Intelligence for a complex environment: transforming traditional intelligence with insights from complexity science and field research on NATO

Spoor, B.E.P.

4. Intelligence & Complexity

This chapter examines complexity science along the research question *How does complexity science relate to intelligence*?[375] It grounds the complexity terminology from the previous chapters and will provide an understanding of complexity to perform the case study research of the subsequent chapters. The first section starts with a review of existing intelligence literature on complexity to see how much attention is given to it, how it is combined with intelligence and what opportunities for improvement there are. This concerns publications that adopt more of complexity thinking than just terminology but cover topics that are not observed in the previous two chapters. The second section introduces complexity science in relatively general terms before the third section will explore in depth several characteristics that are an integral part of complexity science. The fourth section applies complexity science and presents three design properties to better align organisations with their complex environment. The fifth section is the conclusion.

In examining complexity, several instances of its usage in the study of war and warfare will be explored. This serves to balance against a too theoretical and abstract treatment of complexity and give an example on how complexity is used in related fields and topics.

4.1 Complexity in intelligence literature

As seen with the trinity of transformation the nexus of complexity and intelligence is not entirely new. Next to this, there are more applications of complexity present in the study of intelligence. Often this is only reflected in the terminology used in publications but several explicit theoretical approaches with more analytic depth exist as well. However, the volume of these works remains small, as described in the first chapter

To gain more insight in the nexus of complexity and intelligence already present in the existing literature, an explorative – but by no means exhaustive – search was conducted. This is based on two main sources; the WorldCat Discovery database of scientific publications and Google Scholar. This provides access to the major outlet of intelligence publications. The search queries were several combinations of the terms complex(ity), non-linear/nonlinear, intelligence (analysis). These terms have

---

[375] Parts of this chapter have been published in Spoor and de Werd, "Complexity in Military Intelligence."

to relate to the title of the publications and/or the key words assigned to it. In varying depth, between 100 and 300 query results per combination were scanned for anything substantive on intelligence and complexity. This was cross checked against a direct search in the databases of the following journals:

- International Journal of Intelligence and Counter Intelligence (IJIC)
- Intelligence and National Security (INS)
- The International Journal of Intelligence, Security, and Public Affairs (IJISP)
- Journal of European and American Intelligence Studies (JEAIS)
- Journal of Intelligence History (JIH)

Only 48 publications were found to match the criteria with only a few having complexity as the main topic and most treating it as a partial topic or background of the changing intelligence environment. Out of this total only 13 were articles in academic, peer-reviewed intelligence journals and 10 were academic books or book sections on intelligence. The remaining publications were spread among non-intelligence and/or non-academic journals and books, conference papers, websites, reports and theses. Although this database search is not exhaustive, it provides a good impression that the amount of publications on intelligence and complexity is quite small. This underlines the earlier observation by Beebe and Beebe.

Section 2.4 on intelligence paradigms already found that when complexity terminology is used to describe threats it often lacks theoretical and analytical depth. Rather than studying the external complexity (threats) the literature review found that the 48 selected publications focus more internally on the organisation of intelligence and changes to analysis. A complete review is not the aim here, rather a synthesis is presented to identify main themes and publications. This will be done according to three categories; organising intelligence, intelligence analysis, and the last category will present several ideas from intelligence on uncertainty that are useful for this research.

4.1.1 Organising intelligence

Two prominent perspectives on organising intelligence for complex problems are those of Treverton and Moore. Each author takes a more holistic approach and differentiate between problem types before linking this to considerations for organising intelligence. Treverton builds on Nye’s puzzles and mysteries categories (see section 2.3) and classifies intelligence problems as puzzles, mysteries and complexities, see Table 6 below.[376]

Type of issue	Description	Intelligence product
Puzzle	Answer exists but may not be known.	*The* solution.
Mystery	Answer contingent, cannot be known, but key variables can, along with sense for how they combine.	Best forecast, perhaps with scenarios or excursions.
Complexity	Many actors responding to changing circumstances, not repeating any established pattern.	'Sensemaking'? Perhaps done orally, intense interaction of intelligence and policy.

Table 6: Puzzles, mysteries, and complexities[377]

A puzzle is fairly straightforward; the question is clear and there is a finite answer but it is yet unknown. For instance, the number of North Korean nuclear weapons. Mysteries are less clear as they are about the future and therefore contingent. For instance whether North Korea will dismantle its nuclear arsenal. Mysteries have no definitive answer as they depend on multiple future variables, there are only possibilities. Still, mysteries have some shape, they are 'bounded'; it is known what variables are important for an outcome and there may be some historical evidence or theory about how they interact. Forecasts or scenarios can be created that form the space in which key variables lead to a small range of outcomes. Complexities are unbounded, they have no shape. Because there are no comparable cases or theory

---

[376] Gregory F. Treverton, "Addressing "Complexities" in Homeland Security," in *The Oxford Handbook of National Security Intelligence*, ed. Loch K. Johnson (New York, NY: Oxford University Press, 2010), 343-45; See also: Agrell and Treverton, *National Intelligence and Science: Beyond the Great Divide in Analysis and Policy*, 32-35.

[377] Treverton, "Addressing "Complexities" in Homeland Security," 344. Emphasis in original.

it is unclear what to look for. The key variables are also unknown. Therefore it is impossible to deliver a definitive assessment of a complex threat or even frame it in probabilities. The way to engage with complexities is through the concept of sensemaking.[378] Sensemaking will be explained in depth in section 4.4.2, but for now it is enough to define it as a collective and reflexive process to make sense of the world by creating frameworks to interpret information from, and observation of, the developing environment.

While Treverton compares his complexities to wicked problems after Rittel and Webber's 'Dilemma's in a General Theory of Planning', Moore categorises intelligence problems directly into tame and wicked problems.[379] With a tame problem there is general agreement on who or what the adversary is. A tame problem is clearly defined and its solution is obvious even though it might be difficult to achieve. Methods to solving the problem come from a small set of alternatives that can be tested against the knowledge of the systems. Wicked problems are ill-defined, there are multiple and new adversaries, defying a single solution. Any perceived solution only changes the problem as they evolve and adapt to interference making them exhibit emergent complexity. Moore therefore states complexity is a viable method to look at wicked problems. Moore places wicked problems in the same category as Treverton's mysteries.[380] Moore does not mention 'complexities' but like Treverton, Moore sees sensemaking as a method to deal with 21st century intelligence problems – it is the title and premiss of his entire book.

The differentiation of intelligence issues by Treverton and Moore goes beyond adopting mere complexity terminology. It presents a broader and descriptive framework of the topology and characterisation of intelligence problems that draws on several complexity approaches from organisational sciences or ideas that are related or have influenced complexity thinking. For instance, next to Rittel and Webber's wicked problems both authors also refer to Snowden, from who's article

[378] Ibid., 343-45.

[379] Moore, *Sensemaking: A Structure for an Intelligence Revolution*, 17-29; Horst W. J. Rittel and Melvin M. Webber, "Dilemmas in a General Theory of Planning," *Policy Sciences* 4, no. 2 (1973); Treverton, "Addressing "Complexities" in Homeland Security," 345-46.

[380] Moore, *Sensemaking: A Structure for an Intelligence Revolution*, 18.

Treverton's complexities category is derived, and to Weick who introduced the idea of sensemaking in complex environments.[381]

In the search for new organisational models to adapt to the changing environment several more publications argue complexity science is useful.[382] A notable article that is firmly grounded in complexity is 'The Complexity of Peacekeeping Intelligence' by Gans.[383] Using the United Nations mission in Mali (MINUSMA) as a case study and applying complexity it shows that stabilisation operations can be seen as complex adaptive systems. Information sharing is crucial in dealing with internal and external complexity and uncertainty. However, Gans argues, the UN mission in Mali is seen and operated as a linear organisation with a formalised structure based on hierarchy and centralised decision-making. This impacts the processing of information and intelligence, and as a result the mission as a whole.

Another noteworthy publication, that also uses the UN mission in Mali, is 'Learning in complex public systems: the case of MINUSMA's intelligence organization' by De Waard et al.[384] As the title states, the article examines the learning ability of a large multi-stakeholder organisational constellation. The article finds that the combination of centralised and distributed agency substantially complicates organisational learning in MINUSMA.[385] This directly connects back to Rovner and Long's conclusion on intelligence as a complex, tightly coupled system from section 3.6.2.[386]

Andrus argues that an intelligence organisation should continuously learn and adapt to the environment. By applying concepts from complexity science, e.g. self-

---

381 David Snowden, "Complex Acts of Knowing: Paradox and Descriptive Self-Awareness," *The journal of knowledge management* 6, no. 2 (2002); Karl E. Weick, *Sensemaking in Organizations* (Thousand Oaks, CA: Sage Publications, 1995).

382 See also: "A Decadal Survey of the Social and Behavioral Sciences: A Research Agenda for Advancing Intelligence Analysis," 90-92, 117-22.

383 Ben Gans, "The Complexity of Peacekeeping Intelligence," *Journal of European and American Intelligence Studies* 1, no. 1 (2018).

384 Erik J de Waard et al., "Learning in Complex Public Systems: The Case of Minusma's Intelligence Organization," *Public Management Review* (2021).

385 Ibid.

386 Rovner and Long, "The Perils of Shallow Theory: Intelligence Reform and the 9/11 Commission," 627.

organisation, emergence, and feedback, he suggests how to transform intelligence organisation.[387] Barger propagates the need for a revolution in intelligence. Current intelligence organisations are based on an industrial-age stove piped and hierarchical model. An organisational model from the information age is needed to enable flexibility and adaptability of design. Barger deems complexity can deliver this.[388] Cooper goes so far as to state US intelligence is already a complex adaptive system because it *'resembles a living ecology with a complex web of many interacting entities, dynamic relationships, non-linear feedback loops (often only partially recognized), and specific functional niches'*.[389]

4.1.2 Intelligence analysis

This second category describes publications that deal with the actual analysis of complex intelligence problems. These publications have in common that their analysis is sensitive to complexity because it emphasises the interactions between problem components where most analysis is focused on components themselves. In this regard the article 'Understanding the Non-Linear Event: A Framework for Complex Systems Analysis' by Beebe and Beebe, as already mentioned, is exceptionally rich in complexity theory.[390] To accommodate for complexity in intelligence analysis it introduces a framework to cope with non-linearity. Second to analysis of a system – breaking up the whole into its constituent parts – a diagram of all the parts and their interactions is to be visualised. This is basically a variation on the Causal Loop Diagram; a technique to visualise the interrelated agents (both actors and factors) in a system. According to Beebe and Beebe their systemic approach counters the extrapolation, or linear projection, of singular causes and effects.

Coulthart points to the importance of defining the problem, called problem structuring, like Treverton and Moore. Unlike Treverton and Moore, Coulthart,

[387] D. Calvin Andrus, "The Wiki and the Blog: Toward a Complex Adaptive Intelligence Community," (Washington DC: Central Intelligence Agency, 2005).

[388] Barger, "Toward a Revolution in Intelligence Affairs."

[389] Cooper, "Curing Analytic Pathologies," 9.

[390] Beebe and Beebe, "Understanding the Non-Linear Event: A Framework for Complex Systems Analysis."

drawing from policy analysis, offers several analytic methods for complex problems to help analysts structure the problem.[391]

The Intelligence Preparation of the Battlefield/Environment process (IPB/IPE) – perhaps the most vivid example of *military* intelligence – is the subject of several publications. This process, also known as intelligence preparation of the operational environment (IPOE), is part of NATO intelligence doctrine and also national doctrine of many member states. It is a process and product to assess the influence of the actors and factors from the operational environment on the planning and execution of military operations. The original term 'battlefield' referred to an enemy-centric analysis in the context of major combat operations. The population-centric approach that came with the counterinsurgencies in Iraq and Afghanistan is reflected by the label 'environment' that enables a broader view of relevant conflict actors.

Carter characterises the IPB as too enemy centric with little regard for root causes of conflict, relations between actors and the human domain in general. It fails to capture the complexity of the operating environment. Therefore the operational environment should be considered as a complex adaptive system and intelligence analysis should incorporate more systems theory and systemic approaches into IPB, according to Carter.[392] Brown employs a more practice-oriented approach and applies several concepts from complexity science to the IPE process.[393] These serve as system components to examine in addition to the already existing systems. In later publications Brown, together with Pike, apply complexity to IPB in a technological way.[394] They shift the original IPB focus on threat to a population centric approach

[391] Stephen Coulthart, "What's the Problem? Frameworks and Methods from Policy Analysis for Analyzing Complex Problems," *Intelligence and National Security* 32, no. 5 (2017).

[392] Donald P. Carter, "Clouds or Clocks: The Limitations of Intelligence Preparation of the Battlefield in a Complex World," *Military Review* 96, no. 2 (2016).

[393] Eddie J. Brown, "Conveying the Complex: Updating U.S. Joint Systems Analysis Doctrine with Complexity Theory," ed. School of Advanced Military Studies and United States Army Command and General Staff College (Fort Leavenworth, KS 2013).

