

**DISCUSSION PAPER**

# The social dynamics of basins of attraction.

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# THE SOCIAL DYNAMICS OF BASINS OF ATTRACTION

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## **Abstract**

This paper conceptualizes social-ecological, or socio-environmental transformations as societal shifts from one basin of attraction to another. Such transitions occur when a society's information processing apparatus is no longer suitable to deal with the dynamics in which the society is involved. To understand when this might be the case, we conceive of two dynamic niches, one in the mind, containing an individual's or a society's knowledge, values, language, customs and technology that structure the information processing, and one consisting of the dynamics of the environment. The two niches interact through resonance and co-evolve to shape both the information-processing of a society (its culture) and the interplay with the environment. Crucial in this dynamic is the process of category formation. Here, we differentiate between 'closed' and 'open' categories, which allows us to dynamically relate, but distinguish, a certainty sphere (closed categories dominate), a possibility sphere (open categories dominate) and a problem sphere (absence of categories) in relation to shifts in basins of attraction. Narratives anchor societies' values and dynamics and, therefore, are of significance in the dynamics of basins of attraction. They shape the wider culture of society, making phenomena comprehensible. In order to foster cultural transitions, narratives need to be modified. To do so, one has to search for narratives in which open categories dominate, and then insert new elements in them. This requires an analysis of the narratives to determine their degree of openness. A tentative approach to such an analysis is offered and discussed in relation to emerging new narratives coevolving with the dynamics of the realities of the Anthropocene.

## **Introduction**

The concepts of "attractor" and "basin of attraction", which originated with the emergence of the Complex Adaptive Systems approach (Milnor 1985, Grebogi et al 1987), are increasingly relevant to discussions around the need to transform our societies in order to attain a more sustainable relation between them and the environmental dynamics in which they are embedded (Westley et al. 2011, Carpenter et al. 2019, Schlüter et al. 2019). Yet there is insufficient clarity and agreement on the meaning, function and impact of these concepts (e.g. <https://be-benevolution.com/2020/01/31/attractors/>). Here, we present a perspective on the dynamics of societal transitions that details the role of basins of attraction.

In studying the Anthropocene it is not effective to separate societal from environmental dynamics. They are deeply intertwined (Reyers et al. 2018). As expressed by McGlade (1995), there is no social (sub)system nor an environmental one; there are only human perceptions of, and actions on, the integrated, dynamic, social and natural environment.

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With the introduction of the Anthropocene as a concept, our societies are no longer seen to be (merely) re-acting (adapting) to environmental dynamics, but to be inter-active, impacting in a major way on and even shaping the non-human dynamics. The scale, connectivity and speed of the human dimension have become a major driver of Earth system dynamics (Steffen et al. 2018). It follows that in order to understand these integrated dynamics, we need to complement an essentially external, environmental perspective with an internal one, conceiving them as societally driven. Societies selectively define what they consider their environments, what they see as challenges in those environments, and what might be potential solutions for these challenges. Or, as Luhmann (1992) has phrased it, “societies do not exchange information with the environment, they exchange information about the environment among themselves, in a self-referential manner”.

Society interacts with its environment through the filter of its cognition of the phenomena in that environment, i.e. through its information processing apparatus. Only those aspects of the environment that pass through that filter are perceived as social-environmental interactions and form the basis for human interpretations, behaviors, norms, and actions relative to the environment. This implies that interactions not captured by a society’s information processing apparatus remain invisible to society. Such hidden phenomena often appear later as surprises, caused by broader scale patterns emerging from interactions of local actors and agents that feed back onto society (Holling & Meffe 1996, Levin et al. 2013).

*Essential to an improved understanding of our current sustainability conundrum, therefore, is knowledge about the interaction between on the one hand our understanding of the realm of external phenomena, and on the other our actions upon that realm.* Though important efforts have been devoted to studying the dynamics of our environments and their impacts on our societies (e.g. IPCC 1996-2019), comparatively less attention has been devoted to the internal dynamics of our societies and how they impact on and shape our interactions with the environment.

For its survival, any society has to deal with the environmental conditions it is facing, including those it has created itself because of unintended consequences of its earlier actions. To do so, following Luhmann’s (1992) approach, society’s information-processing apparatus must be up to the task. This includes capturing the significant features of the external dynamics and the management of the society’s internal dynamics. That apparatus has itself co-evolved with the society and its environment, and we need to understand that co-evolution (e.g. Jørgensen et al. 2019).

