, and cant be influenced anymore by the elements. How can one avoid this from happening? I propose two strategies: make sure there is enough diversity, and endorse a constant opposition. To illustrate this last countermeasure, I built a simulation. This showed that it is possible to avoid the emergence of the classical power-law distribution, giving rise to a more dynamical situation where the top agent is constantly changing. These considerations are applied to the concept of the global brain, in order to avoid that this becomes another imposing structure.

The standard model of evolution assumes a fixed fitness landscape. Usually there is coevolco-evolution, though: besides being influenced by its environment, an agent also shapes its environment (as described by niche construction (Laland et al., 2001)). View this as a swamp-like fitness landscape that changes as an agent moves through it and acts in it.

This interplay is happening on different similar aspects: between 'natural and cultural', 'social and infrastructure', 'function and structure', 'society and technology', 'decisions and acts', 'theory and practice' and 'micro and macro'. In general, out of the interactions of local elements, there is a bigger structure that emerges. This structure could then impose itself onto the agents, so that a status quo is reached: agents are influenced by the structure, while they do not have any more influence in return (Stirner and Leopold, 1995; Stewart, 2014).

One of these structures could be the global brain. The global brain can be defined as the distributed intelligence emerging from the coordination of humans and technology through the internet (Heylighen, 2014a). The global brain thus is shaped by humans, but on the other hand it can influence humans and construct its environment.

1. The problem

Aimpstrsystem could start to live "its own life": it strives for its own survival, instead of that of the agent(s) who created it. Stirner (Stirner and Leopold, 1995) describes this process on several levels. In the individual mind, first you have the creative process where ideas get created. But then this transforms into a "fixed idea", a dogma, where the person starts to live to serve the dogma, instead of the idea serving the person. The same mechanism happens on the societal level: first people start to cooperate because then they are all better off. A society is created. But then rigidity comes into play, this social mode (for example, a state) becomes a higher value, for which the people constituting it are subordinate. The goal of the system thus stops being aligned with that of the agent(s).

Heylighen (Heylighen, 2006) explains how this process works in several steps. First, a collective forms a medium, a support for carrying interactions. These interactions start to get coordinated, the medium becomes a mediator. Finally, this mediator evolves into a manager: instead of passively mediating actions of the agents, it starts to actively initiate and control such actions. This is when this system becomes to have its own goals, since it starts to have a control function. e the "imposing structure" I spoke about can come into play: But why would the goals of this system be in the best interest of the agents?

Heylighen (Heylighen, 2006) and Stewart (Stewart, 2014) explain this by the evolution from an extoculexploiter to a cultivator. An exploiter that is too successful will weaken and eventually kill the exploited, and thus endanger its own survival. That's why exploiters tend to evolve into cultivators: they become more benign, thus being able to harvest an ongoing stream of benefits from those they control. However, there is still an asymmetrical relationship between the cultivator and the cultivated. While the cultivator will let the cultivated survive as long as that's in its interest, it won't enable them to grow and develop, to live. It is only interested in these aspects of the agents that give it benefits, and does n ot care about the rest.

An example of the emergence of a cultivator is the rise of the welfare state. First, there were factories that exploited the workers and put them into horrible working conditions. The workers could not accept this, and started to protest against this in various ways: strikes, sabotages, demonstrations, …. Until the state saw this as a threat for its

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survival. So it decided to do some reforms to silence the protest: voting rights, social security, …. It thus became a cultivator, being more benign. But the fundamentals of the system were not really changed: people still were n ot able to form the society they wanted to live in, and they still had to work in factories for little (although a bit more) money, while others earned a lot simply because they owned these factories.

One of the main characteristic of this situation is that there is some depdependency. The agents usually need this bigger structure to survive. Examples are the cells in a human body, or humans in society (most humans will not survive anymore in the jungle). But it can also be another goal than survival that cannot be reached anymore without this structure. An example is a drug addict: he feels like he can not continue anymore without the drug. Previously (and maybe still in some respects) the drug has fulfilled his desires, but now it is actually detrimental. This is a specific case of supernormal stimuli (Barrett, 2010): these are stimuli that used to be beneficial in the past, but because the situation has changed (for example, because they are now there in bigger quantities), it has become detrimental.

This dependency also manifests itself in an asymmetry in influence: the bigger structure can influence the agents, but the agents that are constituted in it can not influence the bigger structure. This is why this structure can be rigid and maladapted to the agents. autThe agent loses its autonomy, since it can no longer accomplish its goals itself, but depends on the bigger structure to provide its needs.

Whether one considers this dependency problematic, is dependent of ones value system. In some cases and for some agents, a loss in autonomy might cause an increased survival. I personally value autonomy, and thus considers dependency as problematic. I can give some arguments for this (as done before), but in the end there is no accounting for taste. That is why in this paper I am mainly focusing on how this rigid structure can emerge, and how this can be avoided, rather than trying to prove why this rigid structure is indeed problematic.

We could in fact differentiate three configurations of the influence in a system:

- The 'dictator': one (or few) agents can influence the bigger structure, the other agents have no influence.
- 'not-my-metasystem': none of the individual agents have any influence on the bigger structure. Though the structure emerges out of these individual agents, they are components of the system, but they are interchangeable.
- 'shared world': every agent can partly shape the world around him, where and how he wants to live, everyone has influence.

