UNIVERSITY
OF TECHNOLOGY
SYDNEY

It's Just Not That Simple

A complex adaptive systems approach to understanding changing dynamics in leadership teams

by Chris Maxwell

Thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy (PhD)

University of Technology Sydney
Faculty of Business

February 2022

Certificate of Original Authorship Template

Graduate research students are required to make a declaration of original authorship when they submit the thesis for examination and in the final bound copies. Please note, the Research Training Program (RTP) statement is for all students. The Certificate of Original Authorship must be placed within the thesis, immediately after the thesis title page.

Required wording for the certificate of original authorship

CERTIFICATE OF ORIGINAL AUTHORSHIP

I, *Christopher Robert Maxwell* declare that this thesis, is submitted in fulfilment of the requirements for the award of *Doctor of Philosophy (PhD)*, in the *Faculty of Business* at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.
**If applicable, the above statement must be replaced with the collaborative doctoral degree statement (see below).*

**If applicable, the Indigenous Cultural and Intellectual Property (ICIP) statement must be added (see below).*

This research is supported by the Australian Government Research Training Program.

Signature: Production Note: Signature removed prior to publication.

Date: 28/01/2022

Acknowledgements

First and foremost, thankyou to my primary supervisor, Associate Professor Melissa Edwards. Of all my supervisory panel, Mel was with me the whole way, offering support, encouragement, and the odd tough word when it was needed. Thankyou to my supervisors Professor Shankar Sankaran and Associate Professor Natalia Nikolova for their invaluable input, and Dr Marco Berti for assessing my late draft. Thanks also to Christine Burton and Ellen Baker who supervised me at the start of my journey, but moved onto other things along the way.

I received enormous benefit from debating and arguing about complexity with Professor Chris Mowles at University of Hertfordshire, who kindly shared a lot of his time and his wisdom, including reviewing an early draft of mine and introducing me to Ralph Stacey.

A Part time PhD also requires a lot of support outside of academia. Thank you to my business partner Marcus Crow for his tolerance of my writing needs and eight years of conversations on complexity, helping refine the application of my theoretical work. Thank you to my mother, Wendy, for buying me the book that started my interest in complexity, and for her unflagging interest.

Lastly and most importantly, thank you to my wife Claire for putting up with this thesis' intrusion into our lives, for the years of support and encouragement, and for her continual belief in me and what I might achieve. That belief sustained me when the going got tough. And to my daughter Emily, I have been writing this as long as you have been alive. I dedicate it to you, and the person you will become. Dada loves you very much.

Chapters

Detailed Table of Contents

List of Tables and Figures

Abstract

The aim of this thesis is to employ complexity theory to better understand organisational leadership team dynamics.

Complexity in management and organisation studies is a relatively new field. At present the field is split by scale: computational modelling is applied at population scale to understand and predict how large groups behave, while complexity concepts are woven into allegorical narratives and frameworks to help leaders understand and respond to how individuals engage with complexity. What is missing is complexity applied at the level of small groups: the scale at which organisational teams – and in particular leadership teams – most commonly work.

This study subjected five diverse leadership teams to a series of quasi-experiments involving simulated challenges, after which the researcher and each group engaged in co-created sensemaking through a group debrief. It was found that complex challenges trigger teams to enter states characterised by complex dynamics, and further that these complex states operate away from the team's baseline states. The complex state was found to be metastable and dissipative, readily decaying back to the equilibrium state if not sustained.

This study offers three contributions to the field. The first is an "Uncertainty Landscape", a phase or state diagram that maps how team states change in response to uncertainty and complexity. The second is the beginnings of a theory of "complex dissipative teams" which explains the relative stability of complicated and complex states, the reasons why – and mechanisms by which – such states decay, as well as how complex states might be maintained. The third contribution

is in the construction of the research methodology, and its positioning in between the mathematical and narrative approaches to complexity.

The results inform our understanding of how leadership teams behave when tasked with complex decisions. They highlight how avoidance behaviours aimed at dissipating the complex state result in sub-optimal decisions, false consensus or lack of progress to solution. By contrast, it was found that teams that were able to maintain working in a complex state worked faster, achieved greater consensus and resolved the complex problems they were set.

1. Introduction

“So what do we do now?”

Earlier this year I was asked to run a series of strategy workshops with the extended leadership team (ELT) of a listed SAAS (software as a service) business (Company “X”). An ELT is a common corporate grouping, comprising in this case the senior executive team (six members: CEO, CFO, CTO, Head of Product, Commercial Director AUS [CD AU] and Commercial Director US [CD US]) as well as selected next-level reports. The scope of the engagement was to help the team clarify their mission, their three-year vision, and to create a product and market roadmap for those three years with resource and funding implications.

On the second day of the engagement the team was gathered around a long whiteboard with a staggered timeline as we wrestled with the various interwoven streams of activities that needed to happen. Team members were vigorously discussing the interdependencies of various tasks and moving these tasks (on sticky notes) up and down the timeline as they worked together in shifting pockets on various parts of the plan. At this stage a photograph taken of the team would have shown the attention and focus of team members to be on the whiteboard and sticky notes, in other words on task. The client’s expectations were that my role was organisational and in the background, that I should be providing process and remaining objective with respect to content. There are two assumptions here that are typical for this type of work: that content (what we talk about) can be considered to some degree separately from process (how we talk about it), and that any participant in the room can remain objective with respect to either. I will address these assumptions below.

