Resilience and Complexity
Conjoining the Discourses of Two Contested Concepts

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Abstract

This paper explores two key concepts: *resilience* and *complexity*. The first is understood as an emergent property of the latter, and their inter-relatedness is discussed using a three tier approach. First, by exploring the discourse of each concept, next, by analyzing underlying relationships and, finally, by presenting the Cynefin Framework for Sense-Making as a tool of explicatory potential that has already shown its usefulness in several contexts. I further emphasize linking the two concepts into a common and, hopefully, useful concept. Furthermore, I argue that a resilient system is not merely robust. Robustness is a property of simple or complicated systems characterized by predictable behavior, enabling the system to bounce back to its normal state following a perturbation. Resilience, however, is an emergent property of complex adaptive systems. It is suggested that this distinction is important when designing and managing socio-technological and socio-economic systems with the ability to recover from sudden impact.

Introduction

Resilience has gained remarkable popularity over the last decade, after the 2005 Hyogo Framework for Action adopted the concept as a core element in its strategy for global disaster risk reduction (Dahlberg et al. 2015). Countries adopt "resilient strategies" in emergency planning and disaster preparedness (Cabinet Office 2011; National Research Council 2012; Rodin 2015) to a degree that in just a few years has elevated 'resilience' to buzzword-status. For instance, following the 2004 national plan in the USA, even critical infrastructure (CI) was subjected to resilient strategies meant to imbue CI "with a particular agency that literally breathes life into what was once deemed inanimate" (Evans & Reid 2014: 19). Resilient communities and cities are wanted and needed everywhere (World Bank 2008; Ungar 2011; Walker & Cooper 2011: 144). Further, corporations as well as individuals need to be resilient, and able to not only accept but also cope with the stress and shocks of modern-day society (Kupers 2014; Rodin 2015). Resilient citizens thus become subjects who "have accepted the imperative not to resist or secure themselves from the dangers they face (Evans & Reid 2014: 42). Unsurprisingly, a Google Ngram search shows an increase in the use of the word 'resilience' in English-language publications during the last two decades.[2]

Figure 1. Google Ngram showing the percentage of publications in English with the occurrence of "resilience" (case sensitive) 1800-2008.

The term resilience has been widely used over the last decade to describe man-made systems' ability to recover from sudden impact. This widespread use has in fact led to the concept's origins in ecological systems theory to be sometimes forgotten. A basic distinction that is both useful and necessary when working with the concept of resilience is the distinction between what one of the founding fathers of the concept, Canadian ecologist Crawford Stanley Holling, has termed *engineering* and *ecological* resilience (Holling 1996). On the one hand, engineered ecological, economical, or technological systems are governed by an equilibrium steady state, and in such systems resilience denotes the ability to "bounce back" to this steady state

after a shock. On the other hand, in natural ecosystems and complex adaptive systems, instabilities can flip the system into new stable domains with very different inner functions: "There is strong evidence that most ecosystem types can exist in alternative stable regimes, for instance lakes, coral reefs, deserts, rangeland, woodlands, and forests" (Brand & Jax 2007).

The meaning of resilience has been transformed over the last decade and a half. Before the early 2000s resilience was primarily defined as a descriptive concept that in itself was neither perceived as good nor bad. An ecosystem may be highly resilient, but unwanted by humans, and some of the most feared and hated social systems such as terrorist networks and organized crime can be extremely resilient and therefore difficult to eradicate. Brand and Jax (2007), however, identified a general movement towards a more normative view of resilience that followed the introduction of the concept into a much broader spectrum of disciplines around the turn of the millennia. They suggested that resilience was becoming a "boundary object", rather than a well-defined scientific concept, providing scholars from many disciplines with a crosscutting theme with common vocabulary that could enhance cooperation and coordination. This however happened at the cost of losing the practical value in a more precise ecological definition. More recently, Davoudi updated this analysis by asking in the title of a paper if resilience was "a bridging concept or a dead end" (2012).

How to measure resilience is a question that has occupied researchers from many disciplines over the last several decades, and one which continues to do so. With regard to measurement, the above-mentioned distinction also proves useful: while engineered resilience can be thought of in terms of *elasticity* – resilience is exactly what provides such systems with the ability to absorb a shock and return to their steady state, and that which can be observed and measured – ecological resilience is more difficult to grasp. Holling states of ecological resilience, "In this case the measurement of resilience is the magnitude of disturbance that can be absorbed before the system changes its structure by changing the variables and processes that control behavior" (1996: 33).