A lot of systems, like most of the democratic countries, are in the second configuration. This is pretty difficult for a lot of people to grasp, because there is not a clear structure ruling over another structure. This is how a lot of the conspiracy theories saw birth: they correctly see a world which seems to have its own goal, which is beyond their control. So they conclude there should be a small group of people responsible for the situation in the world (the first configuration). They do not see that the problem lies in how society is configured, in which the individual agents are interchangeable. Probably, if they would get into power, the situation would remain the same. On the other hand, if one tries to explain that there are certain social forces, that there is a 'system' with its own goals, its own need for survival, which is n ot always the best for the individual, this system is assumed to be a separate body with clear boundaries. This puts one in the conspiracy camp. The concept of aspect system (Heylighen, 2006) can put some clarity in the matter. An aspect system is a subset of the set of relations, interactions and properties that characterize the structural components of a system. The idea is thus to distinguish on the basis of function, instead of structure. An example are the cultural, political and economical systems in society. It is therefore important to note that this system that emerges out of local interactions, is often not some external agent or well-defined body, but more of an aspect system of the whole system (although it has distinguishable attributes). Often people will search for a small group of people responsible for the situation in the world (the dictfirst configuration). They do not see that the problem lies in how society is configured, in which the individual agents are interchangeable. Probably, if they would get into power, the situation would remain the same.

luhmLuhmann's theory (Moeller, 2012) also states this: that humans are n ot really part of the social system in the sense that they are interchangeable, and the social system will maintain itself, it is an autopoietic system. According to Luhmann, society has changed from stratified differentiation to functional differentiation, with function systems that are autonomous. Luhmann uses the term function systems for what we have previously called aspect systems. Elsewhere in this issue, Lenartowicz (Lenartowicz, 2016) applies Luhmann to interpret social systems as intelligent, evolving 'creatures'.

What is described here is a meta-system transition: a transition to a higher level of complexity. The global brain can be understood in this respect: as a higher structure that emerges and develops its own goals, which might become more and more independent of individual goals (although these individuals constitute and sustain the global brain). This is already more or less happening today (where we for example see that a state is n ot really fulfilling individual needs), but the danger with the global brain is that it would be more intelligent than the hierarchical system of today. It would be a self-organizing, emergent system, and thus it could n ot simply get dismantled by taking away the top. The stronger this structure will be, the more difficult it will be to break it down. Thus, if it would be omnipotent and omnipresent (as argued in (Heylighen, 2014a)), will it not be also impossible to resist?

I now elaborate how this process works in several domains.

2. Aspects

2.1. Technology - creating the environment

Technology is in interaction with a certain kind of society and ideas. Technology strengthens a certain type of society, while it is also out of current ideas that a technology is created. Technology creates the circumstances, the environment, in which one can act. Even if in the beginning or in its roots a technology is n ot configured for the current social mode, a technology can easily be recuperated for a certain dominant idea. Thus, technology often reinforces the status quo, the current tendency.

This is a basic manifestation of co-evolution. The classical view of evolution is that species adapt to an assumed fixed environment. With the rise of technology, humans more and more created their environment themselves. We thus created the selection criteria for our species ourselves. This is the flaw in using the 'survival-of-the-fittest'-argument in the present human societyof some capitalists. Their argument is that it is only natural that only the strongest individuals, firms, …. survive. But we artificially created the selection criteria of what defines 'strongest' (in capitalism, this is basically what can make the most profit). These selection criteria could be changed so that a wholly different kind of social organization would rise.

But new ideas from society can create new technology, which could change society. Technology could thus help liberationThere might be technology that helps to liberate though, either because it is constructed for it or because technology does n ot always follows the path its creator had in mind. With liberation I mean moving away from a depdependency relation and becoming autautonomous. This relates to the concept of self-actualization: "the desire for self-fulfillment, namely the tendency for him [the individual] to become actualized in what he is potentially." (Maslow, n.d.). Bakunin's definition of freedom is quite in line with this, in "the full development of all the material, intellectual and moral powers which are to be found as faculties latent in everybody" (Bakunin and Kenafick, 1950).

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But no-one can self-actualize someone else, one can only self-actualize itself. One of the core attributes of how I conceive freedom, is that it is a decision (Passamani, 2010). That is why technology can never liberate in itself. Excepting from technology to create a more free society, is in contradiction with this notion of freedom. This is similar to the economic determinism in Marxism, that assumes that the economic mode determines the society completely, and it is thus by changing this economic mode that a free society can be created. In these scenarios,Technology ca n ot save us, because then we aren'tstill not the drivers, the players, of our own future.

Technology can reinforce certain liberating tendencies, but if these tendencies are not present, even the most liberating technology will evolve to serve the current system. We can find support, tools in technology to liberate ourselves, just as there are circumstances where it's more difficult to do so.

We can see an example of theseis mechanisms in agriculture. The appearance of agriculture drastically transformed the way society was organized. Private property and patriarchy could flourish by this technology (Feinberg, 1996). This is thus an example of how technology shapes society.

Today, we see how every technology gets recuperated by capitalism. The main drive is to make profit, thus every technology will serve this goal. A classic example is the story of bio-fuel.

First, there were some people who found out they could use there used vegetable oil for driving their car. Recycling things, and being less dependent on fossil fuels, that's better for the environment, right? But then big businesses saw profit in it, and now there are lots of big fields that grow plants just for fuel. This means there is less land available for food production, and brings forth all the problems coming with mass monoculture: deforestation, soil erosion, loss of biodiversity, …. This thus shows how a certain society can create a certain kind of technology.