[394] Thomas D. Pike and Eddie J. Brown, "Complex Ipb," Smallwarsjournal.com, (accessed 16-3-2019); Eddie J. Brown and Tomas D. Pike, "Complex Intelligence Preparation of the Battlefield," in *International Studies Association Conference* (Baltimore, MD 2017). (Conference paper); See also: Victor R. Morris, "Complex

with attention to different groups and their behaviour and interactions. This is transformed into an agent-based model to examine how the system of the operational environment reacts to changes. Agent-based models are computational models of large ecosystems that enable to study the interaction and adaptation of many agents. It is a common feature in complexity research and as such several publications address it in the context of improving intelligence analysis.[395]

Menkveld focuses on the uncertainty of analysing complex intelligence problems.[396] He states the complexity of an intelligence problem can be approximated by combining the estimated number of entities involved in the problem with the estimated number of interactions. It is not about ascertaining the complexity of a single problem but the value lies in realising what factors contribute to the level of complexity. An increase in complexity (more involved entities and connections) also constitutes an increase in available, relevant intelligence. However, because relevance is not immediately obvious, increased collection does not equal an increase in relevant intelligence. This means the gap between available relevant intelligence and collected available intelligence grows exponentially with an increase of complexity. As a result the uncertainty in analysis grows.

4.1.3 Resulting uncertainty

How to engage complex problems and associated uncertainty is a central theme in complexity science and complexity approaches in other fields. There are also several ideas and concepts in intelligence that deal with uncertainty. Although these do not directly and explicitly fit this current synthesis of intelligence literature on complexity, they are very helpful in understanding the problems intelligence encounters when dealing with fundamental uncertainty as a result of complexity. Three of these ideas on uncertainty will be presented briefly: a Clausewitzian

Intelligence Preparation of the Battlefield in Ukrainian Antiterrorism Operations," *Military Review* 97, no. 1 (2017).

395 Aaron Frank, "Computational Social Science and Intelligence Analysis," *Intelligence & National Security* 32, no. 5 (2017); Daniel Javorsek and John G. Schwitz, "Probing Uncertainty, Complexity, and Human Agency in Intelligence," ibid.29 (2014); "A Decadal Survey of the Social and Behavioral Sciences: A Research Agenda for Advancing Intelligence Analysis."

396 Christiaan Menkveld, "Understanding the Complexity of Intelligence Problems," *Intelligence and National Security* 36, no. 5 (2021).

approach to intelligence, the Rumsfeld matrix, and a critical look at intelligence hypothesis testing.

Building on the puzzle/mystery/complexity typology Agrell and Treverton compare two intelligence approaches to uncertainty based on the strategists Antoine-Henri Jomini and Carl von Clausewitz (see Table 7).

Jomini	**Clausewitz**
Goal is to eliminate uncertainty.	Goal is to assess uncertainty.
There is a 'right' answer.	'Fog of war' is inescapable.
More information and better concepts narrow uncertainty.	Single-point high-probability predictions both unhelpful and inaccurate.
Large uncertainty indicates shortcomings in analysis.	Better analysis may identify more possible outcomes.

Table 7: Jominian versus Clausewitzian Intelligence.[397]

Agrell and Treverton state that in Jomini's perception strategy is a series of problems with definite solutions. Mathematical logic could uncover fundamental principles of strategy that, if followed, could eliminate uncertainty. Contrary, Clausewitz, with his ideas of friction and fog of war, believes strategy to be about the interplay of many possibilities and thus uncertainty is a constant. For Jomini analysis is about information and the goal is to reduce uncertainty. With Clausewitz analysis begins where information ends and uncertainty can only be assessed. While intelligence pays lip service to a Clausewitzian understanding of war in practice it often seeks to eliminate uncertainty in the vein of Jomini. In other words, intelligence is tempted to turn all intelligence problems into puzzles. While a Clausewitzian approach cannot negate this temptation it can serve to improve issues of problem definition and so keep analysis from neglecting issues.[398] This leads to the (in)famous reply by then US

[397] Agrell and Treverton, *National Intelligence and Science: Beyond the Great Divide in Analysis and Policy*, 37.

[398] Ibid., 36-39; For another contrasting perspective on Clausewitz and Jomini see: Ismael R. Rodriguez, "Uncertain About Uncertainty: Improving the

Secretary of State Donald Rumsfeld during a press conference on 12 February 2002 regarding suggestions on the absence of a link between the regime of Saddam Hussain and terrorists seeking weapons of mass destruction. Rumsfeld said *'there are known knowns: there are things we know we know. We also know there are known unknowns: that is to say we know there are some things [we know] we do not know. But there are also unknown unknowns—the ones we don't know we don't know'*.[399]

While the comment has often been ridiculed as political rhetorical obfuscation it connects to thinking about epistemic (un)certainty since Socrates and closely resembles the Johari window self-reflection method.[400] Though Rumsfeld never mentioned known unknowns, his words are often made into a matrix similar to the one below:

	Known	**Unknown**
Known	Things we know we know.	Things we know we do not know.
Unknown	Things we do not realise we know.	Things we do not know we do not know.

Table 8: The 'Rumsfeld matrix'.

Known knowns can be factual certainties or assumptions about possessed knowledge. Known unknowns are knowledge – or better, intelligence – gaps and can be seen as missing puzzle pieces (puzzles or tame problems). Unknown knowns were not mentioned by Rumsfeld but can be seen as tacit knowledge or simply failure to retrieve information from a database. Unknown unknowns are the domain of complexities (or wicked problems) where knowledge is unknown and undiscovered. Mysteries are between known unknowns and unknown unknowns as we are aware of some of their aspects but their outcome is still contingent. Attempting to reduce unknown unknowns can be framed as intelligence' aim to not miss a threat. This is

Understanding of Uncertainty in Mi Doctrine," *Military Intelligence Professional Bulletin* 37, no. 2 (2011): 40.

399 Donald Rumsfeld, *Known and Unknown: A Memoir* (New York: Sentinel, 2011), xiii.

400 Joseph Luft and Harry Ingham, "The Johari Window, a Graphic Model of Interpersonal Awareness," *Proceedings of the western training laboratory in group development* 246 (1955).

linked to the difference between science and intelligence when it comes to hypothesis testing. Science usually is aimed at proving causal connections. In other words, reducing the α, the chance of incorrectly concluding that there is a relation between phenomena. This is also known as a Type I error, or false positive. Intelligence is primarily concerned with not missing a threat. It seeks to reduce the β, the chance of not discovering a link between phenomena (Type II error or false negative).[401] This is especially the case with unknown unknowns where there is no previous information, conception or pattern to start from. However, while some intelligence publications touch upon β aspects – for example when covering SATs such as scenario building or red teaming – the literature on β-reasoning, let alone with regard to research design, seems to be non-existent according to De Valk.[402]

The puzzles/mysteries/complexities typology, the Jominian and Clausewitzian understandings of intelligence, the Rumsfeld matrix and a β-approach to intelligence combine into a rough cognitive map, or problem space, and associated wording that is grounded in intelligence literature to relate to complexity in the following chapters of this research. Overall, the body of literature on the convergence of complexity and intelligence is small and often discusses how complexity is applicable to intelligence on a general level. However, few publications show how intelligence can actually be improved with complexity science by applying concepts. This is not strange given the apparent novelty of complexity research into intelligence. These observations, together with the usage of complexity terminology in the Trinity of Intelligence Transformation and the evolution of the intelligence habitus from the previous chapters, strongly resemble the status of the convergence between complexity and international relations, of which intelligence studies is considered a subfield, that is described by Bousquet and Curtis in a very apt manner: *'There have […] been a number of disparate studies applying specific aspects of complexity theory to problems and debates in IR, as well as a wide range of scholarly output in which conceptual language developed to a sophisticated degree within complexity is*

---

[401] Giliam de Valk and Onno Goldbach, "Towards a Robust B Research Design: On Reasoning and Different Classes of Unknowns," *Journal of Intelligence History* 20, no. 1 (2021): 73; Giliam de Valk, "Case Studies into the Unknown - Logic & Tooling," *Romanian Intelligence Studies Review*, no. 21 (2019): 245.

[402] Valk and Goldbach, "Towards a Robust B Research Design: On Reasoning and Different Classes of Unknowns," 73, 74; Valk, "Case Studies into the Unknown - Logic & Tooling," 247, 52; See also: Rus Patrick, "Exploring Unknown Unknowns in Intelligence Analysis," ibid., no. 19-20 (2018): 11.

employed but a full appreciation of that underlying sophistication is absent or left unstated. Furthermore, a number of rich ontological debates have emerged within IR over the past decade that resonate with many of the characteristics of a complexity ontology, although so far these connections have been insufficiently drawn out.'[403]

To avoid grounding this research on complexity without an appreciation of its sophistication the next two sections will aim for a deeper understanding.

4.2 Introducing complexity science

This section will start with comparing the terms simple, complicated, complex, and chaos – to gradually introduce concepts and associated terminology from complexity science. Next, complexity science itself is introduced. Several topics will be examined: the problems regarding a definition, its origins and ensuing scientific paradigm shift, and descriptions of complex adaptive systems. The last part of this section examines the nexus of complexity and the study of war and warfare, or military science.

4.2.1 Simple, complicated, complex, and chaos

Simple and complex are etymologically related through the Indo-European root 'plek'. In Latin it gives the verb 'plicate', which means 'to fold'. This leads to the term 'simplex' that literally translates to 'once folded' from which the English word 'simple' is derived. However 'plek' also constitutes the Latin past participle 'plexus' that means braided or intertwined and from which 'complexus', literally 'braided together', is derived.[404] It is obvious that when something is once folded, its parts are easily recognisable and can be separated but if something is intertwined this is less so.

Weaver uses the concepts of simplicity and complexity to explain the progress of science.[405] Prior to 1900, physical science was largely concerned with 'problems of simplicity', the study of problems with only two variables. Around 1900 it began to deal with problems with a great many variables: 'problems of disorganized

---

[403] Antoine Bousquet and Simon Curtis, "Beyond Models and Metaphors: Complexity Theory, Systems Thinking and International Relations," *Cambridge Review of International Affairs* 24, no. 1 (2011): 44.

[404] Murray Gell-Mann, "Let's Call It Plectics.," *Complexity Journal* 1, no. 5 (1996): 3.

[405] Warren Weaver, "Science and Complexity," *American Scientist* 36, no. 4 (1948).

complexity'. Weaver calls these problems disorganised because the variables' behaviour is individually erratic or even unknown. However, *'the system as a whole possesses certain orderly and analyzable average properties'*.[406] Probability theory and statistical mechanics allow scientific inquiry to explain and solve problems of disorganised complexity. The law of large numbers, where outliers are evened out by normal behaviour, making the average close to the expected outcome, is valid in disorganised complexity.

The middle region between problems with two variables and problems with a great amount of variables is inhibited by 'problems of organized complexity', according to Weaver. These possess a moderate amount of variables; more than two but less compared to disorganised complexity. More important, as apparent from the name, these problems, in contrast to the erratic nature of disorganised complexity, possess an organising feature. Organised complexity is about problems that deal *'simultaneously with a sizable number of factors which are interrelated into an organic whole'*.[407] Many problems in the biological, medical, psychological, economic, and political sciences are far more difficult than problems of simplicity, while at the same time they cannot be statistically explained in average behaviour. Drawing on experiences from the Second World War, Weaver saw two possible methods to deal with organised complexity: the power of computational development and the interdisciplinary approach from operation analysis. The development of science and the role of computational and mixed team approaches to tackle complex problems, are revisited later on. For now both the distinction and relation between simplicity and complexity, especially the latter's distinguishing interrelational and organisational feature, will suffice to work to understanding complexity.

Another useful and often used distinction to build understanding of complexity is the difference between complicated and complex.[408] The term complicated is often used to describe something that is difficult to understand because it consists of many parts. Star-restaurant cooking or landing a robot on Mars are complicated undertakings. They are both difficult to do but the recipe or Mars does not change.

---

[406] Ibid., 538.

[407] Ibid., 539.

[408] See, for example: John H. Miller and Scott E. Page, *Complex Adaptive Systems: An Introduction to Computational Models of Social Life* (Princeton, N.J.: Princeton University Press, 2007), 9-10.