In other words: if an engineered resilient system bounces *back*, an ecological resilient system bounces *forward* to a different state. These introductory remarks on the concept of resilience lead into a more historical approach to its development.

A Brief History of Resilience[3]

Resilience is a contested concept with a long and winding history, and numerous definitions or resilience exist – scholars have identified as many as 46! (Tierney 2014: 162). It is not my aim to provide the reader with an exhaustive conceptual history of resilience (for such reviews, see Folke 2006, Brand & Jax 2007, Walker & Cooper 2011, Davoudi 2012 and Alexander 2013), rather I wish to highlight important milestones and definitions.

First of all, resilience must be differentiated from resistance, which is "the extent to which disturbance is actually translated into impact" (Adger 2000: 349). While a system's resistance protects it from an agent of threat by deflecting the shock, resilience is what enables the system to absorb and bounce back from the impact. In his etymology of resilience, David Alexander demonstrates that the concept originates from Latin (resilire, "to bounce"), and that resilience was first used in a somewhat modern sense by Francis Bacon in 1625. Historically, the term developed from literature and law through scientific method in the 17th century, and entered the language of both mechanics and child-psychology in the 19th century. The engineers of the Industrial Revolution thought in terms of resilience when they added redundant strength to structures such as buildings and bridges. In general, the concept retained the original core meaning of "bouncing back" regardless of the system being mechanical or psychological. It was not, however, until the second half of the 20th century that resilience found its way into ecology and the social sciences (Alexander 2013).

Overall, resilience denotes a system's ability to withstand shock through absorption and adaptation. Traditionally, engineering, economy, and ecology viewed technological, financial, and natural systems as being able to return to equilibrium (a "normal state") after subjection to a sudden, violent disturbance. From this ability arose robustness of such systems. The turning point came in 1973 when C.S. Holling in a seminal paper defined resilience as "a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling 1973: 14). This idea of "resilient homoeostasis" (dynamic equilibrium) became highly influential in the following decades of integration of the concept into social science and climate studies, even if it was debated if it could be "transferred uncritically from the ecological sciences to social systems" (Adger 2000; Gallopín 2006: 299). Holling's original ideas eventually matured into the Resilience Alliance, established in 1999 as a multi-disciplinary research organization providing advice for sustainable development policy and practice.

The modern multidisciplinary understanding of resilience also has its foundations elsewhere. In the middle of the 20th century, Austrian economist Friedrich A. Hayek laid out the foundations for the Austrian school in Neoliberalism with his thoughts on self-organizing economies. Hayek "understood that shocks to economic systems were caused by factors beyond our control, hence our thinking about such systems required systems of governance that were premised upon insecure foundations" (Evans & Reid 2014: 31). Rejecting the stable equilibrium sought by Keynesian economists, Hayek argued that markets exhibit such complex behavior that no government or other regulating body could ever hope to predict or control them. At the same time, markets themselves "have proven to be among the most resilient institutions, being able to recover quickly and to function in the absence of government" (ibid.: 35-36). Walker and Cooper point out that Holling and Hayek

worked in very different fields and were inspired by very different political concerns, but that their contributions nevertheless "have ended up coalescing in uncannily convergent positions" (2011: 144).

Around the time Holling wrote his 1973-paper, the term resilience was also picked up by psychologists (via anthropology) as the discipline's substitute for robustness (Kolar 2011). By the turn of the millennium the term continued its transformation, when the relationship between social and ecological resilience was developed into a broader understanding of community resilience (Adger 2000). The Hyogo Framework for Action (an UNISDR-initiative), adopted by 168 UN members in 2005, placed resilience on the international agenda by focusing on the concept of *resilient communities* – such as cities, neighborhoods, and networks – as a corner stone in future humanitarian development. And in recent years both the UK and US governments have taken on a "resilience approach" to Disaster Risk Reduction/emergency preparedness (Cabinet Office 2011; National Research Council 2013).

Although different disciplines and traditions still disagree on the exact meaning of the concept of resilience, a broad and commonly accepted definition today would be along the lines of "the capacity of an individual, community or system to absorb and adapt in order to sustain an acceptable level of function, structure, and identity under stress". Note the emphasis on adaptation: what makes a complex adaptive system resilient is it's learning and transformational capabilities, not its ability to merely resist a shock. As phrased by Folke: "[R]esilience is not only about being persistent or robust to disturbance. It is also about the opportunities that disturbance opens up in terms of recombination of evolved structures and processes, renewal of the system and emergence of new trajectories" (2006: 259).