Since the global brain is highly technological, this discussion is also relevant for global brain research. The global brain could enable people to build the world they want to live in, where the technology, structure and coordination will be formed to aid with this liberation. The internet could enable people to put their ideas into practice, by providing tools, resources and people. But as I argued, people will still have to put effort to actually do these things, and decide to liberate themselves.

It is also possible, and this partly depends on whether this decision will be made, that the global brain becomes another technology from which people are totally dependent, which influences their life, but where they have no influence on. This can be seen in how nowadays technology is often used for surveillance and repression by a state apparatus. For example with internet surveillance, that often uses (big) data (mining), or with tracking people through (smart)phones and an increased number of CCTV-cameras.

2.2. Democracy - separating thinking and acting

Today's democracy creates a sharp separation between decision making and acting. Some politicians make the decisions, which other people put into practice. This makes it possible to avoid responsibility, and creates alienation. Dreams can ot evolve into acts.

With alienation I mean when there is an incongruity, a discrepancy. This can for instance be between self and environment, between thoughts and acts, or between one part of self and another. Often the cause is a mal-adaptation, where one part has undergone sudden changes, and the other part can not follow. An example is how humans are sometimes not well adapted to the sudden (in an evolutionary respect) changes our society has undergone - which gives rise to “diseases of civilization”.

Distributed governance is a step in the right direction. But often there is the assumption that we should make a global decision, and then all act by that decision, for example in (Banathy, 2013). Although these decisions and acts have come about in a distributed way, there is still a separation between them. A global decision is made out of local decisions, which lead to local acts bringing forth a global act. Another practice is where local decisions lead to local acts, out of which a global behavior, a global direction, emerges (see Fig. 1).

Take for example the shaping of a neighborhood. One way is that people from the neighborhood come together, share ideas on how they want their neighborhood to look, form a consensus plan on what should change, and then act by that plan. Though the plan is formed by consensus, this often does n ot feel very empowering, because on the day of the planning you did n ot really know yet what you wanted. That only becomes clear once you see it into action. You still feel pretty alienated because it does n ot really feel like your plan. Something completely different is a neighborhood where people just act on what they think should happen, sometimes discussing with others to see whether there is support. Then others build further on this when they see something they like. This way people are n ot restrained in acting, because they should n ot go anymore through a whole (bureaucratic) process before they could act.

The scientific process also sometimes creates a separation between thinking and acting (acting is usually by communicating thoughts to the world). Right now, a researcher develops a plan for an experiment, performs an experiment and writes down the results in an article, and only then his ideas are peer-reviewed. At that stage, they might find out that actually there are some problems with the experimental setup. A more continuous peer-review could be interesting, where every step gets peer-reviewed. Something comparable is already happening with crowd-sourced research (Silberzahn and Uhlmann, 2015).

This can be applied to the global brain. We already see nowadays how an increased connection can actually create isolation, where people are constantly behind their computer or smartphone and do not have any deep human contact anymore, or when they are constantly in a computer game and do not come outside any more. This thus creates a separation and incongruity between the self and the environment. The internet could further alienate our decisions from our acts, where people are stuck in a virtual world where they can raise all kinds of opinions, but without these being connected to their acts and everyday lives.

But this could also evolve more positively, where the global brain enables people to ease the transformation of ideas and thoughts into actions, by making it easier to coordinate and find other people to accomplish your wants.

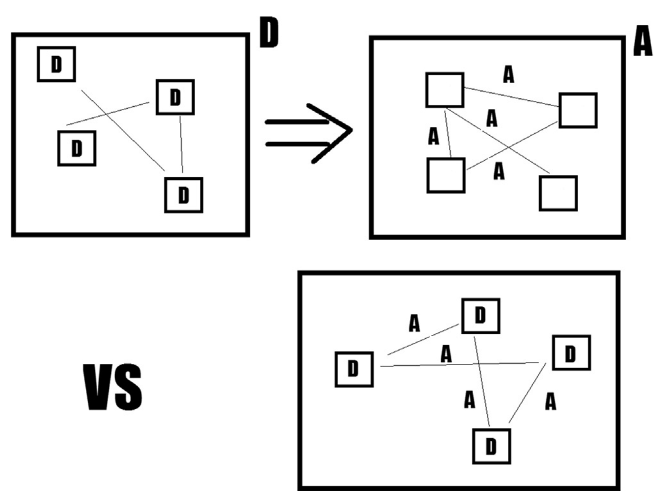

Fig. 1. In the upper figure, local decisions (D) lead to a global decision, which determine local acts (A) that brings forth a global act. Decisions and acts thus get separated. In the lower figure on the other hand, local decisions directly lead to local acts. From all of this there pops up an emergent behavior.

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3. Alternatives

A solution to this structure that imposes itself could be a more hybrid structure, one that is constantly evolving, a variation and selection of different ways of organizing (Veitas and Weinbaum, 2014). There is not one utility measure that imposes a hierarchical ordering (Roughgarden, 2013). Instead of trying to reach a global, united decision or view, there would be local groups or individuals who develop themselves and work together to do so. It would be diverse and even contradictory. This conflict will boost a dynamic play.

A constant opposition can be used against the natural tendency of a system for unification, for getting stuck in a status quo. Naturally, a system will move into an attractor, unless it constantly has external challenges. That is why life is possible, and why we are not in a static state. The idea is thus that a system will impose itself and become rigid , unless there is constant opposition. But this does n ot mean that a complex or anti-authoritarian society is impossible.