To apply this to the need for a fundamental organizational transformation of our societies (Westley et al. 2011), we could re-define the current crisis as *an incapacity of our societies’ information processing to deal with the dynamics in which they are involved* (van der Leeuw 2019a: 334). This perspective highlights the subjectivity of human perceptions of, and actions upon, the environment and emphasizes societies’ internal cognitive dynamics. A society’s conceptual, institutional and material organization is seen as part of its information processing apparatus because its ideas, its social organization and its technology favor certain perceptions and neglect other ones. The current system is driving us in the wrong direction (Zhang and van der Leeuw in press). In order to achieve a sustainable, healthy relation between our societies, their environments and the biosphere within which they are embedded, we need to structurally change our collective ways of doing things!

## Attractors and basins of attraction

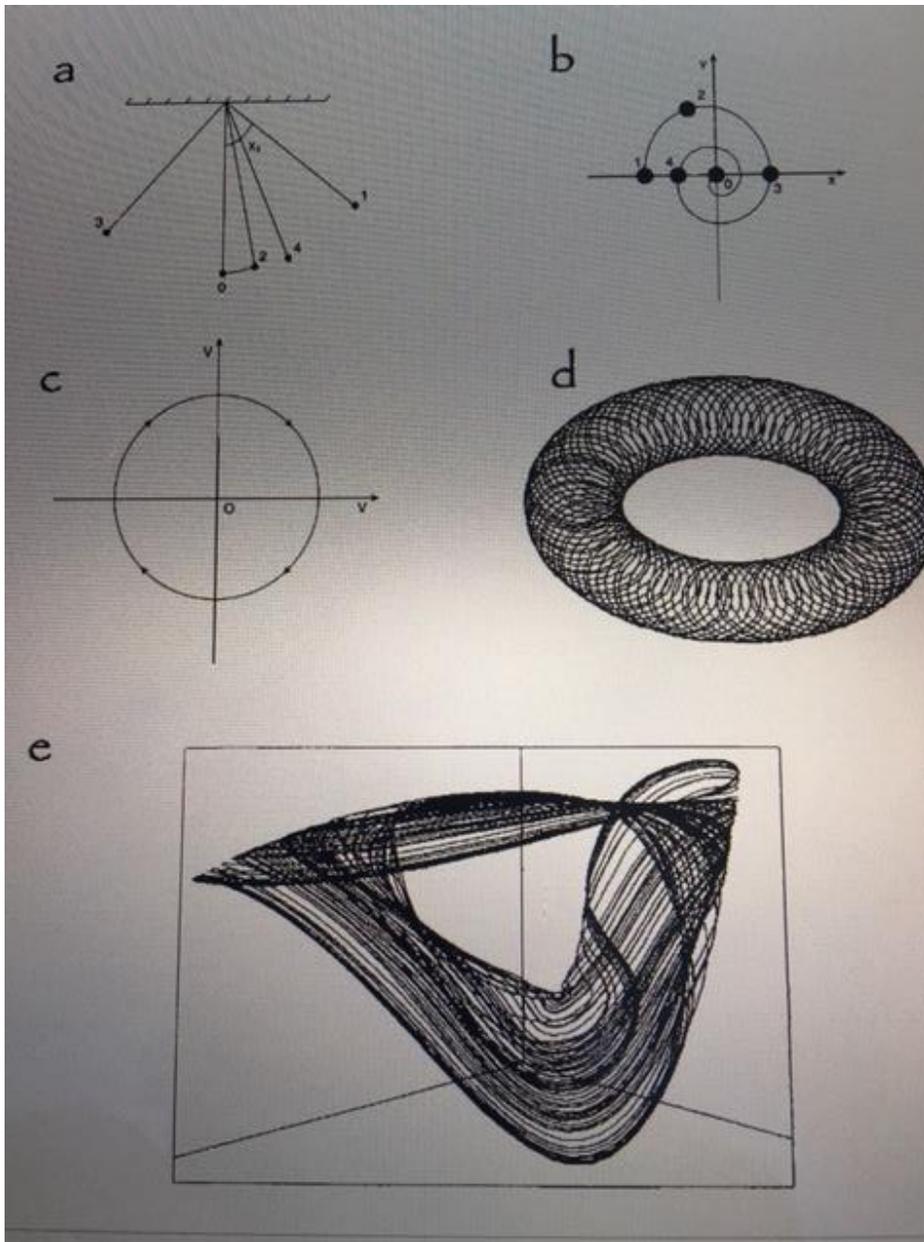
Now let us focus on the core of this paper: attractors and basins of attraction. Any system's trajectory through time is determined by its interaction with its environment. If, within that environment (whether natural or societal, technological or other), a number of factors together exert a sufficiently strong and focused attracting influence on the system's trajectory, we can speak of a "basin of attraction". In the (in social dynamics improbable) case that one factor completely dominates the system, we can speak of a single "attractor".