Complexity

As with resilience, 'complexity' has permeated the scientific and, to a lesser degree, public discourse over the last few decades, addressing the still tighter coupling and growing interdependencies of modern societies: "As technological and economic advances make production, transport and communication ever more efficient, we interact with incrementally more people, organizations, systems and objects" (Heylighen et al. 2007: 117).

Pioneered in the 1880s by Henri Poincaré, who showed that deterministic systems need not be predictable, the understanding of complexity was propelled forward by Edward Lorenz and his famous "Butterfly Effect" in the 1960s. Complexity science in its purest form originated in general systems theory and cybernetics in the second half of the 20th century. Complexity science is, however, "little more than an amalgam of methods, models and metaphors from a variety of disciplines rather than an integrated science" (ibid.), but it nevertheless offers fundamentally

new insights into the properties and functions of man-made as well as natural complex systems.

Central to complexity science is an anti-reductionist approach. Contrary to the basic approach in Cartesian, Newtonian, and Laplacian science, complex systems cannot be fully understood by taking them apart and studying each of their parts individually. This is due to the "emerging properties": synergies that are created through interactions and interdependencies within the system in an unplanned way. An aircraft or a cruise ship is a highly complicated, but predictable system, where you can tell exactly what will happen if you press a button or pull a lever. Insert operators and place the system in an environment with fuzzy boundaries (e.g. an airspace with other planes or a busy shipping lane), and performance variances that no designer ever thought of are bound to happen eventually. Emergence is thus key to understanding complex systems (Perrow 1999; Dekker et al. 2011).

Unpredictability is not only a property of complex technological systems. Large social systems such as organizations, communities, and institutions also exhibit complex behavior due to many interactions between agents and subsystems. Such systems are therefore unpredictable and uncontrollable – something that often comes as a total surprise to economists, city planners, legislators, and regulators. Consequences are usually expensive and often also fatal. The failure of risk management in the late Industrial Age may be seen as the outcome of continuous application of linear predictive methods on unpredictable complex systems. Such misinterpretations and misapplications have produced disasters such as Bhopal, *Challenger*, *Deepwater Horizon* and *Costa Concordia* (Dahlberg 2013b).

In the Industrial Age, accidents and failures were understood as "a disturbance inflicted on an otherwise stable system" (Hollnagel et. al. 2006: 10), exemplified by Heinrich's Domino-model (1931) representing the linearity of a technical system with chains of causes and effects. From this perception of systems came the hunt for "The Root Cause Effect" and an overall reductionist focus on broken/weak components. The late Industrial Age saw the rise of complex linear accident models such as James Reason's Swiss Cheese Model (1990), adding more contributing factors in the form of "holes" in the barrier layers – but still based in error-trajectory.

A much more non-linear approach to understanding performance and safety in complex systems was taken by the Resilience Engineering movement founded in 2004 by Erik Hollnagel, David D. Woods, and other safety researchers. While Charles Perrow's Normal Accident Theory (first published in 1984, see Perrow 1999) represents the pessimist approach to complexity and adaptive systems, Resilience Engineering took from the outset an optimist's stand, assuming that "an adaptive system has some ability to self-monitor its adaptive capacity (reflective adaptation) and anticipate/learn so that it can modulate its adaptive capacity to handle future situations, events, opportunities and disruptions" (Hollnagel et al. 2011: 128).

Resilience and Complexity

The Resilience Engineering movement investigates socio-technological systems in which predictable technological processes interact with unpredictable human behavior. Together they form complex adaptive systems that are dynamic (ever changing) and able to adjust to conditions that cannot be built into the system at the design-phase. The movement's definition of resilience reads: "The essence of resilience is therefore the intrinsic ability of an organization (system) to maintain or regain a dynamically stable state, which allows it to continue operations after a major mishap and/or in the presence of a continuous stress" (Hollnagel et al. 2006: 16). David D. Woods, however, noted in the same publication that *all* systems adapt, even though some adaptation processes are very slow. Therefore, resilience in his view could not simply be the adaptive capacity of a system, prompting him to reserve the term to a system's broader capability of handling performance variations. Failure, either as individual failure or performance failure on the system level, was seen by the founding fathers of Resilience Engineering as "the temporary inability to cope effectively with complexity" (ibid.: 3). Following from this, David D. Woods argues that "organizational resilience is an emerging property of complex systems" (ibid.: 43), thus connecting the two concepts explicitly.