The idea is to create the environment that helps people to develop and enables them. But there are two different perspectives to do this (Busseniers, 2016): to start from yourself, constructing the world you would like to live in, or to start from the other, constructing a world where an assumed better behavior is more easily achieved. Libertarian paternalism (Thaler and Sunstein, 2003) fits in this last case: the idea here is to 'nudge' people into 'good' behavior. This distinction is similar to what is described in Section 2.2. One could try to reach one globglobal view, one global decision, or one could see the world as a diverse amalgam, where lots of possible ways of living are possible.

The global brain could be a constantly evolving structure, a dynamical play full of differentiation and experimentation. To make this possible, I think there needs to be a constant opposition to avoid being stuck in a stable attractor state. We should avoid that the new vision becomes a dogma, where it becomes a restricting structure that owns us instead of we owning it. There should be a diversity of methods, and we should as much as possible avoid to use one utility measure or make one global decision.

4. Constant opposition

One of my main hypotheses is that a constant opposition can be used to avoid getting in a status quo. Here, I will back up this hypothesis by providing some sources and theory, and I will do a little simulation to show how it can work if there is just one variable.

This idea is very much in line with the argument in Peter Gelderloos' essay 'Rise of Hierarchy' (Gelderloos, 2005). He argues that hierarchy did n ot arise because of a change in material mode (the classical Marxist view), but whereverthere was no organization to prevent it. He explains that there were hierarchical hunter-gatherer societiey's (based on patriarchy and gerontocracy), and egalitarian agricultural societies. In these egalitarian societies, there were mechanisms to prevent hierarchy to rise. He does however agree that there is a positive feedback, caused by interplay: oppressive hierarchies can allow techtechnologies to become oppressive, and technologies can help these hierarchies to develop.

This can be explained in general as in that a system will usually get into an attractor - for example a hierarchical organization. An attractor is a part of the state space which can be entered, but can not be left any more. It is possible to move out of the attractor by external challenges, by changing the dynamics of the system. The second law of thermodynamics states that in a closed system, a system will evolve to a state of maximal entropy. This state of maximal entropy is an example of an attractor. But because the world is an open system, they are constant challenges, and it is thus more dynamical, which is why a complex phenomenon like life is possible. We can further explain this by using Heylighen's (Heylighen, 2014b) interpretation of this law, which is that.

without selection, a system will evolve to a state of maximal entropy. It is because of selection that certain states are more probable, since they have a higher chance of survival. Thus with the second law of thermodynamics, there is a uniform distribution, where all states are equally probable - there is maximum entropy. But because of selection this changes, where certain states are more probable.

Analogously, there is the common belief that there will always be power imbalances, 'Those with power, will get more', 'the rich will get richer, the poor will get poorer'. The scientists see this in the abundance of power-law distributions, caused by a positive feedback mechanism (Mitzenmacher, 2003). An attractor is thus reached. But this is because there is no mechanism to prevent this: if there would be a constant opposition, so that as soon as someone gets a bit more, he gets a headwind that restrains him from accumulating it, the hypothesis is that the distribution would get flattened.

To sum up, in both of these cases there is a certain law that seems difficult to avoid (either the second law of thermodynamics or a positive feedback mechanism giving rise to a power-law). In general, the system moves into an attractor. But there can be a mechanism (selection or constant opposition) to overcomesurpass this.

To illustrate this, I built a little simulation. This can be a general model of a positive feedback phenomenon, but I made this with the present socio-technological complex in mind. Here, there are several agents A_i with a certain fitness $f_i(t)$ at time $tf(x_i)$. The more fitness they have, the more possibilities they have to influence the development of technologies and thus to form the environment. Thus, the more fitness they will be able to gain. We can represent this by the following formula's:

$$f_i(t+1) = f_i(t) + k \cdot f_i(t) - \sum_{j \neq i} \frac{k}{n-1} f_j(t) \tag{1}$$

with $k>0$ a constant and n the total number of agents. Thus, the more fitness an agent A_i has, the more it gains (namely $k \cdot f_i(t)$), and it takes an equal amount from the fitness of all other agents to get this (agent A_i thus looses the amount $\frac{k}{n-1} f_j(t)$ due to agent $A_j(1)$). We thus assume the total fitness remains constant. This can be a general model of a positive feedback mechanism (where f can represent something else than fitness).

Now we introduce a constant opposition mechanism in this model. The idea is that agents now steal the fitness from the agent with the highest fitness, instead of from all agents. In the language of formula, for all but the agent with the highest fitness, the formula changes into: Eq. (1) is get changed into:

$$f_i(t+1) = f_i(t) + k \cdot f_i(t) \tag{2}$$

while for the agent A_j with the highest fitness, the formula becomes:

$$f_j(t+1) = f_j(t) + k \cdot f_j(t) - \sum_{i \neq j} k \cdot f_i(t) \tag{3}$$

I did a simulation with 1000 agents, for 100 iterations and $k = 0.1$, for both cases (either the standard case Eq. (1), or the one with opposition Eq. (2) and Eq. (3)). In the two cases, the values of agents started from the same normal distribution. In the simulation I ensured that the fitness did not become negative, by instead taking more from (an) other agent(s) if an agent's fitness would reach under zero - evenly in the standard case, and from the one with the second highest fitness in the opposition case: a normal distribution with mean 1, and standard deviation 0.1. But after 100 iterations, there was a clear difference between both methods (see Fig. 2). In the classical case, there were only two agents with a huge fitness, around 300 and 700, while all other agents had a fitness of almost zero. Because of the positive feedback, the agent with the highest fitness could steal the most from the other agents, until none of them had any fitness left. The distribution follows a power-law. In case of opposition, there is still a power-law, but the range of values reaches only until 6, in contrast with a range of values