To illustrate this, we can look at trajectories that are impacted by one or a few different attractors with different periodicities (Figure 1). If there is only one attractor, such as gravity in the case of a swinging pendulum, no matter in which direction the pendulum is moving at the outset, that pendulum will end, stably, at the bottom of its trajectory (Figure 1a,b). If there are two attractors of equal force and periodicity, the case may occur that the system keeps going around and around, as is illustrated in Figure 1c. If there are two attractors of different force and/or periodicity, we may also see a "torus" trajectory (Figure 1d). However, in the reality of a complex social system, in which there are always many different forces at play, the most probable situation is that of a "strange attractor", which makes the system move in very complex directions (Figure 1e).

Any societal system is always subject to forces of many kinds, attracting it in different directions. As the system's dynamics unfold, it will be attracted at different times towards different basins of attraction, and move in different directions. There will be substantive transitions when the system's dynamics move from the attraction of one basin to that of another. Of course, this is driven by the interaction between the internal dynamics of the system and the external dynamics among the basins of attraction involved (Scheffer 2009). That interaction, in turn, is shaped by the co-evolution of the society's information-processing apparatus with its environment. It may steer the system towards very different future states. The question to ask is therefore: *"Could tweaking basins of attraction and a society's perceptions of them, at least theoretically, influence the trajectory a system takes?"*

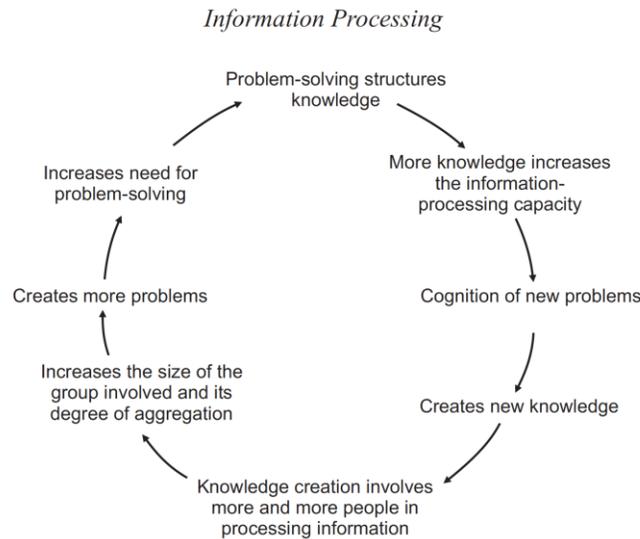
## Human information processing structures societies

But before we can answer that question, we must first answer a different one: *"What is it exactly that constitutes a basin of attraction for a society?"* In a simple way, we might define a basin of attraction for a society as *the ensemble of dynamics, external, internal and intertwined that resonate with the cognitive capabilities of a society*. One way to represent a basin of attraction is as a dynamic network in which some dynamics may be repelling, while others are attracting. There may also be unperceived dynamics, but society can only act upon the perceived ones.



**Figure 1:** Examples of the (relatively simple) trajectories a system follows under the impact of one, two, three or more attractors. For explanation, see text.

Hence, all perceived interactions between human beings, groups or societies and their environments pass through the filter of human cognition in the form of information. We propose the following model of that filter, and how it processes information (Figure 2).



**Figure 2:** The information processing loop (see text) (after van der Leeuw 2006)

The loop links the outside world (the realm of phenomena) with the cognitive capacity (the realm of ideas), of the human beings involved, which interact through resonance. This refers to the work on “niche construction” (Schrödinger 1944, Lewontin 1983, Odling-Smee et al. 2003), reflecting situations where animals change local conditions to suit their characteristics. Examples include the building of nests, burrows, mounds, and other artifacts by animals; the alteration of physical and chemical conditions; the creation of shade, influencing wind speed; and the alteration of nutrient cycling by plants. When such modifications alter natural selection pressures, evolution by niche construction is a possible outcome. In this approach, the fundamental idea is that the animal and its environment impact on each other, so that there is an interactive dynamic between the two. The environment enables a species to flourish, and in doing so, the species shapes the environment (Laubichler & Renn, 2018). Others have used the same, or a related, approach to sociotechnical innovations (e.g. Geels et al. 2017).

Following Iriki (2019), in this paper we conceive of the interaction between a society and its basin(s) of attraction as an interaction between two dynamic niches, an internal one (comprising the information-processing apparatus, including mental and external elements such as artefacts) and an external one (the external niche the mind interacts with), which resonate with and shape each other.

Observations are interpreted when resonating with existing interpretative schemes and provide information to those schemes. But because the outside world is more highly multi-dimensional than the interpretive tools it resonates with, observations are not completely interpreted by those tools. The resonance therefore also triggers challenges to the information-processing apparatus in the form of questions or problems. Meeting them will further enhance the processing capacity involved, which will then resonate with new observations, so that the cycle starts anew.