It follows from the above that an up-to-date understanding of resilience is more or less synonymous with what Nassim Nicholas Taleb, author of *The Black Swan*[4] (2007), recently has termed "the antifragile": systems that not only survive disturbance and disorder but actually develop under pressure. In his usual eloquent style, Taleb in a footnote addresses the relationship between his antifragility concept and resilience: "the robust or resilient is neither harmed nor helped by volatility and disorder, while the antifragile benefits from them" (Taleb 2012: 17). But in this he confuses the terms in viewing resilience and robustness as synonymous: "Antifragility is beyond resilience or robustness: The resilient resists shocks and stays the same; the antifragile gets better" (ibid.: 3).

Taleb's understanding of resilience is pre-Holling, and therefore somewhat undermines Taleb's otherwise interesting aim to "build a systematic and broad guide to *nonpredictive* decision making under uncertainty in business, politics, medicine, and life en general – anywhere the unknown preponderates, any situation in which there is randomness, unpredictability, opacity, or incomplete understanding of things" (ibid.: 4). He sees complex systems as weakened, even killed, when deprived of stressors, and defines the fragile as "what does not like volatility" in the form of randomness, uncertainty, disorder, error, stressors, etc. (ibid.: 12). However, he underlines that complex systems are only 'antifragile' up to a certain point. If the stressor is too powerful, even the most resilient system will be unable to absorb and adapt. The result, then, is catastrophic (ibid.: 69).

If the resilience of complex systems cannot be designed (as it is an emerging property), it can, however, be exercised and cultivated. The principle of "hormesis",

known by the ancients and (re)discovered by modern scientists in the late 19th century, states that a small dose of poison can stimulate the development of an organism (ibid.: 37). Hormesis, on the social scale, means "letting people experience some, not too much, stress, to wake them up a bit. At the same time, they need to be protected from high danger – ignore small dangers, invest their energy in protecting themselves from consequential harm. […] This can visibly be translated into social policy, health care, and many more matters" (ibid.: 163). Hormesis can be likened to what Evans and Read call "endangerment" of agents in social systems which "is productive of life, individually and collectively" (Evans & Reid 2014: 64). Erik Hollnagel and David D. Woods also note the need to provoke complex systems in their epilogue to Resilience Engineering movement's first publication: "Resilience requires a constant sense of unease that prevents complacency" (Hollnagel et al. 2006: 355-56). This exact formulation also connects the resilience discourse with High Reliability Organization theory, as formulated by Karl Weick et.al, with its emphasis on chronic unease, fear of complacency, and attentiveness to weak signals (Weick & Sutcliffe 2007).

The point is that for complex systems, disturbances, performance variations, etc. are beneficial. As Taleb points out: "machines are harmed by low-level stressors (material fatigue), organisms are harmed by the *absence* of low-level stressors (hormesis)" (Taleb 2012: 55. He also lists the most important differences between the mechanical (non-complex) and the organic (complex) (ibid.: 59). While the mechanical needs continuous repair and maintenance, dislikes randomness, and ages with use, the organic is self-healing, loves randomness (in the form of small variations), and ages with disuse.

While fully accepting the need for constant endangerment of agents in complex systems in order to cultivate resilience, Evans and Reid also deliver a critique of what they identify as a Neoliberal strategy of governance:

> Rather than enabling the development of peoples and individuals so that they can aspire to secure themselves from whatever they find threatening and dangerous in worldly living, the liberal discourse of resilience functions to convince peoples and individuals that the dream of lasting security is impossible. To be resilient, the subject must disavow any belief in the possibility to secure itself from the insecure sediment of existence, accepting instead an understanding of life as a permanent process of continual adaptation to threats and dangers which appear outside its control. (Evans & Reid 2014: 68)

In their view, the Neoliberal discourse, stemming from the theories of Hayek and Friedman, has been the main force driving resilience to its current omnipresence: "'Resilient' peoples do not look to states or other entities to secure and improve their well-being because they have been disciplined into believing in the necessity to secure and improve it for themselves", they write. "Indeed, so convinced are they of the worth of such capabilities that they proclaim it to be fundamental 'freedom'" (Evans & Reid 2014: 77).