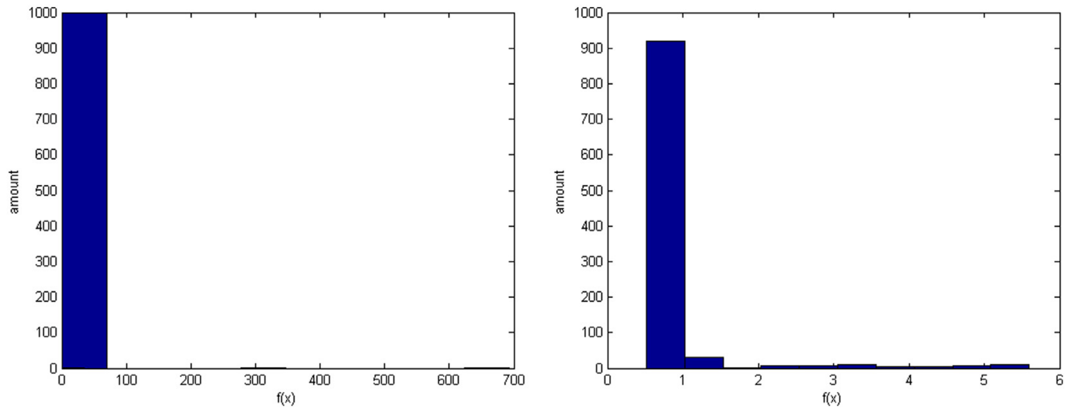

Fig. 2. Left: the distribution at the end of the simulation in the standard case. Right: the distribution at the end in the case of opposition. Note the difference in range of the x-axis between left and right: in the standard case, the highest fitness is 700, while in case of opposition, the fitness does not go higher than 6.

until 700 in the standard case, with only a couple with a big value, and all the rest around 0. The power-law is also less profound in the case of opposition.

In the standard case, we see a power-law at the end of the simulation, as expected. Two agents have almost all the fitness, while the rest has almost none. In the opposition case however, we also see a power-law, although way less profound (see Fig. 2 for the distributions). But the distribution is constantly changing here: the power-law evolves to a more equal distribution and back again to a power-law (see Fig. 3). Which agents have the highest fitness, is constantly changing (see Fig. 4).

What is the relevance of this simulation for global brain theory, since the global brain is emergent and way more complex? This simulation also looked to how a global distribution arose out of local behavior. In the standard case, the distribution moved to an attractor: it got stuck into one distribution, ie a power-law. In the opposition case, the distribution was constantly changing. This thus shows how the local influences the global.

In both cases, the global/environment also influences the local: in the standard case, since the total fitness is kept fixed, it depends on one's position whether one's fitness will grow or decay. In the opposition case, there is no influence except for the one at the top, who feels a big influence.

One reason I choose to do this simulation however, is that I want to focus on human agency, and do not want to assume a technological or economic determinism. I thus want to investigate how local decisions can influence the bigger structure. With technology for example, we could imagine a scenario as represented in the standard case: big corporations control everything, with a surveillance using the internet of things. But we also see the germs of an opposition to this tendency with open source, hacktivism, ….

5. More variables

In the previous model there was only one variable at play per agent (the fitness). The reality however, is more complex. We can represent the state of a system by a vector. A part of these variables will matter for a certain agent, its goal state is represented in this partits goal is in it. But an agent can have several preferred states, thus its goal is to getput the variables at one of these states. It might prefer some of these states overmore than others, but therey are also states for which it does n ot prefer the one over the other (we thus have a partial order). The variables can also depend on each other: changing the one might influence another.

Lets look at an example to illustrate this idea. Consider a system represented by the vector (a,ab,b,u), with two agents A anden B in it.