The two niches concurrently co-evolve to shape both the information-processing of a society and the environment with which it interacts. But there is an important difference related to the direction of the interactions between the mind and the outside world. The categories that humans

derive from their observations selectively reduce the total, almost infinite, complexity of the dynamics observed. And when human beings act upon the environment they have observed, their simplified conceptions are confronted with the much more complex dynamics in the outside niche involved. Because of the difference in dimensionality between the perception and the reality of the environment, any human action upon the latter has unperceived consequences and is subject to “ontological uncertainty” (Lane & Maxfield 1997) – the impossibility to predict the outcome of such actions, at least at the systemic level and over the longer term. The evolution of a society’s knowledge structure *drives* the trajectory of human-environmental interaction, but only partly *directs* it.

Each group of human beings thus constructs its information processing apparatus, which anthropologists call ‘culture’ (Wyer 2009). It is formed path-dependently by observing phenomena, interpreting them, testing the interpretation until deemed adequate, then adopting it to observe new phenomena, gain new insights, develop new analytical methods, and further enlarge the scope of the phenomena that can be interpreted coherently. The result comprises the ensemble of what the group can collectively perceive and how it cognizes, what it responds to, and how it responds. Culture is thus the result of a long-term *path-dependent* interaction between the internal and the external niche, an interaction specific for each and every society, group or individual. Although the impact of the society on the basin(s) of attraction that it interacts with reflects that culture, it is only known by the members of the society involved in so far as it resonates with their information-processing apparatus.

### **The extended epigenetic evolution of the human information processing system**

The main constraint on the growth of individual or societal information-processing capacity is the development of the inside niche, the human knowledge system itself (for a detailed example, see van der Leeuw 2013). This is where Iriki’s concept of “extended epigenetic evolution” (2019) comes in. He argues that in the process of expanding human information-processing capacity, some of that capacity is delegated to language, technology, the environment etc. Concepts and artefacts, for example, fix certain kinds of information processing in the conceptual and linguistic, or the material, technological or institutional realm by ‘crystallizing’ them as specific ‘tools for thought and action’. They determine that certain actions in the material realm follow set patterns, short-circuiting part of the information-processing involved and alleviating the overall information processing load.

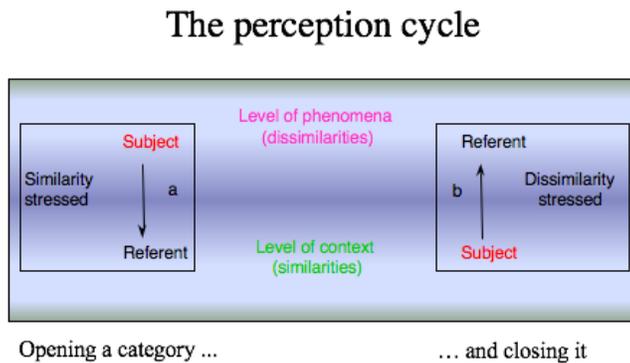
In this manner, part of information-processing is simultaneously routinized and displaced outside the mind. The mechanics of a car, for example, relieve the driver from thinking about the engine, reducing the information processing needed for driving to steering, signaling and regulating the car’s speed. At the societal level, the same is ensured by establishing the legal and administrative rules needed to function adequately.

In the process, through communication and collective information processing, a society also aligns its members by adopting a set of behavioral rules. These rules enables the members to function collectively and to be selectively aware of their basin(s) of attraction. As the information-processing system evolves, it relates to more and more dimensions of the basin(s) of attraction that shape its trajectory.

## The role of categorization

In the interaction between the realm of ideas and that of phenomena, the dynamics of categorization play an important role. To discuss these, we will use a simplified model of categorization in relation to decision-making under uncertainty (Tversky 1977, Tverski & Gati 1978, Kahnemann et al. 1982) (Fig. 3).<sup>4</sup>

Categorization combines a number of phenomena into a category that is distinguishable by adopting one or more of their characteristics as a label. That process requires pattern recognition, a comparison between similarities and dissimilarities among the phenomena observed. In the first phase of that process, the category is the subject and the phenomena is the referent. There is thus a bias in favor of similarity: an emphasis on what might unite the observed phenomena into a category. But when the relevant category is firmly established, the process is inverted: the categories become the referents and the phenomena the subjects, so that the comparisons are biased towards dissimilarity, and it is determined which phenomena, after all, did not belong in the categories established.



**Figure 3:** Category formation according to Tverski and Gati 1978 (illustration from van der Leeuw 2019a)

We all know this phenomenon in our scientific work since Kuhn's research on scientific revolutions (1962). When faced with unknown phenomena, we first create open categories by developing hypotheses about those phenomena that emphasize their similarity. Little by little, we then whittle away at the phenomena concerned by the hypotheses, in order to get a better handle on them. In so doing, we emphasize what seem the most important dimensions of the phenomena concerned, thus transforming the hypotheses into definitions (closed categories). And once we have defined a set of categories, those co-determine further investigations on different phenomena, so that a path-dependent knowledge structure is built up.