Another characteristic of complex system is "hysteresis" – a consequence of emergence among entities connected by nonlinear relationships. If a linear, predictable system shifts from one stable state to another, it can be switched back by reversing the process, Newtonian-style. This is what happens when you change gears back and forth in your complicated, but (usually) predictable car. In complex systems, however, "if a system is to return to its original configuration, it must take a different path" (National Research Council 2007: 26).

A complex system, however, not only depends on its current inputs, but also on its history. Hysteresis contributes to the irreversibility of complex systems, and renders the "Best Practice"-approach to problem-solving in organizations and societies virtually useless, as the multitude of historical factors in any socio-economic system create vastly different initial states, even if they look similar on the surface. The path-dependency of complex systems forms the basis for what could be called the mantra of the turn towards resilience in emergency management: "Stop planning – start preparing." We may predict that catastrophic events will unfold in the future, but it will always be different from last time. A resilient approach to emergency planning and crisis management is based less on rigid contingency plans than on heuristics and adaptability.

Introducing the Cynefin Framework

Complexity is not absence of order – rather it is a different form of order, of un-order, or emergent order. While ordered systems are designed, and order is constructed top-down, un-ordered systems are characterized by un-planned order emerging from agents and sub-systems to the system as a whole. The Cynefin Framework developed by David Snowden offers a useful approach to sense-making by dividing systems and processes into three distinct ontologies: (1) Order, (2) un-order and (3) chaos. Order and un-order co-exist in reality and are infinitely intertwined. Separation of the ontologies serves only as a sense-making tool at the phenomenological level, as assistance in determining the main characteristics of the situation you find yourself in, thus guiding you towards the most useful managerial and epistemological tools for the given ontology (Snowden & Boone 2007; Renaud 2012).

In the ordered ontology, there is a correct answer, which may be reached through observation or analysis. In un-order, multiple right answers exist, but their nature defies observation and analysis. The three ontologies are divided into five domains. Two of them are in the ordered ontology: while the *simple* domain is characterized by obvious causalities that may be immediately observed and understood, the *complicated* domain requires expert analysis – yet still yields an exact answer after reductionist scrutiny. The un-ordered ontology is home to the *complex* and *chaotic* domains in the Cynefin Framework. In the complex domain, analysis fails due to feedback: any diagnosis is also an intervention that disturbs the system. Emergent

order may be facilitated, but is difficult to design, and impossible to predict. The chaotic domain is characterized by the lack of perceivable causality rendering any form of planned intervention useless – here you can only act and hope for the best, because chaos has no right answers at all as there is no relationship between cause and effect. There is also a fifth domain, namely that of disorder which is impossible to label and make sense of (Kurtz & Snowden 2003: 468).
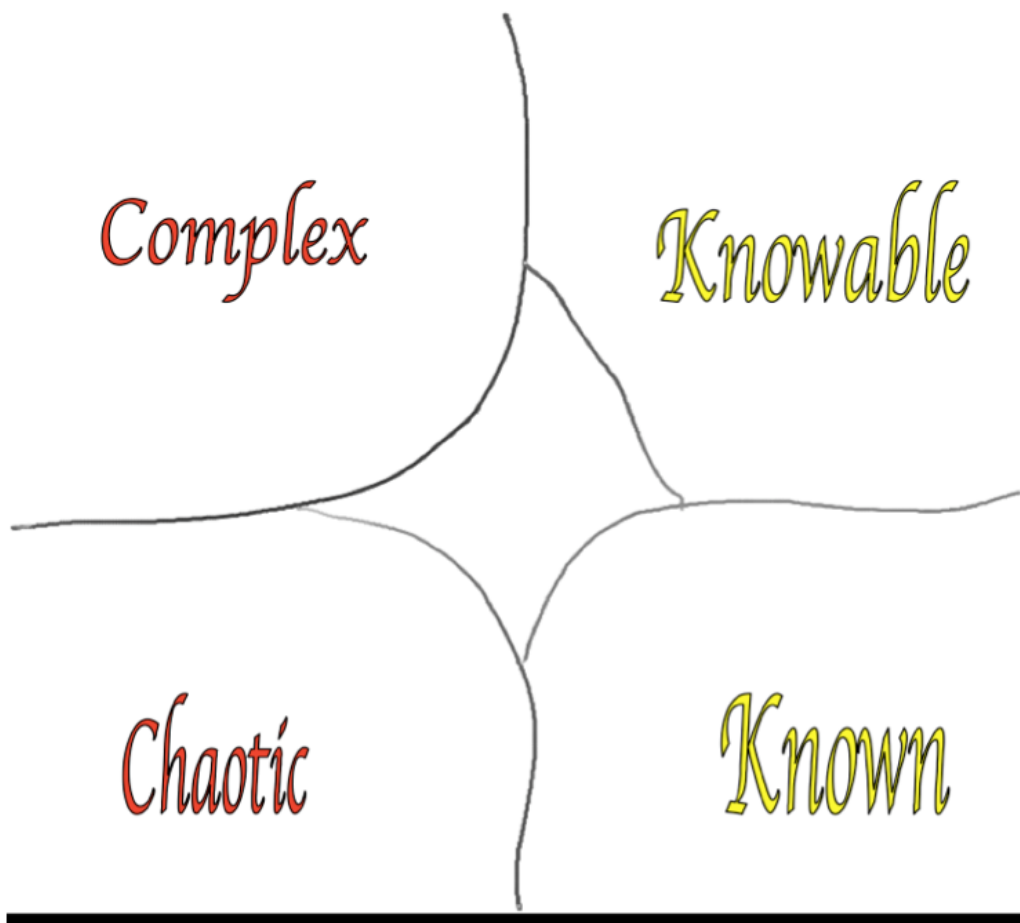