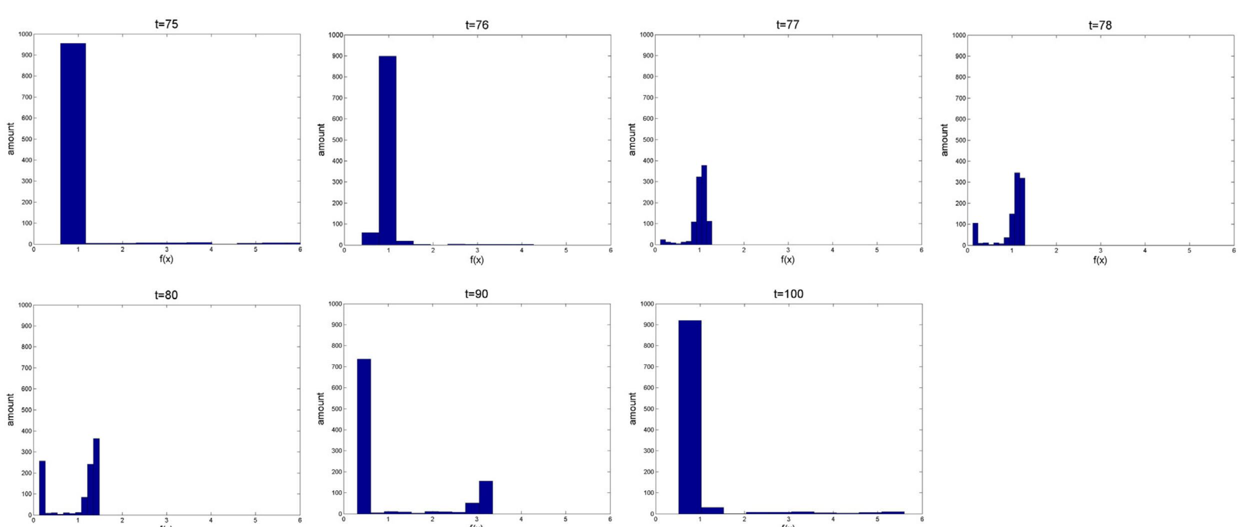

Fig. 3. The histograms in the case of opposition for $t=75,76,77,78$ (upper) and 80,90,100 (lower) respectively. This loop takes 25 iterations, and thus repeats itself four times during the simulation of 100 iterations.

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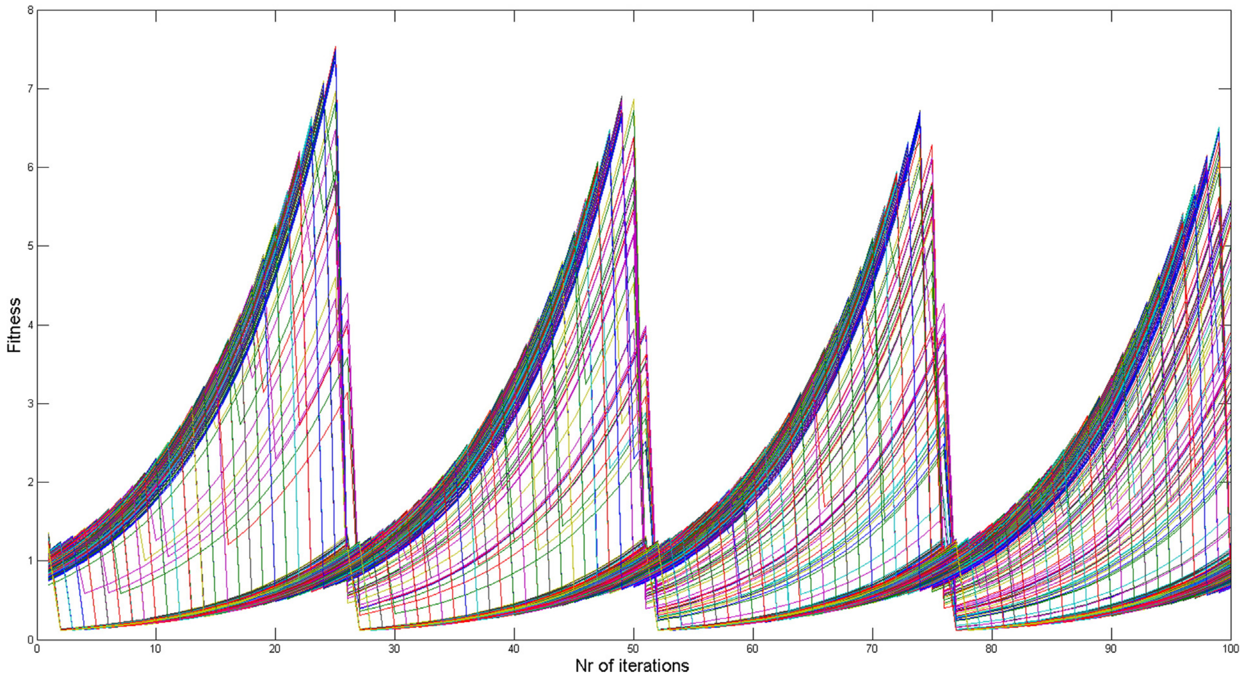

Fig. 4. The evolution of the fitness of all agents over time (100 iterations). We see that the fitness oscillates for all agents.

Imagine this as a game with four tiles that are on the one side black ("1"), and on the other side white ("0"). One could turn a tile to change its color, but this can also cause other tiles to flip. Agent A is interested in the variables (a,ab), and prefers them to have the states $(1,1)$ or $(0,0)$. Agent B cares about the variables (ab,b), and wants them to be $(1,1)$ or $(0,0)$. Thus agent A wants the first two tiles in (a,ab,b) to be the same, while B wants the last two variables to be equal. u is a variable none of the agents is interested in, but it influences the other variables. For $u=1$, we have following states for (a,ab,b): $(1,0,0)$, $(0,0,1)$, $(0,1,1)$, $(1,1,0)$. Thus the outer variables are always different from each other. Envisage this as that as soon as one of the outer tiles is turned (for example b), the other outer tile is also flipped (for example a). For each of these states, only one of the agents will be satisfied. Thus the agents will be in competition: each agent will constantly try to push to a state the other does n ot want. Unless one of them thinks about changing the variable u (although he is n ot affected by it). For $u=0$, following states of (a,ab,b) are possible: $(1,1,1)$, $(0,0,0)$,$(0,1,0)$, and $(1,0,1)$. The outer variables remain equal in this configuration. This can be achieved when flipping the tile u also changes a. Flipping one of the outer tiles still changes the other outer tile, but now this causes them to remain equal. Thus, only for the first two state s both agents are satisfied, for the other states none are satisfied. Then they will be in a cooperation mode: while there are states they both do n ot want, they will both strive for the same state.