In this process, one can distinguish three different 'cognitive spheres' or 'cognitive spaces' that are interact in the mind (van der Leeuw 1993):

- A '*certainty sphere*' which is made up of the 'closed' categories, ensuring that a person, group, or society knows exactly what is what, and has fixed ideas on how to proceed;

<sup>4</sup> For a more extensive summary, see van der Leeuw 2019a

- A *'possibility sphere'*, which consists of the 'open' categories, where the mind is still to some extent undecided, and therefore flexible in its interactions;
- A *'problem sphere'*, consisting of the domain for which there are no categories (yet), and which therefore is that of unknown or dimly perceived, unsolved challenges.

If we then consider in detail how the problem sphere is shaped, one needs to take into account that human perception of the present iteratively relates information about an assumed past to information about personal experience in the present, and projects the resulting vector into the future. In other words, there is an interaction between perception from an 'a posteriori' perspective (of the past) which limits variation, and perception from an 'a priori' point of view (of the future), which opens opportunity for variation. The latter is focused on emergence, on novelty and on possibilities and probabilities ('opening' categories), while the former is focused on origins, on tradition, and on causality ('closing' categories). It is in that interaction that invention takes place. Often, crisis (perceived or 'real') opens up space for an intense interplay between such 'memory' and 'novelty' that may lead to shifts in basins of attraction (Gunderson and Holling 2002)

### **The role of narratives**

What anchors a culture is an incredibly complex dynamic between a society's cognitive and perceptual dynamics, its network structures and its environmental context, all interacting within the path-dependent trajectory that shaped its dynamics. As a function of these a society defines its identity, shapes the epistemology through which it interacts with its environment, establishes its fundamental values and much more. All these are deeply anchored in the minds of its members, and determine their outlook, their opinions and their decisions. This anchor is so complex that we can only partly hope to unravel it, map it, understand it, or modify it.

The way to approach that problem is through the identification and modification of the culture's narratives (van der Leeuw 2019b). Narratives occur in all societies, from the distant past (e.g. the 3<sup>rd</sup> millennium BCE Gilgamesh epic in Mesopotamia) to the present and have a similar function: as superficially linear (and therefore low-dimensional) told or written stories, they summarize events in a highly multidimensional world by referring to "Gestalts". Such narratives emerge to 'explain' an unknown phenomenon in terms of the culture that experiences it. The narrative acculturates a phenomenon into the wider culture of the society involved.

The "Gestalts" involved are deeply anchored in the culture – so that the narratives or myths connect the people among whom they are told with their culture. A narrative asserts their identity and their way of doing things. The link between the (uni-)linear stories and the multi-dimensional world is constructed through resonance: the narrative refers to multidimensional characters that are part of the symbolic riches of the cultures involved.

### **Imagined futures**

Jens Beckert (2016) argues that human decisions and actions are driven by "imagined futures". Since 1750, according to him, as the western perspective on the future opened up (Girard 1990), this set in motion a (uniquely 'Western') cognitive feed-forward loop that creates in our individual and collective minds "imagined futures" and then develops "fictional expectations" that motivate people towards realizing them. In Beckert's words: "... expectations of the unforeseeable future

inhabit the mind not as foreknowledge but as contingent imaginaries (2016, 9) [...] they create a world of their own into which actors can (and do) project themselves” (2016, 10). These fictional expectations are anchored in narratives that are continually adapted.

The exchange between such imagined futures and present conditions shapes the narratives people develop or adhere to, which in turn drive our imagined futures and our decision-making. Hence, “fictionality, far from being a lamentable but inconsequential moment of the future’s fundamental uncertainty, is a constitutive element of capitalist dynamics, including economic crises (Beckert 2016,12)”. He illustrates that in his book in detail for four main pillars of any economy: money, credit, investment and innovation.

The implications for the role of narratives in shaping our imagined futures stretch far beyond the economy. *First*, narratives express the cultural, institutional and social embeddedness of our human decision-making. Decisions reflect the value systems of the people concerned; they are shaped in the interaction networks of these people. The UN’s Sustainable Development Goals, for example, are in essence based on a Western imagined future of continued ‘progress’ that, as part of globalization, has been projected onto other cultures. In other parts of the world, one finds very different imagined futures underneath that global projection.

*Second*, imagined futures are constructed by comparing the present to an experienced past and an imagined future (van der Leeuw 2019b), and they are maintained only as long as there is confidence in that future, and by implication as long as the balance between open and closed categories is in favor of the latter. In the absence of such confidence, when open categories dominate, a degradation in the clarity of a society’s perceptions and certainties, or even a crisis, is experienced.