As with disorganised complexity, the laws of physics help to solve the problem. With ample time and resources both can be accomplished and, over time, a standard procedure can be formulated. Kreienkamp and Pegram summarise the differences between complicated and complex systems in the following table:

Complicated systems	**Complex systems**
Complicated systems are closed, their boundaries relatively fixed, impermeable and easy to determine.	Complex systems are open, making it difficult or impossible to determine their boundaries.
Complicated systems are ordered and deterministic. They can be fully understood in terms of the properties of their component parts and they always tend towards equilibrium.	Overall behaviour of complex systems is not determined by the properties of their elements but their interactions. The system is usually far from equilibrium but without dissolving into random disorder, it exists 'at the edge of order and chaos'.
Cause and effect relationships are linear such that for each input to the system there is a proportionate output. We can identify a clear cause for each observed effect and predict system-level outcomes of change.	The relationship between cause and effect is non-linear and effects are the result of several interacting causes. Due to feedback loops, we cannot establish clear cause-and-effect relationships or predict system-level outcomes.
Complicated systems can only evolve with the help of an external force. System elements are static and not able to adapt […] on their own. If a key part of the system breaks down, the whole system will stop functioning, unable to repair itself.	Elements in a complex system are able to learn and adapt to changing conditions. Simultaneously adapting elements give rise to self-organisation. As a result, complex systems can display remarkable resilience and sometimes even continue functioning if key elements break down.
Because cause and effect relationships in complicated systems are stable over time, any kind of change is reversible.	In complex systems, change creates path dependencies that may be difficult to alter. If we could turn back time to the same starting conditions, the system is unlikely to evolve exactly the same way.

Table 9: Complicated or complex? Key differences[409]

[409] Julia Kreienkamp and Tom Pegram, "Governing Complexity: Design Principles for the Governance of Complex Global Catastrophic Risks," *International Studies Review* (2019): 7.

Chaos in scientific terms is also described as sensitive dependence on initial conditions, or sensitivity to initial conditions, meaning a small changes in input can lead to vastly different outcomes.[410] This is popularly known as 'the butterfly effect' metaphor in which the flap of a butterfly's wings in one part of the world can create a hurricane in another part, meant to illustrate the complexity and unpredictability of meteorological systems.[411] This is not the same as randomness. Where in chaos there is still a link between cause and effect, with randomness there is none. Complex systems that produce randomness are also very sensitive to initial conditions. Complexity lies between order and chaos and between order and randomness.[412]

Another method to reflect on different problems, or systems, is the Cynefin framework by Dave Snowden (Figure 3). Cynefin will be part of the analysis of the research data, see section 5.2.3. For now its use is to explain how different problems relate to each other. Cynefin consists of four domains (clear, complicated, complex, chaotic) that act as reference on how to see the world and act accordingly.[413] Cynefin is a framework meant to determine what approaches one should adopt, depending on the domain one is in or wants to move to. This is important as Cynefin is not meant to merely categorise different types of problems, but to enable moving between the domains as the situation demands; in other words, adaptation. The space between the domains is one of confusion. This is caused because one does not know in which domain one is.

---

[410] John H. Holland, *Emergence: From Chaos to Order* (Oxford University Press, 2010), 43. Melanie Mitchell, *Complexity: A Guided Tour* (New York, NY: Oxford University Press, 2009), 20.

[411] Edward Lorenz, "Predictability: Does the Flap of a Butterfly's Wing in Brazil Set Off a Tornado in Texas?" (paper presented at the American Association for the Advancement of Science, Cambridge, MA, 1972).

[412] Page, *Diversity and Complexity*, 32-33.

[413] R. Greenberg and B. Bertsch, eds., *Cynefin: Weaving Sense-Making into the Fabric of Our World* (Singapore: Cognitive Edge Pte Ltd, 2021); Dave Snowden and Alessandro Rancati, "Managing Complexity (and Chaos) in Times of Crisis," (Luxembourg: Publications Office of the European Union, 2021).

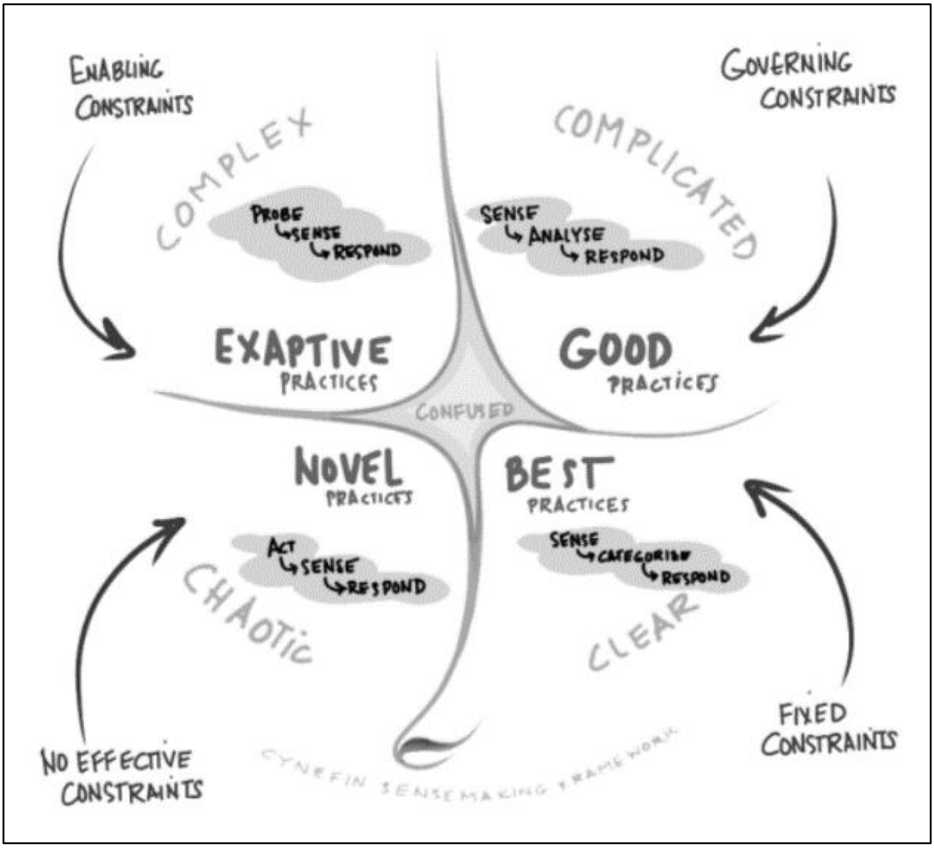

Figure 3: Cynefin framework.[414]

The four domains are expressed in three features; how well the cause and effect relations (constraints) can be observed, the type of practice that is employed, and the decision model needed to address the problem. These are discussed below.

The type of constraints for the Clear and Complicated domains constitute order. Order is constrained, meaning future outcomes are predictable as long as the constraints can be sustained. There is however also a difference between the constraints of the two domains. The fixed constraints of Clear means the relationship between cause and effect is self-evident, or clear. In a way the system is static and single-point forecasts are possible. The governing constraints in Complicated means causal relationships exist in chains that are difficult to understand. They are hidden

[414] Website The Cynefin Company, 'The Cynefin framework', accessed 6-10-2021. https://thecynefin.co/about-us/about-cynefin-framework/

or unknown, and require expertise or analysis to be discovered. Hereby the (future) state of a system is derived from its properties. Forecasts are along a range of probabilities of main-driving factors of causality, such as with scenario-planning. This is valid only as long as the system is stable. The Complex domain has enabling constraints meaning cause and effect are perceivable but not predictable because cause and effect stem from many interacting agents. This defies any description of a single and stable state of the system, rather the states of the system appear in emergent patterns. These are however not readily discernible or understood and as a result there is no clear linear causality. Forecasting or any prediction is therefore impossible but examining the system from multiple perspectives may gain knowledge on the nature of the system. Chaos means the absence of effective constraints; there are no perceivable cause and effect relations whatsoever. The system is turbulent meaning anything resembling a general understanding, let alone prediction of the system is impossible. The only knowledge is limited to feedback when interacting with the system. This knowledge is unique and only valid in the context of own actions and their particular circumstances.

The type of practice used in a domain is determined by the constraints. In the Clear domain this is best practice based on proven solutions over time from comparable clear problems and situations. Manuals and Standard Operating Procedures (SOP) ensure efficiency and consistency for proven processes. For Complicated, the expert advice and analysis needed here constitute good practices. The approach works for now but it is unknown if it is the most effective over time. In the Complex domain the emergent patterns of cause and effect require multiple perspectives to gain knowledge on the nature of the system. As a result practice is a re-purposing of existing capability, and is exaptive, or emergent. In Chaos practice is novel and accidental.

The decision models following from the constraints and the type of practice are as follows: In the Clear domain the problem input is sensed, put into existing frames of reference (categorisation) and this allows a standard response. For Complicated problems the problem input is sensed but does not fit to existing explanations. Therefore analysis of the problem is needed to respond. Complex problems lack any clear input on the situation. Instead of passively receiving input one has to probe the problem to sense its behaviour or pattern before responding. Chaotic situations defy any sensible input, passively or actively, and therefore one has to act first to generate input. Only then can this input be sensed and responded to.[415]

It was the Cynefin framework by Snowden that inspired Treverton's 'complexities' category, and Cynefin is also mentioned several times in intelligence publications.[416] In his turn Snowden has applied Cynefin and associated thinking to intelligence such as Singapore's Risk Assessment and Horizon Scanning program.[417] While the idea of Cynefin remains the same, the framework evolves over time. For instance, earlier the Clear, Complicated, and Complex domains were expressed as known knowns, known unknowns, and unknown unknowns (Chaos being unknowable).[418] This brings Cynefin very close to the Rumsfeld matrix.[419]

The take-away is that complexity is concerned with systems with intricate dynamics, for example the workings of the human brain or the global economy. The behaviour of these systems is not determined by the properties of the individual parts but by the interaction between these parts. Out of these interactions, in a bottom-up process, the macro-level organisation emerges. In other words, complexity deals

---

[415] Cynthia F Kurtz and David J. Snowden, "The New Dynamics of Strategy: Sense-Making in a Complex and Complicated World," *IBM systems journal* 42, no. 3 (2003); Dave Snowden, "What Cynefin Is in Brief," in *Cynefin: Weaving Sense-Making into the Fabric of Our World*, ed. R. Greenberg and B. Bertsch (Singapore: Cognitive Edge Pte Ltd, 2021).

[416] Magdalena Adriana Duvenage, "Intelligence: Lessons from Knowledge Management," in *International Studies Association* (San Francisco2013); Kwa, "Postmodern Intelligence: Strategic Warning and Crisis Management," 109; James L Lawrence, "Activity-Based Intelligence: Coping with the" Unknown Unknowns" in Complex and Chaotic Environments," *American Intelligence Journal* 33, no. 1 (2016).

[417] David J Snowden and Mary E Boone, "A Leader's Framework for Decision Making," *Harvard business review* 85, no. 11 (2007): 2; Dave Snowden, "Cynefin: A Tale That Grew in the Telling," in *Cynefin: Weaving Sense-Making into the Fabric of Our World*, ed. R. Greenberg and B. Bertsch (Singapore: Cognitive Edge Pte Ltd, 2021), 46.

[418] Snowden and Boone, "A Leader's Framework for Decision Making," 7.

[419] Sonja Blignaut, "Introduction," in *Cynefin: Weaving Sense-Making into the Fabric of Our World*, ed. R. Greenberg and B. Bertsch (Singapore: Cognitive Edge Pte Ltd, 2021), 14.

with phenomena where the whole is more than the combination of its parts. This is examined further in the next section.

4.2.2 What is complexity science?

Defining research on complexity is not easy. Research on, or the study of, complexity would logically be called complexity *science*. However, the idea that there exists a single science of complexity can be disputed. Instead, there are rather several sciences that differ enough not to be considered a unified science.[420] Furthermore, the term complexity itself has many definitions, just as intelligence. *This 'reflects less a lack of agreement than an inability of any single approach to capture what scientists mean by complex'*, or intelligence for that matter.[421] Complexity *theory* is an ambiguous term as well. Capra and Luisi differentiate between scientific theory and mathematical theory. A scientific theory, is *'an explanation of a well-defined range of natural phenomena, based on systemic observation and formulated in terms of a set of consistent but approximate concepts and principles'* and a mathematical theory (citing mathematician Ian Stewart) is *'a coherent body of mathematical knowledge with a clear and consistent identity'*.[422] According to Capra and Luisi complexity theory is a mathematical theory as it is no scientific advance of itself but a basis for new scientific theories to explain non-linear phenomena.[423] Irrespective of this distinction many publications use complexity theory in a scientific theoretical meaning.

To add to the ambiguity, scientific theory itself is no clear and singular phenomenon either. For instance, there is a difference between physics and social science when it comes to matters of accuracy and truth value with regard to theoretical deductive implications, definitions, measurement and sampling sizes.[424] This does not help for the interdisciplinary approach that is (required for) the study of complexity. Therefore it is helpful to regard complexity – whether theory or science – not as a

[420] Mitchell, *Complexity: A Guided Tour*, 95.

[421] Page, *Diversity and Complexity*, 24.

[422] Fritjof Capra and Pier Luigi Luisi, *The Systems View of Life: A Unifying Vision* (Cambridge University Press, 2014), 98.

[423] Ibid., 89-99.

[424] Steven Bernstein et al., "God Gave Physics the Easy Problems: Adapting Social Science to an Unpredictable World," *European Journal of International Relations* 6, no. 1 (2000).

definitive and unified theoretical body but as a collection of conceptual tools that still show enough coherence and complementarity.[425] This enables a methodological pluralism that is necessary to try to understand complex issues in all their aspects.[426] This somewhat loose interpretation is how complexity in this research is seen: a toolkit of minor theories and concepts that are bounded by the idea that systems cannot be explained by their components but rather by the component's interactions, and from this, the whole becomes more than the combination of its parts. For all the ambiguity and definitional problems regarding a *science* or *theory* of complexity, this research uses complexity *science*, but will mainly just refer to complexity.