The amount of variables that are considered important, also influences how the system will work. If there is just one variable, there is automatically an ordering, and thus in some sense a hierarchy. Having more variables makes it more difficult to order. The ability to order (and thus make a hierarchy) depends on how much the variables are correlated: if being good in one variable, automatically also makes one better in other, you will get a hierarchy again. This is also one of the reasons there is a hierarchy in capitalism: money is almost the only variable that matters in this system, and you will need money to reach a lot of your goals, it thus influences a lot of other variables.

6. In Chemical Organization Theory

The framework of Chemical Organization Theory (COT) (Dittrich and Fenizio, 2007) can be used to allow for multiple variables and model the emergence of a "bigger structure". The basic idea is to look at a certain *reaction network*, this is a set of molecules together with a set of reactions, and search for organizations formed by these reactions. These molecules can be anything, thus it is n ot constrained to the chemical sphere. A reaction hasis from the form $a+b\rightarrow c+d$, where a and b aregot *consumed*, and c and d are *produced*. Chemical organization theory then looks atto whether a certain subset of reactions-molecules can maintain itself (the consumption of a molecule is smaller than the production) and closed (there are no molecules produced that were n ot yet there). If this is the case, this subset is an organization. Everything in an organization got produced by the organization itself. COT thus gives a neat mathematical formalism forto the concept of autopoiesis (Varela et al., 1991).

Since this organization is an attractor state that maintains itself, it can be used to model how and when an imposing structure can rise. luhmLuhmann uses the concept of autopoiesis to discuss how social systems can maintain themselves. (Dittrich and Winter, 2008) applies Luhmann to COT, but it does this in a specific rather than conceptual way: it gives the specific reactions of a political system, and searches for the organizations in it.

COT is however still a deterministic model: the reactions are given, and given a certain set of molecules, the system will always evolve to the same set. Goals, and thus goal-directed behavior, are not directly defined in COT. Since I want to model how the emergent goals of the bigger structure interfere with the goals, and how a local agency can influence the bigger structure, indeterminism and goal-directed behavior should be introduced.

Areaction can be seen as a certain method, and the products of this reaction as the goal of the method. Extending to multiple reactions, we can say that in an organization (this is, a set of reactions that is closed and self-maintaining), the molecules involved are its 'goal' (since an organization wants to keep these molecules in existence).

To allow for indeterminism, I extend the model by introducing agents. This will allow agents to strive for their goals. An agent can choose certain methods (reactions) to reach its goal. An agent is thus a catalyst of a reaction: it makes a reaction possible, but it is n ot itself consumed or produced by it. We consider that each agent A_i has survival as its main goal, which we model by the molecule S_i. It has several sub-

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goals to reach survival. The set of goals is $G_i = G_{i,rival} + G_{i,non-rival}$, which is split according to whether a goal is rival or non-rival. We can explain the survival of an agent by following formula:

$$G_{i,rival} + G_{i,non-rival} \rightarrow G_{i,non-rival} + S_{i.}$$

Rival goals are thus goals that get consumed by the reaction, so that no other agent can use them anymore. An example are most material resources. A non-rival goal however does n ot get consumed, thus another agent can also use it. Note that the rivalness depends on the agent: a molecule can be rival for one agent, and non-rival for the other, depending on how one uses it.

It is however not necessary that all the goals are reached in order to have survival, and certain goals are more important than others. For this the formula of the reaction should get specified.

We would now want to check whether and when the impstrimposing structure spoken about in the beginning of this paper, emerges. The idea is to let certain methods emerge and disappear, by a trial-and-error of the agents. Hopefully after a while an organization emerges, where all the goals of the agents are satisfied, in a self-maintaining way. The question is then whether this organization will be rigid. To test this, the idea is to introduce a mutation (since the environment constantly evolves), and check whether the organization will adapt with it, or whether it will remain the same, despite not satisfying the goals of the agents anymore. A mutation can be a change in a reaction, in the goals of an agent, or by introducing/leaving out an agent.

The evolution from extoculexploiter to cultivator can be explained in cotcultCOT terms. We can see an exploiter as an agent that monopolizes (a) resource(s). It thus catalyzes a reaction of the form $A \rightarrow 0$ (with A the resource it monopolizes). It evolves to a cultivator by building an organization that overproduces A, so that it can take A out of it in a maintaining way. A resource is overproduced when it is more produced than consumed.

But this organization creates a dependency relationship for the agents in it: they can no longer provide for their goals themselves, but depend on the bigger structure to reach them. There is also only a part of the agent the bigger structure is interested in: the part that provides the resources it is interested in. If it can find an easier way to get these resources, it will replace the agent (for the bigger structure, the agent is simply an input-output blackbox).

These are some useful starting points for using COT to model this process, but elaborating this is work for the future.

7. Conclusion: lessons for global brain

To summarize, I investigated in this paper the coevolinterplay we see in several domains, where agents create a system, but this system in turn influences the agents. This system could then become more impstrrigid, where it escapes out of the control of the agents and starts to follow its own goals. This system might be a extoculcultivator, enabling the survival of the individual agents, but I argued how this can create a dependency relationship for the constituting agents.