The anticipatory loop can then, very rapidly, be turned in a negative direction characterized by self-fulfilling negative dynamics driving towards uncertainty, as in the case of recent financial crises. But this is not confined to such sharp crises – it can also slowly undermine the totality of our confidence in the future and result in hesitations, contradictory actions and general loss of self-confidence.

*Third*, we need to consider the relationship between our imagined futures and the ‘real world out there’. That interaction is clearly an open-ended one that is not fully controllable. As the imagined futures are confronted with the material and social “real” world, it is impossible to predict the outcome of such confrontations, especially over the longer term, due to changes in the second-order dynamics of the context in which shorter-term decisions are made. This can theoretically very rapidly transform peace into war, progress into the opposite, trust into distrust.

But shocks, extreme events or real world crises may also unlock competing narratives and imagined futures that have slowly emerged and been in the shadow, been waiting in the wings for windows of opportunities to transition communities, economies, societies, into other pathways (Gunderson et al. 1995, Gelcich et al. 2010, Herrfahrtd-Pähle et al. 2020). Such events may also move the information processing loop (Figure 2) into systemic understanding of the bigger picture, triggering paradigm shifts, spread of social innovation, and new forms of collective action (Olsson et al. 2008, Westley et al. 2017, Carpenter et al. 2019).

## **A society always sits astride different fields of tension and has to make choices**

Could tweaking basins of attraction and a society's perceptions of them, at least theoretically, influence the trajectory a system takes?

To answer that question, we must first look at the wider dynamic landscape around the society. It encompasses numerous basins of attraction. The society's trajectory is therefore in part determined by the fields of tension existing between these basins of attraction. As that trajectory unfolds, there will be moments when those tensions make themselves felt or seen, so that the need for systemic choices between different trajectories becomes clear. In Complex Systems language, one speaks of "bifurcation points", points in the trajectory at which it is necessary for human information processing to adopt a radically different structure ("paradigm change") to enable a society to continue to coherently exist. One such moment in our history is the present one, at which a transformation in our fundamental societal values and culture is called for if we, as a human species, are to find a sustainable relationship with the broader environment, the Earth system and its biosphere, which we are embedded within and dependent upon (Folke et al. 2016).

That raises two questions: "Can we influence the way in which a societal system proceeds once it has reached a bifurcation point?", and "If we can, how do we do so?" We will devote much of the remainder of this paper to an attempt to answer these two questions.

The core of the answer to both questions lies in the relationship between Iriki's (2019) two niches. If we were to be able to influence the internal niche, that would imply that other aspects of the environment were cognized, and that the external niche would resonate differently with the internal one. This is what underlies efforts towards sustainable futures or biosphere stewardship (Westley et al. 2011, Folke et al. 2016). In effect, the basin of attraction would be modified and the society's trajectory would become subject to the influence of other attractors. So, the first question is: "What anchors a society's basin of attraction?"

### **What anchors a basin of attraction?**

In a study of the dynamics of innovation in technology, one of us came to conclude that any approach to exercising a technique is anchored at minimally three different levels, in increasing order of flexibility and opportunity for change (van der Leeuw 1993):

1. The slowest to change is the collective knowledge that is shared between the members of the community involved. Change at this level involves changing the worldview of the community, its habitus, its approach to technology. The main barrier to such change is that the perspective of the community is limited by the things it has never thought about and which it therefore has no way to describe, analyze or conceptualize. Breaking through that barrier is itself a major invention/innovation.
2. At the level of the individual one has to take tacit knowledge ('know-how') into account, which has either been subsumed under more conscious conceptual knowledge and customs or resides in the physical, neuro-muscular behavior of the human body. It is difficult to change as it is not embedded in our conscious memory but is exercised as routine, without conscious thought.
3. But the individual also has conscious knowledge ('know that'), which is subject to conscious learning and is therefore the easiest and quickest to change. It actively involves the conscious mind, planning and changing behavior. Yet one must remember that such conscious knowledge

is also limited by its boundary with the unknown—those processes, questions, and challenges that one has never thought about. It is in this domain that changes are made most easily.

As we have argued above, categorization is fundamental to niche creation. It is reflected in the narratives that maintain a niche. The three levels just mentioned distinguish between the narratives (or parts thereof) that are open to change, and those that are not. If the narrative is predominantly constituted of closed categories, it will fall in category 1 – the collective knowledge that is difficult to change. But if open categories dominate, there is a degree of indeterminacy about the narrative that implies that variations can be considered in the implementation of the narrative concerned, as in the case of category 2. Category 3 refers to the resources involved in the implementation of the narratives – these are easiest to change. Knowing this, the next question is of course “Where and how does change occur?”