In scientific terms the idea that the whole is more than its combined parts constitutes a paradigm shift. It disrupts established ideas on how to see the world and study it. Ever since the Scientific Revolution the world was regarded as a machine that operates according to mathematical laws formed by the scientific ideas of e.g. Copernicus, Galileo, Descartes and Newton. This mechanistic universe could be studied because it works according to linear causality. Associated with this is the method of analytic thinking whereby difficult problems can be broken up into their constituent parts whose properties explain the behaviour of the whole, also known as reductionism.[427] Scientific progress however led to discoveries that are inconsistent with the mechanistic paradigm. For instance in biology, if cell development proceeds by splitting into exact copies with the same genetic information how can cells specialise and become bone cells or muscle cells? Ideas began to develop that organisation, behaviour between parts, could perhaps explain what makes the whole more than the sum of its parts. In the early 20th century the term system came in usage to denote an integrated whole whose essential properties stem from interactions between its parts. This in turn gave rise to 'systems

---

[425] Bousquet and Curtis, "Beyond Models and Metaphors: Complexity Theory, Systems Thinking and International Relations," 45; Sylvia Walby, "Complexity Theory, Systems Theory, and Multiple Intersecting Social Inequalities," *Philosophy of the Social Sciences* 37, no. 4 (2007): 456.

[426] Kurt Richardson and Paul Cilliers, "What Is Complexity Science? A View from Different Directions," (2001): 12.

[427] P. W. Anderson, "More Is Different," *Science* 177, no. 4047 (1972); Capra, *The Web of Life: A New Synthesis of Mind and Matter*, 19-20. For a more detailed account, see: Capra and Luisi, *The Systems View of Life: A Unifying Vision*, Chapters 1-3.

thinking', the idea that wholes cannot be explained by their parts but rather by their organisation in the context of the whole. Systems thinking and the closely associated concept of network – which emphasises interconnectedness and exchange rather than organisation – provided a language to define the departure from the mechanistic paradigm.[428]

One of the most influential disciplines that came from systems thinking and would heavily influence complexity is cybernetics that developed in the 1940s. Cybernetics comes from the Greek word for governance. In its modern scientific meaning it was introduced by Norbert Wiener who was inspired by war-time mechanical control systems such as servomechanisms and artillery targeting systems. Wiener developed a general theory of organisational and control relations in living and artificial systems and published it as *Cybernetics: Or Control and Communication in the Animal and the Machine* (1948). Cybernetics examines closed systems with behaviour that is *'regular, or determinate, or reproducible'*.[429] As such early cybernetics, employing an engineering approach, was interested in linear processes as this makes systems simple to build and predict. The central idea of cybernetics is the concept of feedback; reinserting results of past performance back into the system. A feedback loop is a circular connection of causally related elements in which an initial cause moves through the loop whereby each element has an effect on the next, until it feeds back into the initial element. Feedback can be self-balancing (negative) or reinforcing (positive). Negative feedback means the energy and matter produced in the feedback is absorbed again and the system keeps its balance. Conversely, positive feedback means it self-amplifies and disturbs systemic balance; it spins out of control.

Cybernetic research into self-regulation, self-control and feedback led to the concept of self-organisation, that would become central to complexity. Early cybernetics still kept close to the mechanistic paradigm.[430] This changed with the advance of what became known as the second-order cybernetics in the 1970s. Whereas the engineering approach of first-order cybernetics tends to study a system as a passive and objective 'thing' second-order cybernetics sees the system and the observer as

[428] Capra, *The Web of Life: A New Synthesis of Mind and Matter*, 24-42.
[429] Ashby, *An Introduction to Cybernetics*, 1.
[430] Capra and Luisi, *The Systems View of Life: A Unifying Vision*, 88.

interacting agents that influence the results of the observation.[431] Next to the parts to the whole shift, this disappearance of the distinction between the problem at hand and its observer also constitutes a major break with the mechanistic paradigm. The certainty of scientific knowledge is replaced with a scientific approach that acknowledges itself to be limited and approximate because the observation, or measurement, is no longer considered to be objective and absolute, but biased.

Around 1940, systems thinking and cybernetics were applied to solve practical problems. Drawing on these, the RAND corporation transformed operations research, the analysis and planning of military operations during World War 2, into systems analysis; a cost-benefit analysis that involved mathematical models to examine the best approach to meet a defined goal. Another application is system dynamics; a method for modelling and simulating systems that exhibit feedback and accumulation.[432] The causal loop diagram, mentioned several times in this research, originates from system dynamics. The common feature of all fields that sprung forth from system thinking is the concept of self-organisation. This is the idea that even though parts of a system appear to behave randomly, over time there emerges a pattern – or order. In the early concept of self-organisation from cybernetics this pattern takes place within a limited range of possibilities, or variety pool. Survival or stability of the system depends on the requisite variety, and resulting adaptability, to match against changes in the environment. This is the law of requisite variety introduced by Ashby which will be further examined in section 4.4.1.[433]

Ideas on self-organisation in the 1970s and 80s expanded the original meaning and share three characteristics, according to Capra: (1) It can lead to new structures and behaviour outside the cybernetic limited range of possibilities. (2) These new structures and behaviour can only appear in open systems that are not stable. A constant flow of energy and matter pushes such a system far from equilibrium. Only then self-organisation can happen. (3) The components of the system are connected in a non-linear fashion. This non-linear pattern results in feedback loops and is described by non-linear equations. Capra then summarises that *'self-organization is the spontaneous emergence of new structures and new forms of behaviour in open*

---

[431] Francis Heylighen and Cliff Joslyn, "Cybernetics and Second-Order Cybernetics," in *Encyclopedia of physical science & technology*, ed. R.A. Meyers (New York, NY: Academic Press, 2001), 3-4.

[432] Capra, *The Web of Life: A New Synthesis of Mind and Matter*, 75-76.

[433] Ashby, *An Introduction to Cybernetics*, 202-19.

systems far from equilibrium, characterized by internal feedback loops and described by nonlinear equations'.[434] The scientific developments that break with the mechanistic paradigm, laid the foundations for complexity, see Table 10.

Traditional	**Emerging**
Reductionism.	Holism.
Linear causality.	Mutual causality.
Objective reality.	Perspective reality.
Determinism.	Indeterminism.
Survival of the fittest.	Adaptive self-organization.
Focus on discrete entities.	Focus on relationship entities.
Linear relationships.	Non-linear relationships.
Newtonian physics perspectives.	Quantum physics perspectives.
World is predictable.	World is novel and probabilistic.
Modern.	Postmodern.
Focus on hierarchy.	Focus on heterarchy (within levels).
Prediction	Understanding
Based on nineteenth-century physics.	Based on biology.
Equilibrium/stability/deterministic dynamics.	Structure/pattern/self-organization/life cycles.
Focus on averages.	Focus on variation.

Table 10: Traditional versus Emerging Worldview[435]

[434] Capra, *The Web of Life: A New Synthesis of Mind and Matter*, 85.

[435] Frans P. B. Osinga, *Science, Strategy and War: The Strategic Theory of John Boyd* (Routledge, 2007), 88.

The theoretical development of self-organisation was only made possible in the late 20th century because the advance of the computer, and with it new mathematical tools, made it possible to model densely interconnected living systems and their non-linear dynamics. This theoretical development enabled scientists and mathematicians to develop new concepts and techniques to engage with these complex problems, coalescing into what is now known as complexity science. This theoretical development coincides, and is likely to have caused, a turn to complexity within the social sciences. This involves the adoption of ideas and methods of complexity science to social research.[436] Mesjasz distinguishes between hard and soft complexity research. Hard research involves mathematical modelling, soft research applies qualitative complexity concepts to social science research and psychology.[437] This research is soft complexity research as it concerns qualitative concepts. Intelligence, seen generally as an approximation of social science, missed the complexity turn.[438] In studying complexity, to avoid the definition issues and paradigm shifts from the previous paragraphs, many scholars prefer to write about complex systems or complex adaptive systems, often using both terms interchangeably.[439] This research does so as well. Complexity science then, is *'the study of phenomena which emerge from a collection of interacting objects'*, or, a complex system.[440]

Mitchell proposes a definition of the term complex system*: 'A system in which large networks of components with no central control and simple rules of operation give rise to complex collective behavior, sophisticated information processing, and adaptation via learning or evolution'*. She proceeds to highlight the importance of self-organisation and emergence in complex systems and, adhering to the pluriform

---

[436] Pete Barbrook-Johnson and Jayne Carrick, "Combining Complexity-Framed Research Methods for Social Research," *International Journal of Social Research Methodology* 25, no. 6 (2021): 835; For example, see: David Byrne and Gillian Callaghan, *Complexity Theory and the Social Sciences: The State of the Art* (New York: Routledge, 2013).

[437] Czeslaw Mesjasz, "Complex Systems Studies and Terrorism," *Conflict and complexity: Countering terrorism, insurgency, ethnic and regional violence* (2015): 40.

[438] Spoor and de Werd, "Complexity in Military Intelligence," 1125.

[439] Mitchell, *Complexity: A Guided Tour*, 13.

[440] Neil F. Johnson, *Simply Complexity: A Clear Guide to Complexity Theory* (London: Oneworld Publications, 2012), 3-4.

understanding of complexity, provides another definition of a complex system: *'a system that exhibits nontrivial emergent and self-organizing behaviors'*.[441] Johnson avoids giving a definition altogether. Instead he describes the workings of complex systems. For Johnson a complex system contains many interacting agents. The interactions take place because agents are in close proximity, belong to the same group or hold certain information in common. A collection of such agents with a shared aspect is a network. Therefore the study of agents and networks is an integral part of complexity science. In a network the behaviour of the agents is influenced by memory, or feedback. This means information from past experience can influence present behaviour and so agents adapt their strategies to improve performance. The system is open, so it can also be influenced by its environment. This results in system behaviour that is characteristic of complexity; The system appears to be alive. It constantly evolves and changes because of the interactions and adaptation of its agents. The behaviour of a complex system is a mix of order and disorder and it moves between these extremes on its own without any form of central control.[442] As explained briefly in chapter one a complex system consists of agents that are diverse and connected and that interact and adapt. These characteristics allow intricate and long interactions between the agents. The concept of complexity refers to the shifting patterns of these interactions, making precise repetition or prediction impossible.

Page refers to Wolfram's *A new Kind of Science* (2002) who classifies systems as producing one of four types of outcomes. While Wolfram gives his categories numbers Page characterises them as fixed points, simple structures/periodic orbits, randomness and complexity, whereby complexity is between simple structures and randomness.[443] As such, complex systems contain contradictions. They are often robust, meaning they have the ability to maintain functionality after perturbations and can resist changing conditions without adapting their initial configuration. Despite this redundant feature complex systems are also capable of producing large and catastrophic events. Complex systems can reach a state of balance, whether fixed point or simple pattern, but also produce long random sequences. Acknowledging the pluriform meaning of complexity Page gives two core principles of complexity; it lies between order and randomness, often referred to as 'the edge

[441] Mitchell, *Complexity: A Guided Tour*, 13.
[442] Johnson, *Simply Complexity: A Clear Guide to Complexity Theory*, 13-16.
[443] Stephen Wolfram, *A New Kind of Science* (Champaign, IL: Wolfram media 2002), 231, 35; in: Page, *Diversity and Complexity*, 26-27.

of chaos', and complexity cannot be easily described, evolved, engineered or predicted.[444]

4.2.3 Complexity in the study of war and warfare

This part examines complexity applications in the study of war and warfare. This is done to lessen the theoretical focus of the two previous parts and to explore how related fields deal with complexity.

The paradigm shift that is complexity and its cybernetic precursor are also described by Bousquet who, based on the mutual influence between science and warfare, distinguishes four regimes of a scientific way of warfare with chaoplexic being a combination of chaos and complex, see Table 11. These regimes represent specific theoretical and methodological underpinnings and are associated with a piece of technology as central conceptual and metaphorical phenomenon emblematic of the particular scientific frameworks.

	Mechanism	**Thermodynamics**	**Cybernetics**	**Chaoplexity**
Key technology	Clock.	Engine.	Computer.	Network.
Scientific concepts	Force, matter in motion, linearity, geometry.	Energy, entropy, probability.	Information, negentropy, negative feedback, homeostasis.	Information, non-linearity, positive feedback, self-organisation, emergence.
Form of warfare	Close order drill, rigid tactical deployments.	Mass mobilisation, motorisation, industrialisation.	Command and control, automation.	Decentralisation, swarming.

Table 11: The four regimes of the scientific way of warfare.[445]

[444] *Diversity and Complexity*, 17, 32.

[445] Antoine J. Bousquet, *The Scientific Way of Warfare: Order and Chaos on the Battlefields of Modernity* (London: Hurst & Company, 2009), 30.