Figure 2. The Cynefin Framework, reproduced by permission from Cynthia Renaud. The known/simple and knowable/complicated domains are in the ordered ontology while the complex and chaotic domains belong to the un-ordered ontology. The domain of disorder is found in the middle.

The complex domain is characterized by weak central connections and strong distributed connections (ibid.: 470), meaning that agents interact directly instead of being controlled by an omniscient puppeteer like in the ordered domains. Lacking the common traits of order (i.e. structures, procedures, rules), the complex domain is governed primarily by co-operation between agents, mutual goals and interests,

and competing forces. It is from these infinite interactions and dependencies that un-order emerges. "Most crises arise as a result of some form of collapse of order, most commonly from visible order" (Snowden 2005: 51). The boundary between the ordered and the chaotic domains is strong, meaning that after a "fall" from order to chaos there is no easy way back other than moving through complexity. Falling over the boundary is also known as "Asymmetric Collapse":

> Organizations settle into stable symmetric relationships in known space and fail to recognize that the dynamics of the environment have changed until it is too late. The longer the period of stability and the more stable the system, the more likely it is for asymmetric threats or other factors to precipitate a move into chaos. (Kurtz & Snowden 2003: 475)

Right at this boundary we find catastrophes such as the *Deepwater Horizon* incident, a disastrous sudden transition from order to chaos produced by the "atrophy of vigilance" (Freudenburg & Gramling 2011). When the offshore semi-submersible drillrig exploded on April 20 210, a delegation from the company was on board to award the rig management a certificate for being the safest installation in the Mexican Gulf because seven years had passed without Lost Time Incidents on the *Deepwater Horizon* (Dahlberg 2013). A strategy of resilience may be seen as a countermeasure to exactly this fallacy: "To be resilient is to insist upon the necessity of vigilance in relation with one's surrounding" (Evans & Reid 2014: 16).

The Cynefin Framework does not imply a differentiated value between the domains. Some systems perform very well in the ordered domain, while other systems benefit from operating (perhaps only momentarily) in the un-ordered domain. Only in the ordered domain, however, does a focus on efficiency through optimization of the separate parts of the system make sense. The reductionist approach to a complex system will never bear fruit. Likewise, traditional command and control-style management approaches are impossible to implement in the complex domain. Instead, complex systems are best managed by setting boundaries and adding or removing path-forming attractors (i.e. fixed points in the time-space of possible states). Constant monitoring and probing through small-scale experiments facilitate continuous development of the complex system towards a desired outcome (Snowden & Boone 2007). This resonates well with Holling's comments on how to manage resilient ecological systems (Holling 1996: 38-41).