### **The dynamics of change as articulation between the two niches**

The challenge, if one wants to change narratives is therefore twofold. First, one has to identify narratives that are changeable because they include a number of open categories, and then one has to insert elements in those narratives that favor the system to change direction. To illustrate this, we focus on how such a move could occur in a technology.<sup>5</sup>

Much of the current advertising industry depends on designing narratives that change people’s attitudes to particular products or ways of doing things. A beautiful published example of the challenges encountered in doing so, but also the success achieved when this is done, is the story of Lane and Maxfield (2009) on the introduction of distributed control networks (LonWorks) by Echelon. An important element in this story is the role of the general cultural background in the acceptance of such narratives. In this case, whereas development of the technology initially was lauded but then hindered in the US, it was accepted in Italy.

At the interface between society and the environment, technologies do not follow either the logic of the society or that of an external basin of attraction, but are determined by the resonance between them. The constraints and affordances of the material world constitute the external niche, and the perspective of the person shaping the technology constitutes the internal niche. Due to the limitations of our Short-Term Working Memory, the latter is always a simplified and biased version of the former (Read and van der Leeuw 2008). Though change may be either exogenous (e.g. a change in raw material use because of an environmental change) or endogenous (e.g. a change in the maker’s perception that introduces a change in the manufacturing process, thus requiring a different raw material), in both cases *it is the change in the internal niche, the information processing by the maker, that instantiates the technology change.*

Narratives reflect the state of the internal niche (the society’s information processing apparatus). Thus, a change in narrative is always the driver as well as the signal of a transition between basins of attraction, whether driven by exogenous or by endogenous dynamics. Such changes in narrative occur regularly in any interaction between the cognitive apparatus of a society and the dynamics of its environment, including consecutive basins of attraction. In science, we call

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<sup>5</sup> For a more extensive explanation of this part of our model, see van der Leeuw 2019a.

them changes of paradigm, occurring when more and more phenomena cannot be explained by the pre-existing one (Kuhn 1962).

Over time, such adjustments between a society's information processing and the succession of basins of attraction that impact on it engender a co-evolution that in turn shapes the wider context of further change. Innovations create a dependency relationship with their niches in a specific context, and when that context changes, the invention may well disappear or be transformed. Conversely, if the innovation is no longer produced, the niche will disappear.

In such a technological co-evolution, each and every choice, once made, limits the total option set for future choices and generates its own set of unintended consequences, eventually leading to new innovations. The domain in which material and procedural inventions occur, which we could call the "technosphere", generates its own dynamics, which does in part shape, but is also shaped by, the path dependency of a society around its evolving technology.

The same is true of every social, organizational, and institutional choice made. We can extend this model of technological change to the wider area of society's non-technological narratives, concerning societal and cultural changes. On the one hand, the model of the external niche should be as complete and unbiased as possible, referring to the different relevant functions, materials, techniques, etc. that constitute that context in the world out there. On the other, the internal niche should include the actor's subjective views, as reflected in the relevant narratives relating to that context. That latter perspective is always partial, biased, and part-driven by social, cultural, personal and other factors external to the material context of innovation, and its object of study is how the maker's perception articulates these factors with the external world.

### **Attractors and basins of attraction for sustainability**

Here, we have suggested that narratives serve as social attractors towards which behavior, society, and culture self-organize. We have also proposed that 'guided by' an overall narrative(s), the complex self-organization dynamics between the 'collective mind' of a society with its information-processing tools and the dynamics of a society's environment - the adaptive dance of the two niches - coevolves and shapes basins of attraction. As a result, some of these basins remain shallow and easy to change, while others become deep, persistent and difficult to move out of.

All human groups operate around shared narratives, which create identity, meaning, and core values and shape the epistemology through which they interact with the broader environment. All these are deeply anchored in the minds of its members, and frame their outlook, their opinions and their decisions, consciously or unconsciously. Some examples of such more or less persistent systemic narratives that have shaped society, culture and civilization are Christianity in Western Europe, Communism in the USSR and Eastern Europe, Manifest Destiny in the USA, indigenous cosmologies among the original inhabitants of the Americas, Sunni and Shiite Islam in many parts of Asia, Fascism in 20<sup>th</sup> century Western European and South American countries. Of course, these are examples at the most general level for large numbers of people. Narratives adhered to by smaller subsections of such populations are often embedded in these larger narratives, such as protestant, catholic and orthodox narratives among the Christian populations of Europe, or, at an even lower level, the narratives of the various evangelical sects in North America.

As we have proposed, an observed change in narratives is a central driver as well as a signal of the likelihood of a transition between basins of attraction, whether driven by exogenous or by endogenous dynamics. When open categories dominate in a narrative, that narrative is to some extent open to change, but when closed categories dominate, it is not.