This research is only concerned with the development from cybernetics into the chaoplexic regime. Bousquet states cybernetic war strives for complete predictability and control. Traditional command was complemented with control to keep the system of waging war in a stable condition. War was reduced to mathematical functions and cost-benefit calculations to be optimised with operations research and system analysis. As a result uncertainty and unpredictability were seen as mere information deficiencies. However, the US failure of the war in Vietnam showed cybernetic warfare did not guarantee victory.

According to Bousquet chaoplexic warfare abandons cybernetic command and control for decentralisation and self-organising networks. This is in stark contrast with the rigid hierarchy in many intelligence cultures and organisations.[446] There are more publications that use complexity to establish that war and warfare are complex phenomena, or complex adaptive systems, or that draw on complexity to examine military strategy and theory.[447] Often concepts from complexity science are shown to be applicable or phenomena from practice are viewed while drawing on complexity.

However, the real impact of complexity thinking on war(fare) is not in individual publications that combine complexity with elements of the military, be it the environment, organisation, or combat. As Lawson and Osinga both show, fundamental aspects of modern military theory are heavily influenced by

---

[446] Ibid., Chapters 5 & 7.

[447] David S Alberts and Thomas J Czerwinski, "Complexity, Global Politics, and National Security," (Washington D.C.: National Defense University, 1997); Yaneer Bar-Yam, "Complexity of Military Conflict: Multiscale Complex Systems Analysis of Littoral Warfare," (New England Complex Systems Institute, 2003); Andrew Ilachinski, "Land Warfare and Complexity, Part Ii: An Assessment of the Applicability of Nonlinear Dynamics and Complex Systems Theory to the Study of Land Warfare," (Alexandria, VA: Center for Naval Analyses 1996); Sean T. Lawson, *Nonlinear Science and Warfare: Chaos, Complexity and the U.S. Military in the Information Age* (Milton Park, Abingdon, Oxon: Routledge, 2014), 106-27; Steven R Mann, "Chaos Theory and Strategic Thought," *Parameters* 22 (1992); James Moffat, *Complexity Theory and Network Centric Warfare* (Washington, DC: CCRP Publication Series, 2003); Samuel Solvit, *Dimensions of War: Understanding War as a Complex Adaptive System* (Paris: L'Harmattan, 2012).

complexity.[448] In the early days of complexity several strategists among whom are John Warden and John Boyd formulated stratagems based on complexity thinking. This led to Boyd's famous OODA-loop (Observe, Orient, Decide, Act) that represents decision-making process in war (see section 4.3.4) but also manoeuvre warfare, mission command, NCW and C4ISR, see section 3.3.1. The common denominator is that both enemy and own organisations are seen as systems or networks. Physical manoeuvre and information warfare are aimed at destroying and disrupting the connections and coherence in the enemy system. This overwhelms his understanding of the battlefield and negates his adaptability.

A more recent example of the application of complexity is military design thinking.[449] As opposed to traditional linear thinking, military design thinking *'as an emerging practice evokes eclectic combinations of philosophy, social sciences, complexity theory, and often improvised, unscripted approaches in a tailored or "one of a kind" practice'*.[450] It rejects standard operating procedures and formats for mindful attention to detail in an iterative manner to adapt to changes in the problem (environment). Design thinking sees military operational art as making sense of complexity by assuming multiple perspectives (paradigms) on a problem, including reflexive examination of how the problem is framed and formulated.[451] Another, relatively, recent application of complexity in military science concerns the study of

---

[448] Lawson, *Nonlinear Science and Warfare: Chaos, Complexity and the U.S. Military in the Information Age*; Osinga, *Science, Strategy and War: The Strategic Theory of John Boyd*, 115-21; "Organizing for Insecurity and Chaos: Resilience and Modern Military Theory," in *Netherlands Annual Review of Military Studies 2016: Organizing for Safety and Security in Military Organizations*, ed. Robert Beeres, et al. (The Hague: T.M.C. Asser Press, 2016).

[449] Cara Wrigley, Genevieve Mosely, and Michael Mosely, "Defining Military Design Thinking: An Extensive, Critical Literature Review," *She Ji: The Journal of Design, Economics, and Innovation* 7, no. 1 (2021); Ben Zweibelson, *Understanding the Military Design Movement: War, Change and Innovation* (Taylor & Francis, 2023).

[450] "An Awkward Tango: Pairing Traditional Military Planning to Design and Why It Currently Fails to Work," *Journal of military and strategic studies* 16, no. 1 (2015): 12.

[451] "'Design' Goes Dutch: Army Considerations for Unconventional Planning and Sensemaking," *Atlantisch perspectief* 39, no. 6 (2015).

peacekeeping and peacebuilding.[452] The general idea is that a peacekeeping mission takes place in a complex adaptive system. The belligerent actors, peacekeepers, and the population constitute a dynamic with non-linear interactions. As such, complexity offers an alternative to mainstream peacekeeping that has *'strong preference for linear models of change, where the input of a range of activities (e.g. patrolling, infrastructural development, technical support, training) is presumed to result in improved security and prospects for peace'*.[453] Other streams of research focus on adaptability of peacekeeping in relation to the volatile crisis situation and warring factions, or what complexity lessons there are for leading peacekeeping operations.[454]

There is criticism on the application of complexity to the study of war and warfare too. An often heard argument is that there was complexity on the battlefields of the past as well and not everything is mired in complexity today.[455] The adoption of complexity thinking into military theory and practice does not mean armed forces are turning into complex systems themselves. Kerbel argues that doctrine often uses complexity terminology far removed from its meaning in complexity science.[456] Two such doctrinal examples are the US Army Operating Concept called *Win in a Complex*

---

[452] e.g. Emery Brusset, Cedric De Coning, and Bryn Hughes, *Complexity Thinking for Peacebuilding Practice and Evaluation* (Springer, 2016); Cedric de Coning, Rui Saraiva, and Ako Muto, *Adaptive Peacebuilding: A New Approach to Sustaining Peace in the 21st Century* (Springer Nature, 2023).

[453] Adam Day and Charles T. Hunt, "A Perturbed Peace: Applying Complexity Theory to UN Peacekeeping," *International Peacekeeping* 30, no. 1 (2023).

[454] Soili Paananen et al., "Embracing Dynamic Tensions: Peacekeeping as a Balancing Act of Complexity," *Public Administration Review* 82, no. 6 (2022): 1169.

[455] Dale C. Eikmeier, "Simplicity: A Tool for Working with Complexity and Chaos," *Joint Force Quarterly: JFQ*, no. 92 (2019); Clay Mountcastle, "The Myth of the New Complexity," *Military Review* 96, no. 2 (2016); Harri Raisio, Alisa Puustinen, and Jaakko Jäntti, "“The Security Environment Has Always Been Complex!”: The Views of Finnish Military Officers on Complexity," *Defence Studies* 20, no. 4 (2020).

[456] Josh Kerbel, "The US Talks a Lot About Strategic Complexity. Too Bad It’s Mostly Just Talk." (9-3-2021), Defenseone.com.

World and the Australian *Army's Future Land Operating Concept: Adaptive Campaigning*.[457]

4.3 Characteristics of complexity

Within complexity science many concepts and terminology are used. This section focuses on four characteristics of complexity: self-organisation, emergence, non-linearity, and adaptation. These serve to deepen the understanding of complexity but also have value of their own. Together with the concepts from the previous sections they are well suited to form the language for the following case study chapters of this research. As such the terms in this chapter will be used to operationalise interview questions for the case study research and serve as analytic lens as well.

Furthermore, apparent from their occurrences throughout the preceding pages the four characteristics lie at the very core of complexity. As with complexity, the four characteristics are not easily defined. They are interrelated which also shows from many books on complexity where they mention or refer to each other in the index. Aside from their close relation, the relative newness of the study of complexity does not help either, as Mitchell explains: *'We use words such as complexity, self-organization, and emergence to represent phenomena common to the systems in which we're interested but we can't yet characterize the commonalities in a more rigorous way. We need a new vocabulary that not only captures the conceptual building blocks of self-organization and emergence but that can also describe how these come to encompass what we call functionality, purpose, or meaning […]. These ill-defined terms need to be replaced by new, better-defined terms that reflect increased understanding of the phenomena in question.'*[458] For reasons of clarity, however, the four characteristics will be explained separately. As with the preceding section, examples from the study of war and warfare will be used to illustrate the often abstract concepts of complexity science.

---

[457] e.g. U.S. Army Training and Doctrine Command, "The U.S. Army Operating Concept: Win in a Complex World," (Fort Eustis, VA: United States Army Headquarters, 2014); Head Modernisation and Strategic Planning - Army and Australian Army Headquarters, "Army's Future Land Operating Concept: Adaptive Campaigning," (Canberra 2009).

[458] Mitchell, *Complexity: A Guided Tour*, 301.

4.3.1 Self-organisation

The first characteristic, self-organisation, means a system is not regulated by a central controller or coordinator. Instead, the entities in the system organise themselves. This does not mean there is no external influence, but it does not directly changes the organisation of the system. It is the system itself that initiates the change. This is referred to as co-evolution between a system and its environment. An adaptation of the system that is triggered by the environment, in its turn, feeds back into the environment and changes it, after which the process is repeated. The extent to which NATO co-evolved with its changing environment permeates the entire case study. As mentioned earlier, self-organisation was already touched upon by cybernetics where it refers primarily to a limited range, or variety, of self-regulatory processes. Complexity science broadens self-organisation *'to the creative, self-generated, adaptability seeking behavior of a complex system'*.[459] Self-organisation came from the natural sciences but it also applies to social systems because these also aim at maintaining a stable but dynamic mode as they incorporate new members and ideas.[460] As such the idea of self-organisation is also applied to studying terrorism.[461] This also directly relates to intelligence. If terrorist networks are self-organising this has implications for the analysis of these networks and how useful leadership targeting is.

A central idea in self-organisation is that a complex system is in a position between order and disorder, referred to as at the edge of chaos. The system is far from equilibrium but not yet in a chaotic state.[462] It is in a stable, yet temporary, position *'where the components of a system never quite lock into place, and yet never quite*

[459] Jeffrey Goldstein, "Emergence as a Construct: History and Issues," *Emergence* 1, no. 1 (1999): 56.

[460] Capra and Luisi, *The Systems View of Life: A Unifying Vision*, 136-37.

[461] Bousquet, "Complexity Theory and the War on Terror: Understanding the Self-Organising Dynamics of Leaderless Jihad."; e.g. Marc Sageman, *Leaderless Jihad: Terror Networks in the Twenty-First Century* (Philadelphia, PA: University of Pennsylvania Press, 2008).

[462] For more background see e.g. 'autopoiesis' in: Humberto R Maturana and Francisco J Varela, *Autopoiesis and Cognition: The Realization of the Living* (Springer Science & Business Media, 1991); And 'dissipative structures' in: Ilya Prigogine and Isabelle Stengers, *Order out of Chaos: Man's New Dialogue with Nature* (London: Flamingo, 1985).

dissolve into turbulence, either'.[463] Self-organisation means that the system is always near a state of change, or at the edge of chaos. In this state, there is always the chance that a small change can create a big or catastrophic event. This is referred to as self-organised criticality and was introduced in a paper by Bak, Tang and Wiesenfeld.[464] In the paper they presented a statistical physics experiment in which single grains of sand were dropped randomly into a pile of sand to study the dynamics of avalanche distribution. They found that most of the time small avalanches would happen but sometimes very large avalanches were caused. However, this was not according to the statistical normal distribution where one would see a bell curve when plotted in a graph. Instead the curve has a very long tail and is called a power law distribution, see Figure 4.

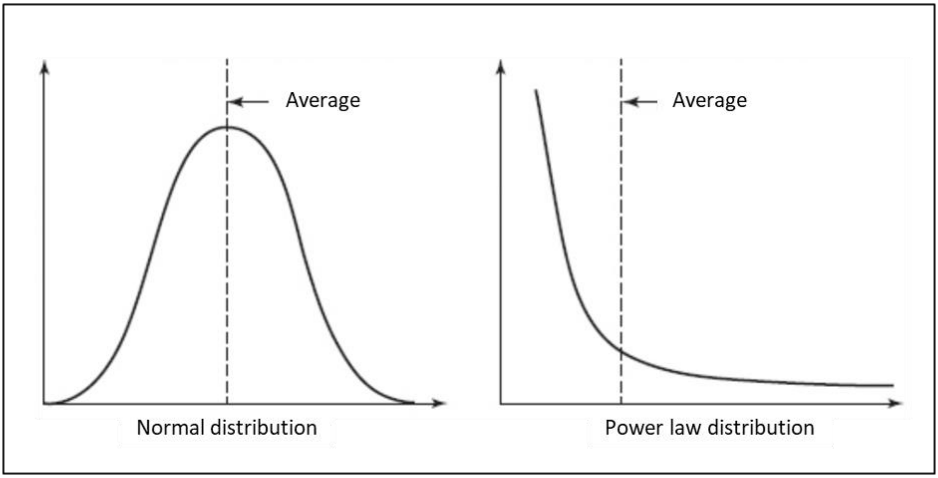

Figure 4: Normal distribution (bell curve) and power law distribution (long tail).[465]

A power law means that there is a higher probability of large events than with a normal distribution. Power laws are found with earth quakes and forest fires, but are also present in war. There are power laws in the frequency of wars related to the total number of casualties per war or force ratio of attacks related to the casualties per attack. The interesting thing is that these power laws are found regardless of

[463] Mitchell M. Waldrop, *Complexity: The Emerging Science at the Edge of Order and Chaos* (New York, NY: Simon and Schuster, 1992), 12.