Next, I gave several alternatives to avoid getting in this status quo, which can be categorized into two practices. First, one should leave the urge to try to make a blueprint for society, to try to reach a globglobal decision. There are manvarmany variables at play in society, and one variable or utility measurement cannot adequately capture the complexity of the world. Second, I argued that a cstoppconstant opposition can be usedagainst such a rigid structure. I did a simulation to illustrate this idea.

These considerations are important to take into account when thinking about the global brain.

It is thus not that difficult to imagine that this structure will develop its own goals, which might become more and more independent of individual goals (although these individuals constitute and sustain the global brain). I discussed how such a process is possible even with the evolution to aextoculcultivator, and described this process with cotcultCOT. This is already more or less happening today (where we for example see that a state is n ot really fulfilling individual needs), but the danger with the global brain is that it would be more intelligent than the hierarchical system of today. It would be a self-organizing, emergent system, and thus it could n ot simply get dismantled by taking away the top. The stronger this structure will be, the more difficult it will be to break it down. Thus, if it would be omnipotent and omnipresent (as argued in (Heylighen, 2014a)), won't it also be impossible to resist?

The internet could further alienate our democrdecisions from our acts, where people are stuck in a virtual world where they can raise all kinds of opinions, but without these being connected to their acts and everyday lives.

But the global brain can also be viewed in a more positive light. It could enable people to build the world they want to live in, where the techtechnology, structure and coordination will be formed to aid with this liberation. The internet could enable people to put their ideas into practice, by providing tools, resources and people. The global brain would be a constantly evolving structure, a dynamical play full of differentiation and experimentation. To make this possible, I think there needs to be a cstoppconstant opposition to avoid being stuck in a stable attractor state. We should avoid that the new vision becomes a dogma, where it becomes a impstrrestricting structure that owns us instead of we owning it. There should be a diversity of methods, and we should as much as possible avoid to use manvarone utility measure or make one globglobal decision.

I do not think the path the global brain will take is already predetermined, it is up to us to build the type of global brain we would like to have.

References

Bakunin, M.A., Kenafick, K.J., 1950. Marxism, Freedom and the State. Freedom Press London.
Banathy, B.H., 2013. Guided Evolution of Society: A Systems View. Springer Science & Business Media, Mar.
Barrett, D., 2010. Supernormal Stimuli: How Primal Urges Overran their Evolutionary Purpose. W.W. Norton & Co. (Feb.).
Busseniers, E., 2016. Is external control important for internal control? J. Sociocybernetics (in press).
Dittrich, P., Fenizio, P.S.d., 2007. Chemical organisation theory. Bull. Math. Biol. 69, 1199–1231 (Apr.).
Dittrich, P., Winter, L., 2008. Chemical organizations in a toy model of the political system. Adv. Complex Syst. 11 (04), 609.
Feinberg, L., 1996. Transgender Warriors: Making History from Joan of Arc to Dennis Rodman. Beacon Press.
Gelderloos, P., 2005. The Rise of Hierarchy. The Anarchist Library.
Heylighen, F., 2006. Mediator evolution: a general scenario for the origin of dynamical hierarchies. Worldviews, Science and Us.(Singapore: World Scientific).
Heylighen, F., 2014a. Return to Eden? Promises and perils on the road to a global superintelligence. The End of the Beginning: Life, Society and Economy on the Brink of the Singularity (Retrieved from http://pespmc1.vub.ac.be/Papers/BrinkofSingularity.pdf).
Heylighen, F., 2014b. Complexity and Evolution: Fundamental Concepts of a New Scientific Worldview. ECCO, Vrije Universiteit Brussel, Brussels (00000).
Laland, K.N., Odling-Smee, J., Feldman, M.W., 2001. Cultural niche construction and human evolution. J. Evol. Biol. 14 (1), 22–33.
Lenartowicz, M., 2016. Creatures of the semiosphere: a problematic third party in the 'humans plus technology' cognitive architecture of the future global superintelligence. Technol. Forecast. Soc. Chang. (in this issue).
Maslow, A.H., 1943d. A theory of human motivation. Psychol. Rev. 50 (4), 370.
Mitzenmacher, M., 2003. A brief history of generative models for power law and lognormal distributions. Internet Math. 1 (2), 226–251.
Moeller, H.-G., 2012. The Radical Luhmann. Columbia University Press.
Passamani, M., 2010. "More, much More" and Other Writings. The Anarchist Library.
Roughgarden, J., 2013. Evolution's Rainbow: Diversity, Gender, and Sexuality in Nature and People. Univ of California Press.
Silberzahn, R., Uhlmann, E.L., 2015. Crowdsourced research: many hands make tight work. Nature 526, 189–191 (Oct.).
Stewart, J.E., 2014. The direction of evolution: the rise of cooperative organization. Biosystems 123, 27–36.
Stirner, M., Leopold, D., 1995. Stirner: The Ego and Its Own. Cambridge university press.
Thaler, R.H., Sunstein, C.R., 2003. Libertarian paternalism. Am. Econ. Rev. 93 (2), 175–179.

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Varela, F.G., Maturana, H.R., Uribe, R., 1991. Autopoiesis: the organization of living systems, its characterization and a model. Facets of Systems Science, No. 7 in International Federation for Systems Research International Series on Systems Science and Engineering. Springer, US, pp. 559–569 http://dx.doi.org/10.1007/978-1-4899-0718-9_40.

Veitas, V., Weinbaum, D., 2014. A World of Views: A World of Interacting Post-human Intelligences (arXiv preprint arXiv:1410.6915).

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