Taleb identifies two separate domains: one where prediction is to some extent possible, and one where it is not (the Black Swan domain): "Social, economic, and cultural life lie the Black Swan domain, physical life much less so" (Taleb 2012: 137-38). These are more or less comparable to the ordered and the un-ordered domains in the Cynefin Framework: "There is, in the Black Swan zone, a limit to knowledge that can never be reached, no matter how sophisticated statistical and risk management science ever gets" (ibid.). The unpredictability of the complex domain is primarily produced by human collaboration. The "superadditive functions" of people working together to innovate and create is impossible to forecast

(ibid.: 233), just as complexity arises in complicated systems when "they are opened up to influences that lie way beyond engineering specifications and reliability predictions" (Dekker et al. 2011: 942). Erik Hollnagel also notes the limits to prediction in the complex domain: "It is practically impossible to design for every little detail or every situation that may arise, something that procedure writers have learned to their dismay" (Hollnagel et al. 2006: 16).

The ordered domain is home to Gaussian curves and "statistical confidence", while the complex domain is haunted by black swans and fat tails. In the ordered domain, normal distributions of height, for example, enable us to predict how tall the next person is likely to be – if we have a large enough sample for measuring the mean. Fat tails are someshat synonomous with Black Swans in the sense that they constitute "high impact, low probability events".

The so-called fat tail distributions found in the complex domain defy prediction: instead of convening around a mean, these samples consist of large numbers of not-very-surprising cases and a few extreme outliers: "In the past decade or so, it seems like fat tails have been turning up everywhere: in the number of links to Web sites and citations of scientific papers, in the fluctuations of stock-market prices, in the sizes of computer files" (Hayes 2007: 204).

The Italian economist Vilfredo Pareto discovered fat tails in the distribution of wealth in the early, industrialized societies, where a limited number of very rich people were balanced by a huge number of workers with a modest income. Paradoxically, a larger sample size provides less useful information about the distribution among the majority of the cases, as the probability of including additional outliers increases.

> The shape of a probability distribution can have grave consequences in many areas of life. If the size and intensity of hurricanes follows a normal distribution, we can probably cope with the worst of them; if there are monster storms lurking in the tail of the distribution, the prospects are quite different. (Hayes 2007: 204)

Taleb even argues that the famous 80/20 rule coined by Pareto in the beginning of the 20th century (that 80 % of land in Italy was owned by 20 % of the population) is outdated: Today, in the network society, we are "moving into the far more uneven distribution of 99/1 across many things that used to be 80/20" (Taleb 2012: 306). Such a development towards increased complexity constitutes an ever-growing challenge to the epistemological strategies we apply. History seems to drive a clockwise drift in the Cynefin Framework, while the Future exercises a counter-clockwise force upon the systems in question. It seems to be natural for people to seek order, for societies to convene towards the simple domain: "This phenomenon of grasping at order is common in people, governments, academia, and organizations of all shapes and sizes" (Kurtz & Snowden 2003: 476). And then disaster strikes and sends us plummeting over the fold into chaos.

Concluding Remarks

The Cynefin Framework was designed by Snowden to be a sense-making device, and as I have demonstrated in this paper, it is an effective lens to view and understand the concept of resilience through. The framework offers an arsenal of useful dynamic strategies that may be executed in the different domains. Many negative performance variances in our modern societies may be seen as the result of people, agencies, and governments trying to solve complex problems with solutions from the ordered toolbox – or vice versa. Instead, we should perhaps focus our efforts on *planning for the predictable* and *preparing for the unpredictable*. And this is exactly what the turn towards resilience in emergency planning and management is about.

Resilience is the ability of a complex system to adapt to disturbances and changing conditions, and resilience should be understood as an emergent property of the complex domain. This complies with recent developments in safety science according to which safety itself is "an emergent property, something that cannot be predicted on the basis of the components that make up the system" (Dekker et al. 2011: 942). Instead of looking for broken components in the causal chain that leads to an accident or disaster, a complex approach to safety science accepts competing truths and multiple explanations. From this follows that an accident might very well be no-one's fault – but merely a negative outcome of unpredictable behavior among tightly coupled interdependencies.