[464] Per Bak, Chao Tang, and Kurt Wiesenfeld, "Self-Organized Criticality: An Explanation of the 1/F Noise," *Physical review letters* 59, no. 4 (1987).

[465] Compiled by author.

when or where conflict takes place.[466] Despite the seemingly chaotic nature of war there appear to be deeper patterns.

This is an important discovery because it enables war to be studied with the same mathematical tools that are used for other networked phenomena. It also leads to other perspectives in the study of war and with it, in intelligence. There is often a focus on trigger events or root causes but if, instead, war depends on the network of political, economic, and cultural tensions in and between societies. Forest fires are an apt analogy. The size, intensity and path of forest fires has little to do with the spark that starts them, it has more to do with drought but the biggest factor is the density (connectedness) of the forest.[467] This holds three important lessons for intelligence. First, conflict is often at the edge of chaos where seemingly small events can trigger large catastrophic events. This requires extreme flexibility in thinking because the situation is volatile and can change quickly, probably requiring a different analytic response. Furthermore, it challenges intelligence to recognise those seemingly small triggers to provide early warning. Second, qualitative analysis of social phenomena is not enough as only quantitative analysis can discover these deeper patterns and power laws. Third, whatever method or technique of analysis is used, complexity emphasises attention for the interconnections in and among phenomena rather than the phenomena themselves.

4.3.2 Emergence

The second characteristic to examine is emergence. Emergence is the formation of higher order structures and functionalities at system level, caused by interacting entities.[468] Emergence produces novel phenomena and, together with self-

[466] Aaron Clauset, "Trends and Fluctuations in the Severity of Interstate Wars," *Science advances* 4, no. 2 (2018); Johnson, *Simply Complexity: A Clear Guide to Complexity Theory*, Chapter 9; Gianluca Martelloni, Francesca Di Patti, and Ugo Bardi, "Pattern Analysis of World Conflicts over the Past 600 Years," (2018); Miller and Page, *Complex Adaptive Systems: An Introduction to Computational Models of Social Life*, 165-67; Moffat, *Complexity Theory and Network Centric Warfare*, 72-74.

[467] "Data Mining Adds Evidence That War Is Baked into the Structure of Society" (4-1-2019), MIT Technology Review, Technologyreview.com.

[468] Page, *Diversity and Complexity*, 25.

organisation, it creates new order.[469] Holland sees emergence as *'interactions where the aggregate exhibits properties not attained by summation'*.[470] As such it is overall system behaviour *'that cannot be predicted or even envisioned from the knowledge of what each component of the system does in isolation'*.[471]

Besides the impossibility of prediction, emergence is also not *'deducible from, nor reducible to the parts alone'*.[472] In a sense there is a disconnect between lower system levels/components and the aggregate outcome.[473] Emergence is a problematic concept to work with. Miller and Page state that for emergence in systems of disorganised complexity there is the law of large numbers, but an equal theorem for dealing with emergence in organised complexity is absent.[474] However, despite definitional differences the general properties that identify something as emergent according to Goldstein are[475]:

- It constitutes radical novelty; features not previously seen, or predicted.
- A certain coherence that spans and correlates separate components into higher level unity.
- The locus of emergence is at global or macro level while its components are only at the micro level.
- There are no pre-given wholes, emergence arise as systems evolve over time.
- Emergence is only recognised by showing itself (ostensively recognised).

---

[469] E. V. E. Mitleton-Kelly, "A Complexity Approach to Co-Creating an Innovative Environment," *World Futures: The Journal of General Evolution* 62, no. 3 (2006): 19.

[470] John H. Holland, *Complexity: A Very Short Introduction*, First edition. ed. (Oxford: Oxford University Press, 2014), 4. Emphasis in original.

[471] J. L. Casti, *Would-Be Worlds: How Simulation Is Changing the Frontiers of Science* (New York: J. Wiley, 1997), 82.

[472] Goldstein, "Emergence as a Construct: History and Issues," 57.

[473] Miller and Page, *Complex Adaptive Systems: An Introduction to Computational Models of Social Life*, 44.

[474] Ibid., 53.

[475] Goldstein, "Emergence as a Construct: History and Issues," 50.

An often invoked example of emergence is that wetness exists of multiple water molecules but a single molecule is not wet. This is a clear cut example from physics. For social phenomena, such as conflict, the exact point of an emergent phase transition is much more vague. When does a terrorist organisation become exactly that from what it was before? When is there enough coherence between radical people, their ideas, and willingness to perform violent acts that we call it a terrorist organisation? This requires more than mere observation, it also asks for critical reflexivity of the observer's own mental models and how these influence the observation – similar to second order cybernetics. Stated differently, beyond definitional issues there is an ontological issue. *'Are emergent phenomena part of the real, authentic "furniture of the world," or are they merely a function of our epistemological, cognitive apparatus with its ever-ready mechanism of projecting patterns on to the world?'*[476] This also asks for reflexive analysis. How do analytic thinking and methods influence the intelligence result?

Attention for reflexivity leads to different ideas on emergence. For instance strong emergence versus weak emergence. Strong emergence is the idea that higher level properties in principle cannot be derived from lower level components. This position would negate any attempts at foresight and prognostic intelligence and seems far from the reality of intelligence practice. The opposite is weak emergence. This is the idea that the relation between the whole and its parts cannot be determined for now, but only because of technical difficulties or insufficient scientific progress. This is a pragmatic argument and not as a matter of principle.[477] Or as Miller and Page state it: *'surprise and ignorance are closely related. It could be that emergent behaviour is simply reflective of scientific ignorance rather than some deeper underlying phenomenon'*.[478] This is the position of traditional intelligence and reminiscent of the idea of simply 'connecting the dots' with regard to the intelligence failure of 9/11. This idea of weak emergence is also strongly present in the case study, see section 6.3.2.

Holland sees difficulty to achieve unity in understanding emergence because of the daunting diversity of emergent phenomena. Furthermore emergence has much similarity with what he calls 'serendipitous novelty'; discoveries that are made by

---

[476] Ibid., 62.

[477] Capra and Luisi, *The Systems View of Life: A Unifying Vision*, 157.

[478] Miller and Page, *Complex Adaptive Systems: An Introduction to Computational Models of Social Life*, 46.

chance because the observer was looking for something else not because the discoveries are novel phenomena.[479] Interesting in this context is Treverton's idea of threat considered as covering a range. At one end are the purposive threats; terrorists and foreign states or armies that have a directed hostile intent towards a target. At the other end are systemic threats; the cumulative and harmful effect of non-hostile actions such as environmental degradation or pandemics. These are not on purpose but emerge from the total of actions in a given system.[480] Although risk would perhaps be a better term to use here and the examples given are not radically novel, they do emerge from many interacting micro-level factors.

4.3.3 Non-linearity

Self-organisation and emergence can be seen as outcomes of the non-linear dynamics of complex systems. Non-linearity is the third complexity characteristic examined in this chapter.

Non-linearity is about the relation between the interactions at the sub-system level of the entities and the system's overall behaviour.[481] These are non-linear because the whole is more than the sum of its parts. Non-linear systems have three properties[482]:

- A relative small amount of simple interactions may still give rise to unsuspected richness and diversity. Vice versa, seemingly complex and chaotic behaviour can produce ordered structures.

- There is a surprising difference in cause and effect relations because the output does not change in direct proportion to a change in any of the inputs. Small changes may give rise to large effects.

- As a result, exact prediction is often impossible.

Earlier system theories, such as cybernetics, included non-linearity to some degree in the sense that feedback loops are non-linear in nature, however these earlier theories included *'neither the "small cause, large effect", nor the intense focus on nonlinear interactivity found in emergent phenomena'*.[483] In essence, non-linearity

---

[479] Holland, *Emergence: From Chaos to Order*, 13.

[480] Treverton, *Reshaping National Intelligence for an Age of Information*, 43-46.

[481] Holland, *Emergence: From Chaos to Order*, 121-22.

[482] Capra and Luisi, *The Systems View of Life: A Unifying Vision*, 105.

[483] Goldstein, "Emergence as a Construct: History and Issues," 55.

refers to the unpredictable dynamics that take place between the initial conditions and emergent phenomena.

Mathematician Stanislaw Ulam is often cited regarding non-linearity of which he remarked it is equal to calling zoology *'the study of non-elephant animals'*.[484] What Ulam meant, was that linearity is the exception as scientist began to discover that non-linearity is a pervasive feature of the natural world. However, from the end of the nineteenth century scientists had developed only linear equations to model natural phenomena. Simple systems were expressed in exact, deterministic equations and systems of disorganised complexity were expressed in the equations of thermodynamics, based on the statistical analysis of average quantities.[485] Linear refers to the straight line when these equations are plotted in a graph. Contrary, complex systems are described with non-linear equations, that form a curve when plotted.[486] The advance of computers in the mid twentieth century enabled non-linear equations, which are extremely difficult to solve by head and hand, to make new models of the natural world.[487] While the whole is not the sum of its parts, the behaviour of the whole can be reduced to the lawful behaviour of its parts but only if non-linear interactions are taken into account.[488] At the same time the increased awareness of non-linearity means *'that our most useful tools for generalizing observations into theory – trend analysis, determinations of equilibria, sample means, and so on – are badly blunted'*, as Holland notes.[489] This does not mean that modelling is the only answer for scientific enquiry but there is above all a need for *'cross-disciplinary comparisons of [complex adaptive systems], in hopes of extracting common characteristics'*.[490] Intelligence, as applied social science (see section 3.5.2), should pay attention to these reservations on what non-linearity means for current methods. This also shows from the research data in section 6.3.3 with respondents

---

[484] James Gleick, Chaos: Making a New Science, (New York, N.Y.: Open Road Integrated Media, 2011). 139.

[485] Capra and Luisi, *The Systems View of Life: A Unifying Vision*, 104-05.

[486] Ladyman and Wiesner, *What Is a Complex System?*, 99-100.

[487] Waldrop, *Complexity: The Emerging Science at the Edge of Order and Chaos*, 64-65.

[488] Holland, *Emergence: From Chaos to Order*, 122.

[489] *Hidden Order: How Adaptation Builds Complexity*, Helix Books (Reading, MA: Perseus, 1996), 5.

[490] Ibid., 6.

problematising the causality of events in their environment in the context of a possible hybrid strategy by Russia.

A very relevant publication on non-linearity is Beyerchen's "Clausewitz, nonlinearity and the unpredictability of war".[491] Beyerchen states non-linearity permeates Clausewitz' thinking. For Beyerchen Clausewitz *'understands that seeking exact analytical solutions does not fit the nonlinear reality of the problems posed by war, and hence that our ability to predict the course and outcome of any given conflict is severely limited'*.[492] This implies a critical reflection on intelligence analysis regarding future-oriented techniques as well as applications such as Indications & Warning. In another publication Beyerchen places Clausewitz in Weaver's evolution of science from problems of simplicity to disorganised complexity to organised complexity, as discussed earlier.[493] Beyerchen argues that Clausewitz was well ahead of his time and already had a grasp of organised complexity in his thinking about war. This is very much in line with Treverton's view of Clausewitzian intelligence from section 4.1.1 and validates it as an approach for complex intelligence problems. While Clausewitz is often regarded as having a certain disdain for intelligence this is perhaps not the case. Clausewitz' perceived negative view is often based on his famous quote that in war most intelligence is contradictory, false and uncertain.[494] However, in the light of Beyerchen's articles Clausewitz' view of intelligence is perhaps better seen as a consequence of uncertainty than a general disqualification. Bousquet uses these

---

[491] Alan D. Beyerchen, "Clausewitz, Nonlinearity, and the Unpredictability of War," *International Security* 17, no. 3 (1992); See also: "Clausewitz and the Non-Linear Nature of Warfare: Systems of Organized Complexity," in *Clausewitz in the Twenty-First Century* ed. Hew Strachan and Andreas Herberg-Rothe (Oxford: Oxford University Press, 2007); Ralf Lillbacka, "An Outline of a Clausewitzian Theory of Intelligence," *International Journal of Intelligence and Counter Intelligence* 32, no. 3 (2019).

[492] Beyerchen, "Clausewitz, Nonlinearity, and the Unpredictability of War," 61.

[493] "Clausewitz and the Non-Linear Nature of Warfare: Systems of Organized Complexity."; Weaver, "Science and Complexity."