We have also proposed that changes in narrative occur when there is an increasing mismatch of the interaction between the cognitive apparatus of a society and the dynamics of its environment, that is, when more and more phenomena cannot be explained by the pre-existing narrative. This is the time for paradigm shifts, or shifts in basins of attraction, and the emergence of new basins of attraction.

There is a discussion whether or not contemporary globalised society is approaching such a shift (or alternatively, that many contemporary societies and cultures are at the brink of such shifts), whether or not open or closed categories dominate the narrative. In science, this is reflected in the growing number of calls for transformative change towards sustainability (Westley et al. 2011, Hackmann and St. Clair 2012). In society, social discontent and rising fluctuations characterize a phase of uncertainty and exploration (Carpenter et al. 2019), and extreme events and shocks have exposed the tightly connected globalised world and its associated vulnerabilities (Nysström et al. 2019).

How can we distinguish closed from open categories in narratives? A promising way forward, tested as part of the ARCHAEOMEDES project undertaken in the 1990's, is a method developed for analyzing interviews (Langevin and Wirtz 1997a,b). By scanning through each interview from beginning to end, the authors looked at the full interview sequence as a whole, and calculated the expected and observed entropy of the individual statements in the interview. They thereby retained the information conveyed by the internal chronology and the contextual dynamics of the interviews, and were able to compare the mode of expression of the speaker on different topics. The difference between expected and observed entropy varied within interviews, along with the topics the interviews were talking about. If the interviewees were talking about the past, for example, life as they lived it in their youth, there would be much less difference between the two entropies than if they were talking about more recent, personal experiences. In that case, the observed entropy was much more important than the expected one. This reflects that less certainty existed about these recent experiences than about "the way things were in the past". In other words, the narrative was dominated by closed categories when discussing the past, as if those discussions were anchored in a canonical vision of that past, whereas in discussing personal experiences in the recent past and the present there was a much higher observed entropy – and thus less certainty about the narrative.

Confronted with uncertainty requires capacities to be able to live with changing circumstances, to keep options alive. Such 'social resilience' refers to the capacity of individuals, groups, communities, societies, and civilizations to secure favourable outcomes (material, symbolic, emotional) under new circumstances and when necessary by new means, even when this entails significant modifications to behaviour or to the social frameworks - the narratives that structure and give meaning to behaviour (Hall and Lamont 2012).

Narratives of hope for transformations towards sustainable futures are in demand. They should broaden cultural membership by promoting new narratives that resonate, inspire, and provide hope centred on a plurality of criteria of worth and social inclusion (Lamont 2019). Narratives

of hope as new attractors for shifting basins of attraction towards sustainability, represent ideas about ‘imagined futures’ or alternative ways of visualizing and conceptualizing what has yet to happen and motivate action towards new development pathways (Milkoreit 2017). As they circulate and become more widely shared, such imagined futures have the potential to foster predictable behaviours. These in turn can stimulate new laws, regulations, and investments in research and development of new technologies that fit the aspirations of the imagined futures (Beckert 2016).

We sense that a collective narrative may be on the rise with new imagined futures of hope emerging, and increasingly dominated by open categories. Such new attractors, currently being formed, seem to appreciate humanities’ interdependence with the planet we are living on, the fact that we are embedded in the biosphere and what this means for the wellbeing and even survival of civilizations. This new ‘collective mind’ of society is coevolving with the dynamics of the realities of the Anthropocene. It will hopefully foster capacities for redirecting societal development into basins of attraction ensuring sustainable futures, with social, economic and political systems acting on such a narrative.

## **Conclusion**

In this contribution we have proposed a model to describe and analyze the dynamics of interaction between a societal system and the basins of attraction surrounding it, which nudge that system into particular directions. The basis of this model is the assumption that there are two interactive niches that shape and construct each other in mutual interaction, one serving as the societal information-processing apparatus (the collective mind and its information-processing tools), and the other encompassing the dynamics of the society’s environment.

As a societal system follows its trajectory, it will inevitably come to points where it experiences a transition from one basin of attraction to the next. We have therefore also described very briefly what happens at such a point of transition.

All this raises the question how the (collective) societal information processing apparatus functions. We have described a model for this in terms of the dynamics of categorization, and their role in shaping the narratives that ensure the coherence of the society’s values and culture. When open categories dominate in a narrative, that narrative is to some extent open to change, but when closed categories dominate, it is not.

Hence, as discussed in the last section, the core issue from the perspective of attempting to move a societal system into a different trajectory and basin of attraction, is whether we can identify open and closed parts of narratives, and then modify the open ones in a direction that moves our societies closer to sustainability.

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