Resilience enables the system to cushion the effects of unforeseen disturbances by absorbing the shock and adapting to changing conditions, thus bouncing not back but forward to a more advanced level better suited for future hazards. Instead of focusing on the vulnerability of a socio-economic or socio-technological system, resilience addresses its potentials (Gallopín 2006: 294). Emergent order does exactly this: Distributed agents of change work together to solve problems and face challenges, and out of their combined efforts emerges a new un-order capable of coping with the perturbation in question. But cultivating resilience means stopping clinging to plans and beliefs in predictive capabilities:

> Disasters do not follow preordained scripts. Even in situations where there is extensive disaster experience, those seeking to respond invariably confront unforeseen situations. One counterproductive way of dealing with the unexpected is to adhere to plans and procedures even when they are ineffective or offer no guidance in the face of unfamiliar challenges. (Tierney 2014: 208)

Should all planning then be abandoned? No. Many processes and systems, technical as well as socio-economic, exhibit complicated or even simple behavior, and for those we should develop and rehearse plans which can be executed in case of emergencies. But at the same time we must accept the unpredictability of complex systems and prepare for the unknown future by cultivating resilience.

For instance, a well-rehearsed method in emergency planning is scenario-building. Most agencies tasked with national emergency preparedness create and maintain registers of risk framed as most-likely scenarios, i.e. earthquakes, flooding, train crashes, industrial accidents (European Commission 2014). While scenario-building and comparable methods work well in the ordered domain with its knowable facts and right answers, they are of limited value when dealing with complex systems. Complexity is the realm of "unknown unknowns", to paraphrase Donald Rumsfeld, and here the shortcomings of methods developed for the ordered domain become evident. How would it, for instance, be possible to construct a scenario to prepare for an emergent calamity that has not yet revealed itself? How can one assess the probability of an event that has happened only once or perhaps never before? No analysis, no matter how thorough, will be able to identify the pattern of such a hazard before it actually manifests itself – because a pattern does not yet exist.

A consequence of such applications of ordered epistemological tools on un-ordered ontologies is 20/20 hindsight, which – unfortunately – doesn't lead to foresight. Taleb calls this the "Lucretius problem": humans have a tendency to prepare for the future by reviewing the past, but are not expecting anything worse than has already happened to happen (Taleb 2012: 46). Improvisation, creativity, and imaginative capacity are key elements in resilient strategies: "The challenge is understand (sic.) when a system may lose its dynamic stability and become unstable. To do so requires powerful methods combined with plenty of imagination" (Hollnagel et al. 2006: 17). The understanding of risk is challenged by complexity as no other concept. Defining risk as likelihood × consequences" of a future event, presupposes our ability to predict and assess the probability of the event in question, but this is much easier to do in the ordered domains than in cases of un-order. Uncertainty must be re-installed in the concept of risk from where it has been largely absent since Frank Knight established the distinction between uncertainty and risk (seen as measurable uncertainty) in 1921 (Jarvis 2011).

Resilience cannot be created – and it does not have to be, as it is already present as an inherent, emerging, property of all natural as well as engineered complex adaptive systems. But it may be facilitated, nudged, exercised, and cultivated, unleashing strengths and resources hitherto hidden from linear-minded planners, controllers, and predictors. Even when faced with clearly complex problems that undergo fundamental changes while being solved ("diagnosis equals intervention"), these heirs of the Enlightenment insist on reductionist thoroughness in hope of full knowledge and perfect prediction. But, as Evans & Reid note (2014: 201): "Reason imagines nothing. It cannot create and thus it cannot transform. [...] It is not made for opening up new worlds, but enabling us to survive present ones."

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Notes

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[2.] Note also the historic increase in usage of "resilience" in books published during the 1880s. This is probably due to the many publications on engineering, shipbuilding, bridges, etc. of this time - which was the apex of the age of engineering: "The first serious use of the term *resilience* in mechanics appeared in 1858, when the eminent Scottish engineer William J.M. Rankine (1820-72) employed it to describe the strength and ductility of steel beams" (Alexander 2013: 2710).

[3.] This section is an elaborated version of Dahlberg (2013a).

[4.] The "Black Swan" is a metaphor for unforeseen events with great consequences that in hindsight look like something that could have been predicted (i.e. the 9/11 terror attacks in the U.S.). The origins of the concept can be traced to Roman antiquity, and the term was common in London in the 1600s as an expression of something most unlikely. In western discourse only white swans existed until 1697 when a Dutch explorer found black swans in Australia. Later, John Stuart Mill used the Black Swan metaphor when he described falsification in the 19th century: If we observe 1,000 swans that are all white and from these observations state that "all swans are white", we fall victim to the *inductive fallacy*. The observation of a single black swan would falsify our claim. Lately, the Black Swan metaphor has also entered professional risk discourse (Aven 2014).

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