[494] Carl von Clausewitz, *On War*, ed. Michael Howard and Peter Paret (New York, NY: Alfred A. Knopf (Random House), 1993), 136.

Clausewitzian insights to formulate his criticism that NCW is still in part cybernetic because it sees information as absolute and true.[495]

4.3.4 Adaptation

This section further explains adaptation as the fourth, and last, characteristic of complexity. The bureaucratic adjustment of intelligence to a changing environment, or lack thereof, is addressed in section 3.6.2. While a connection with complexity theory is already briefly made there, it is conceived more generally.

Adaptation happens at the level of the entities, the system itself does not adapt. Altered behaviour by individual entities, or micro-behaviour, causes system level adaptation, or macro-behaviour. This creates a bigger range of possibilities to react to changes in the system's environment. The response-capacity to any eventuality is much bigger than with a fixed set of rules.[496] After Darwin, adaptation in a biological sense is the process whereby an organism fits itself to the environment. A record of interactions becomes enclosed in a system's structure so, over time, there forms experience and cognition. In the context of complex systems Holland extends this to include learning as well.[497] This is further expanded in complexity science with the concept of schemata. A complex system acquires information about its environment and its interaction with it. Regularities in that information are recorded into a model, called scheme, that is used to understand its environment. In psychology a scheme is a mental framework that organises data to understand the world.[498] This relates to the 'frame of reference' as mentioned with sensemaking in section 4.4.2. In this sense, for intelligence the puzzles/mysteries/complexities topology can be seen as schemata. Analysis techniques in general also function as schemata to organise intelligence.

Furthermore, schemata are not static, they are continuously combined with additional information coming from contact with the environment. Another, more concrete, example of schemata is the intelligence practice of formulating different scenario's against which new intelligence is made sense of. As such, schemata is a relevant concept for intelligence. Schemata form descriptions of observed systems, predictions of events, or a prescription for the behaviour of the complex adaptive

---

[495] Bousquet, *The Scientific Way of Warfare: Order and Chaos on the Battlefields of Modernity*, 220-21.

[496] Page, *Diversity and Complexity*, 25.

[497] Holland, *Hidden Order: How Adaptation Builds Complexity*, 9-10.

[498] Osinga, *Science, Strategy and War: The Strategic Theory of John Boyd*, 98.

system itself. The results of these different schemata feed back into the system and exert 'selection pressures' whereby the viability of schemata is tested, see Figure 5.

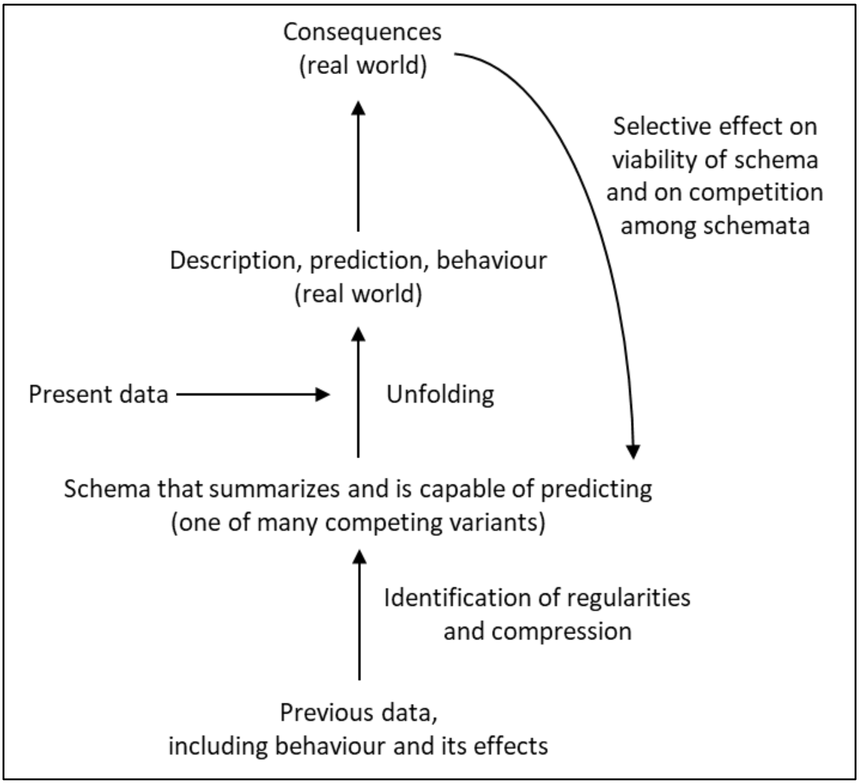

Figure 5: Adaptation of a complex system using schemata.[499]

This results in a competition among schemata in which some are demoted or eliminated and others are promoted according to their viability for understanding the environment.[500] The case study research shows that it is also possible to have a competition of schemata without result, thereby paralysing any correct response. In short, for a complex system the variety of schemata matters for its adaptive capability. For intelligence the variety of schemata matters for analytic adaptivity to

499 Gell-Mann, *The Quark and the Jaguar: Adventures in the Simple and the Complex*, 25.

500 Ibid., 23-24; Holland, *Hidden Order: How Adaptation Builds Complexity*, 31-32.

understand a changing, or unknown, environment. There are four forms of adaptation, described by Osinga as[501]:

1. Direct adaptation takes place as a result of the operation of a schema that is dominant at a particular time (as in a thermostat or cybernetic device). None of the behavior requires any change in the prevailing schema.

2. The next level involves changes in the schema, competition among various schemata, and the promotion or demotion depending on the action of selection pressures in the real world.

3. The third level of adaptation is the Darwinian survival of the fittest. A society may simply cease to exist as a consequence of the failure of its schemata to cope with events.

4. The fourth level is directed evolution which is caused by selection pressures exerted by individual human beings.

These four forms of adaptation all take place at different time scales.[502] When differences in time and intensity are disregarded then, at a fundamental level, evolution, adaptation and learning are all the same.[503]

Going back to schemata, their creation, demotion, or promotion is not flawless. There are also maladaptive schemata; these were once adaptive but under circumstances that are no longer prevalent. It can also be that the delay is in the mechanism that varies and selects schemata. Gell-Mann gives the example that rapidly developing situations can overtax the human ability to alter thought patterns. A maladaptive example is that, instead of changing ways of thinking, humans often cling to existing schemata and even manipulate new information to fit old

[501] Osinga, *Science, Strategy and War: The Strategic Theory of John Boyd*, 99. After; Gell-Mann, *The Quark and the Jaguar: Adventures in the Simple and the Complex*, 292-93, 98-99.

[502] *The Quark and the Jaguar: Adventures in the Simple and the Complex*, 294.

[503] After John H. Holland in Waldrop, *Complexity: The Emerging Science at the Edge of Order and Chaos*, 146.

patterns.[504] In intelligence, among other professions, this is known as a confirmation bias.

As mentioned earlier, Boyd forms a strong connection between complexity and the study of war(fare). His OODA-loop (see Figure 6) resembles Gell-Mann's depiction of the usage of schemata in a complex system from Figure 5.[505] When discussing the Revolution in Military Affairs (RMA) and Network Centric Warfare (NCW), the loop is often invoked.[506] In a truly military interpretation the general idea is to use modern technology to speed up the OODA-loop. Going through the loop faster than the opponent is to be victorious. While this is partly true, Boyd also argued that it is about processing the evolving conflict situation and successfully adapting to it, faster than the opponent.[507] In other words, intelligence must make sense of the environment so military operations can adapt to changing circumstances. Speeding up the loop is also about overwhelming the sensemaking process of the opponent who's schemata are then behind the evolving situation.

With the misconception of the OODA loop, Bousquet formulates another topic in his critique on NCW; it has reduced OODA loop to a cybernetic decision cycle that passes info. However, Boyd stated information not only passes the system but also shapes it.[508] Bousquet's critique on the loop is similar to the observation that the intelligence cycle misses the ability to adapt, see section 2.2. As a cybernetic feedback loop the cycle only passes intelligence but is not shaped by it.

---

[504] Gell-Mann, *The Quark and the Jaguar: Adventures in the Simple and the Complex*, 303-04.

[505] Bousquet, *The Scientific Way of Warfare: Order and Chaos on the Battlefields of Modernity*, 191; Osinga, *Science, Strategy and War: The Strategic Theory of John Boyd*, 98.

[506] Ferris, "Netcentric Warfare, C4ISR and Information Operations: Towards a Revolution in Military Intelligence?," 201.

[507] Osinga, *Science, Strategy and War: The Strategic Theory of John Boyd*, 235-39.

[508] Bousquet, *The Scientific Way of Warfare: Order and Chaos on the Battlefields of Modernity*, 221.

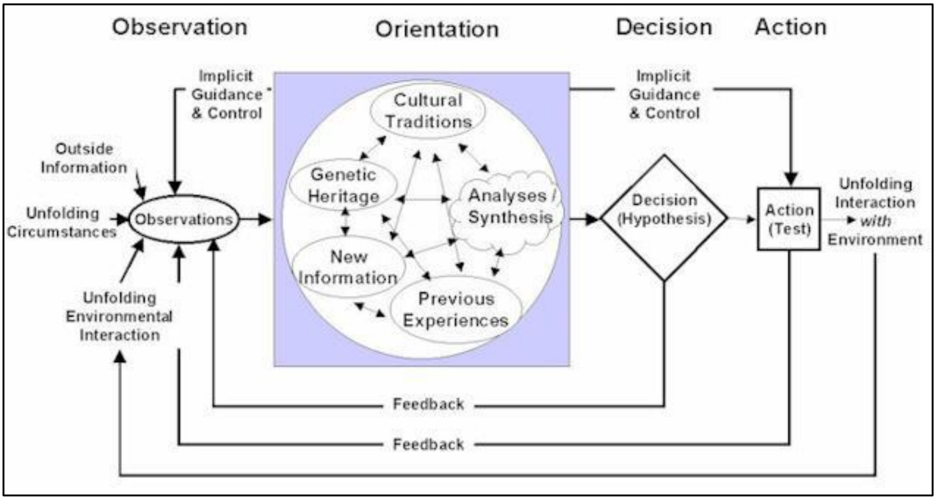

Figure 6: Boyd's OODA loop.[509]

4.4 Organising for complexity

The literature on complexity, both from complexity science proper, and fields applying it, suggest a variety of design properties a system should have to improve its relation with its environment. Three prominent design properties are the law of requisite variety, sensemaking, and organisational learning. These are described in this section. The properties are grounded in the preceding sections and are very relevant to intelligence. Together these principles form a coherence; The law of requisite variety, as the name indicates, is a precondition to understand and adapt to complex situations. By reflecting the external operational environment in the internal organisation the process of sensemaking is more effective. Organisational learning adds the actions that follow on the created situational understanding. In addition, all properties require reflexivity to explicate the role of the self in constituting these practices and achieving success.

4.4.1 Requisite variety

The first design property draws on Ashby's famous 'law of requisite variety', mentioned in section 4.2.2.[510] To reiterate, the law entails that *'for a biological or social entity to be efficaciously adaptive, the variety of its internal order must match*

[509] Osinga, *Science, Strategy and War: The Strategic Theory of John Boyd*, 231.

[510] Ashby, *An Introduction to Cybernetics*, 202-19.

the variety of the environmental constraints'.[511] A diverse, or heterogenous system is able to produce a high degree of combinations of agents, or options (variety), for adjusting its behaviour in mirroring changes in its environment. A homogenous system, lacking diverse agents and thus variety of modes of behaviour, is far less adaptable. Because this strong relation between diversity, variety, and adaptability in constituting complexity several authors reframe the law of requisite variety as the requisite complexity that a systems needs to adapt and survive changing conditions in a complex environment.[512] Regardless, it begins with diverse agents for any variety, adaptation, or complexity to manifest.

A good stratagem to try to understand, and react to, an adversarial complex system is to have a large variety of conceptual lenses, according to Osinga.[513] This is especially true for intelligence. The real issue is to come up with such lenses. This relates directly to the diversity of the workforce in intelligence services, especially for analysts. A diverse analyst workforce results in increased variety of perceptions to understand the security environment. Diversity can be seen in two ways: in the context of a broader emancipatory call for diversity, inclusion, and equity (DEI), or as cognitive diversity. DEI concerns issues such as identity (sexual orientation, gender, ethnicity, culture), demographics (age, national origin, race), and aims for social justice and emancipation of minorities.[514] DEI literature claims that improved

---

511 McKelvey Bill and Boisot Max, "Redefining Strategic Foresight: 'Fast' and 'Far' Sight Via Complexity Science," in *Handbook of Research on Strategy and Foresight* (Edward Elgar Publishing, 2009), 21.

512 Yaneer Bar-Yam, *Making Things Work: Solving Complex Problems in a Complex World* (Cambridge, MA: Knowledge Press, 2004), 67-69; Max Boisot and Bill McKelvey, "Complexity and Organization-Environment Relations: Revisiting Ashby's Law of Requisite Variety," in *The Sage Handbook of Complexity and Management*, ed. Peter Allen, Steve Maguire, and Bill McKelvey (Los Angeles, CA: SAGE, 2011).

513 Osinga, *Science, Strategy and War: The Strategic Theory of John Boyd*, 126.

514 e.g. Hamilton Bean and Mia Fischer, "Queering Intelligence Studies," *Intelligence and National Security* 36, no. 4 (2021); Bridget Rose Nolan, "From the "Lavender Scare" to "out and Equal": Lgbtqia+ Diversity in the U.S. Intelligence Community," *International Journal of Intelligence and CounterIntelligence* 35, no. 4 (2022); Jess Shahan, ""Don't Keep Mum": Critical Approaches to the Narratives of Women Intelligence Professionals," *Intelligence and National Security* 36, no. 4 (2021).

diversity in intelligence services results in improved performance.[515] This is based on the idea that the intelligence workforce must better reflect the society it must protect to reduce bias. On top of that, several authors also claim improved diversity is needed to better understand the increased complexity of the intelligence threat environment.[516]

However, the law of requisite variety does not mean that an equal variety is of itself an effective response, but it is necessary. The different states of the system that come from its variety must still generate effective responses that match against the environmental conditions.[517] In an intelligence context Gentry comments on those voicing more demographic diversity in intelligence services. He rejects claims that this logic, without adjustment, also applies to foreign intelligence tasks.[518] Therefore cognitive diversity is a better term. It includes identity and demographics, but also education, intellect and problem-solving skills. It is a broader concept on the different ways people think, interpret, process information, solve problems, and make decisions. Cognitive diversity better relates to the conceptual lenses, or schemata, that a system needs to have a sufficient variety of options to adapt to changes circumstances. Meanwhile, identity and demographic diversity, receive plenty attention, both in academia and practice, but cognitive diversity is understudied within intelligence.[519] Hackman et al. advocate to balance the cognitive

---

[515] See also: William Y Chin, "Diversity in the Age of Terror: How Racial and Ethnic Diversity in the US Intelligence Community Enhances National Security," *Fla. A & M UL Rev.* 6 (2010); T. Dao, J. Patterson, and P. Roberts, "Diversity and Inclusion: A Mission Imperative for the Intelligence Community," in *Intelligence after Next* (Mitre Centre for Technology and National Security, 2021).

[516] Mendosa, "Expanding Mental Models in Intelligence through Diverse Perspectives," 627; Damien Van Puyvelde, "Women and Black Employees at the Central Intelligence Agency: From Fair Employment to Diversity Management," *Cambridge Review of International Affairs* 34, no. 5 (2021): 30-31.

[517] Yaneer Bar-Yam, "Multiscale Variety in Complex Systems," *Complexity* 9, no. 4 (2004): 37.

[518] John A. Gentry, "Demographic Diversity in U.S. Intelligence Personnel: Is It Functionally Useful?," *International Journal of Intelligence and CounterIntelligence* 36, no. 2 (2023): 772.

[519] Irena Chiru, Cristina Ivan, and Ruben Arcos, "Diversity in Intelligence: Organizations, Processes, and People," ibid. (2022): 11.

skills of intelligence analysts working in teams.[520] Kritz shows cognitive diversity increases problem solving, working through complexity, and improves decision-making.[521] However, not much more publications exist within intelligence literature. Complexity literature contains more on the benefits of diversity, see recommendations in section 9.3. What is clear however, is that diversity has benefits for intelligence analysis. Managing workforce diversity is difficult but essential.[522] The case study also show that managing the diversity is challenging even though everybody realises its benefits.

4.4.2 Sensemaking

The second design property, sensemaking, is often used within organisation science to study complexity.[523] It originates from social psychology where it relates to processes that people use to make sense of the world. In general, sensemaking entails the social practice in which groups of people define and give meaning to their environment.[524] Sensemaking closely resembles intelligence as it is defined as *'the thinking process by which people assign meaning to experience by placing information in context to create understanding and develop beliefs about things, associations, and causality'*.[525]

Weick describes sensemaking as structuring the unknown whereby attention is given to what is constructed, how and why this takes place, and what the effects are. Sensemaking is about putting stimuli into a framework, which is often called a 'frame

---

[520] JR Hackman, SM Kosslyn, and AW Woolley, "The Design and Leadership of Intelligence Analysis Teams," *Unpublished Technical Report* 11 (2008).

[521] David Kritz, "Coming Together: Strengthening the Intelligence Community through Cognitive Diversity," *Global Security & Intelligence Studies* 7, no. 1 (2022).

[522] Oya Aytemiz Seymen, "The Cultural Diversity Phenomenon in Organisations and Different Approaches for Effective Cultural Diversity Management: A Literary Review," *Cross Cultural Management: An International Journal* 13, no. 4 (2006).

[523] E. H. Kramer, B. van Bezooijen, and R. Delahaij, "Sensemaking During Operations and Incidents," in *Managing Military Organizations: Theory and Practice*, ed. J. Soeters, Paul C. van Fenema, and Robert Beeres (London: Routledge, 2010), 126.

[524] Weick, *Sensemaking in Organizations*.

[525] Edward Waltz, *Quantitative Intelligence Analysis: Applied Analytic Models, Simulations, and Games* (London: Rowman & Littlefield, 2014).

of reference'. This enables comprehension, understanding, explanation, attribution, extrapolation and prediction.[526] Klein et al. describe sensemaking as follows: *'By sensemaking, modern researchers seem to mean something different from creativity, comprehension, curiosity, mental modeling, explanation, or situational awareness, although all these factors or phenomena can be involved in or related to sensemaking. Instead, sensemaking is a motivated, continuous effort to understand connections (which can be among people, places, and events) in order to anticipate their trajectories and act effectively.'*[527]

The resemblance, again, between sensemaking and intelligence is remarkable. However, sensemaking is mentioned only several times in intelligence publications and only explored in depth in publications by Moore.[528] This is all the more remarkable because sensemaking offers an alternative to traditional intelligence that operates to solve puzzles by 'connecting the dots', as the 9/11 report reads (see section 3.4.2). The traditional model is a Kentian and positivist idea of intelligence, commented on by Kendall as pulling out tape from a machine and reading it (see section 3.5.1). From a sensemaking perspective Klein et al. also take issue with this analogy of connecting the dots and point to the complexity of intelligence sensemaking: *'We've often seen this metaphorical description of cognitive work, especially in reference to the intelligence analyst's job. It trivializes cognitive work. It misses the skill needed to identify what counts as a dot in the first place. Of course relating dots is critical, but the analyst must also determine which dots are transient signals and which are false signals that should be ignored.'*[529]

---

[526] Weick, *Sensemaking in Organizations*, 4. Weick references and quotes several different authors in his explanation. For reasons of clarity only a paraphrase of Weick given.

[527] G. Klein, B. Moon, and R. R. Hoffman, "Making Sense of Sensemaking 1: Alternative Perspectives," *IEEE Intelligent Systems* 21, no. 4 (2006): 71.

[528] Moore, *Sensemaking: A Structure for an Intelligence Revolution*; David T Moore and Robert R Hoffman, "Data-Frame Theory of Sensemaking as a Best Model for Intelligence," *American Intelligence Journal* 29, no. 2 (2011); D. T. Moore et al., "Sensemaking for 21st Century Intelligence," *Journal of Intelligence History* (2020).

[529] Klein, Moon, and Hoffman, "Making Sense of Sensemaking 1: Alternative Perspectives," 72.

Compounding the difficulty in intelligence sensemaking is that the adversary is actively trying to mislead and avoid detection. Furthermore, all sorts of (cultural) bias and language barriers distort the data, or dots. In the case of hybrid threats the whole idea is to mislead and hide; *'the dots are missing because they fall below the threshold, they look different due to deception or disinformation, or are impossible to understand due to some kind of encryption'*, see also section 2.4.[530] From a post-positivist perspective it is also practically impossible to distinguish between false and true signals because these meanings are very much contextual and situated with the beholder and do not necessarily reflect the values of the opposing party. The case study will show the difficulties that emerge with values and truths when sensemaking is largely absent from the intelligence process.

4.4.3 Organisational learning

The third property for organisations to address complexity is organisational learning (see also section 3.6.2, and 'learning' throughout Chapter 4). Organisational learning is about studying how organisations sense and respond to changes in their environment. Many definitions of organisational learning exist. These can be arranged into two categories: a cognitive perspective about acquiring new knowledge, and a behavioural perspective that focuses on using this new knowledge for organisational efficacy.[531] While new knowledge can serve several objectives the initial aim is almost always behavioural change for the better.[532]

In essence organisational learning is about the relation between acquiring new knowledge and the actions that follow from it.[533] While improved performance is the ultimate goal this does not mean it follows automatically. The acquired knowledge can suffer from flaws and/or the resulting behaviour fails to bring improvement.[534] Within a security context this would be the division between an intelligence failure

[530] Sebastiaan Rietjens, *A Warning System for Hybrid Threats-Is It Possible?* (European centre of excellence for countering hybrid threats, 2020), 5.

[531] Wout Broekema, "When Does the Phoenix Rise? Factors and Mechanisms That Influence Crisis-Induced Learning by Public Organizations" (Leiden, 2018), 24.

[532] Cyril Kirwan, *Making Sense of Organizational Learning: Putting Theory into Practice* (London: Routledge, 2016), 142.

[533] Richard Freeman, "Epistemological Bricolage: How Practitioners Make Sense of Learning," *Administration & society* 39, no. 4 (2007): 490.

[534] George P. Huber, "Organizational Learning: The Contributing Processes and the Literatures," *Organization Science* 2, no. 1 (1991).

or a policy failure. Furthermore, organisational behaviour can lag behind changes in the environment. *'Evidently, this notion is highly relevant to military organizations, where the environment is to a large extent shaped by adversaries […] Moreover, the adversary will strive to adapt to the actions of the enemy and the environment as well.'*[535]

Organisational learning is the combined, or synergetic, effect of individual learning, enabling organisations to adapt to changing circumstances. For this to happen Baudet et al refer to four preconditions: (1) openness across boundaries, (2) resilience or the adaptivity of people and systems to respond to change, (3) knowledge and expertise creation and sharing, (4) a culture, systems and structures that capture learning and reward innovation.[536] Taking these preconditions into account, intelligence organisations are poor at organisational learning: '*They are not open across boundaries, as the secretive nature of their work produces a secretive internal culture. While they do create knowledge, sharing this knowledge is limited to the customer. A complicating factor is the frequent rotation of military personnel within military intelligence organizations. This precludes specialisation. Intelligence organisations perform somewhat better on the last count: they do capture learning (although mostly not in a structured way), and they generally are resilient. Their responsiveness to change is somewhat problematic, however. After all, it was concern for this matter that spurred the debate on the necessity of a revolution in intelligence affairs. Lastly, while individuals may adapt, the secretive culture of intelligence organizations may hamper innovation*.'[537] This critique relates directly to Zegart's adaptation failure from section 3.6.2. Features of it, the rotation of military personnel, learning in a non-structured way, and slow responsiveness to change, also manifest in the case study.

535 Martijn van der Vorm, "War's Didactics a Theoretical Exploration on How Militaries Learn from Conflict," (Breda: Faculty of Military Sciences; Netherlands Defence Academy, 2021), 14-15.

536 V.J. Marsick and K.E. Watkins, "Learning Organization," in *International Encyclopedia of Adult Education*, ed. L.M. English (London: Palgrave, 2005).

537 Baudet et al., "Military Intelligence: From Telling Truth to Power to Bewilderment?," 15.

4.5 Conclusion: How does complexity science relate to intelligence?

This chapter shows complexity offers a radical different way than reductionism and linearity to explain phenomena and their cause and effect relations. In general, intelligence missed the complexity turn in social science. When it comes to incorporating complexity, intelligence has only just reached the point where individual publications are examining complexity for its value. Parallel to complexity approaches in international relations, a bigger debate and cumulative knowledge has yet to emerge. Formulating broadly acknowledged intelligence stratagems, let alone explicit incorporation into doctrine, is still far away. It is also good to remember here that the intelligence cycle, though under growing critique, keeps intelligence firmly placed in the cybernetic age, as seen in section 2.2. This is compounded by the almost complete absence of intelligence in the examinations of the complexity of war and warfare. If it is mentioned, it is often equated to information and any form of analysis, assessment or interpretation is ignored. The broader military sciences do apply complexity, though not all applications are explicit or rich in theoretical foundation.

The examination of existing intelligence publications offers several ideas and perspectives based on, or related to, complexity science; The puzzles/mysteries/complexities typology, Cynefin, Jominian and Clausewitzian understandings of intelligence, Rumsfeld matrix and a β-approach to intelligence combine into a rough cognitive map, or problem space, of complexity intelligence. Next to these characteristics from the intelligence-complexity nexus, the four characteristics of complexity (self-organisation, emergence, non-linearity, adaptation), and the three design properties (requisite variety, sensemaking, organisational learning) offer tools to examine the complexity of intelligence in the case study in the following chapters. How these are operationalised, is presented in the next chapter.