In the early afternoon the CD AU folded his arms and announced to the room that it was his opinion that the company's decision to enter the US market had been a mistake initially and a failure since, and that they should withdraw and consider other geographies such as New Zealand. This was a comment loaded with political and financial context: for the past few years the business had been taking cash from the successful Australian operation to fund the US expansion, and the heads of the Australian business had been growing frustrated at this. Furthermore, the political stocks of the CD AU had been rising as the Australian business performance improved, and so this was as much a power play as a contribution to strategic intent. The suggestion of expansion would presumably fall under the remit of the CD AU, rather than require an additional Commercial Director, and the loss of the US market would make the CD US redundant and consolidate the CD AU's power. On the other hand, the US market potential dwarfed the maximum capacity of the Australian market, and success in the US would eventually lead to a lessening in the CD AU's political power.

After the comment, the room went quiet, activity stopped, and participants started looking from the CD AU to the CD US to the CEO and back again. The dynamics of this group had changed significantly at this point: the focus of participants shifted from task (whiteboard) to other, the energy and tension in the room had increased, the ambiguity and uncertainty had increased. Why was the CD AU bringing this up now? Who would support him? How would the CD US respond? Which way would the CEO lean? What would happen next? Unsure of how to proceed, participants began to look at me to help them find a way forward from this point.

I have been facilitating strategic discussions in leadership teams for two decades, and I have a MBA with a major in management/strategic consulting. I am aware of – and have used – nearly every tool in the strategy landscape, and not one of them was of any use in that moment. Nor was it an isolated experience: in my work facilitating leadership teams, I have had similar experiences to that described above many times before, but no two are precisely the same. The actors in the room and the context in which they interact (both business and interpersonal) are critical considerations in how to move forward, and they differ every time.

Schumacher's (1977, p. 1) *A Guide for the Perplexed* sums up my feelings:

> It occurred to me that this was not the first time I had been given a map which failed to show the many things I could see right in front of my eyes. All through school and university I had been given maps of life and knowledge on which there was hardly a trace of many of the things that seemed to me to be of the greatest possible importance to the conduct of my life.
>
> I remembered that for many years my perplexity had been complete… It remained complete until I ceased to suspect the sanity of my perceptions and began, instead, to suspect the soundness of my maps.

The "map" I have been given to navigate business strategy interwoven with leadership team dynamics is incomplete. The literature abounds with books and papers on leadership as a concept, on the practice of leadership, on transformational leadership, adaptive leadership, situational leadership and more. There are ideas about what it means to be a leader and how to be a better leader, including trait-based theories, behavioural theories, style theories, situational and contingency theories, psychological approaches, and transactional, transformational and exchange theories. There are analyses of the effect of leadership on organisational and team performance and culture. In parallel there are plenty of group and team analysis theories, from Tuckman's (1965) forming and storming to Gersick's (1988) punctuated equilibrium to Hackman's (2003) multi-level perspective. But there are few analyses of the dynamics of leadership teams, or models or frameworks for how to understand and optimise them.

It seems a new map is needed to understand situations facing leadership teams such as the one described above; a new map that:

- is sensitive to context, not context independent;
- provides understanding and instruction at the level of both the actor and the team, and the interactions between these levels;
- provides insight at the interface between content of discussion and socio-political interplay;
- is dynamic and evolutionary in its description, incorporating learning and adaptation; and
- incorporates uncertainty and complex causality.

This thesis aims to provide and test the effectiveness of a new map based on a relatively new approach to leadership team dynamics.

1.1 Structure of this thesis

The thesis is structured in the following way:

Chapter 2 contains a detailed review of the literature relevant to this study of complex leadership teams. It begins by locating the study in the literature. It then moves on to reviewing the field of complexity in organisational studies, focusing in particular on how uncertainty and complexity distinguish such states. Complex or adaptive challenges versus technical or complicated challenges are reviewed as they relate to team states, leading into some of the drivers for state changes and non-equilibrium teams. The ground covered is synthesised into a single sensemaking framework.

Chapter 3 steps back to review the field of organisational complexity itself, discovering that there is something of an epistemological rift in the field, a battle between those who pursue a quantitative scientific approach based on agent-based modelling and those who align with a qualitative metaphorical or narrative approach to the application of complexity concepts to organisations. Chapter 3 explores and reviews the rift in detail, ultimately positioning this study in between the two approaches, drawing from each end.

Chapter 4 lays out and justifies the methodology for the primary research of this thesis. This methodology might be considered novel in its mixed methods approach, borrowing from either end of the complexity epistemological spectrum. There is also some novelty in the construction of the quasi-experimental exercise designed to trigger the complex state in the leadership teams under review. Ultimately, five teams were each subjected to a series of three quasi-experimental exercises followed by a debrief and a researcher’s narrative sensemaking.

Chapter 5 details the results obtained for the primary research. This includes three main subsections. Section 5.1 details how the captured data were to be analysed. Sections 5.2–5.6 contain an extended narrative for each of the five teams. Each one weaves together direct observations, some excerpts of conversation transcripts and the researcher’s reflections to create a sensemaking narrative for each team, detailing how that team tackled the challenges in the quasi-experimental section and how they reflected on it in the debrief section. Sections 5.7–5.10 conduct cross-group analyses using some traditional methods (transcript coding and memos) and some less traditional methods (comparative phase diagrams). This mixture of within-team and cross-team analysis provides extra richness for the theorising of Chapter 6.

Chapter 6 returns to theory to make sense of the results obtained in Chapter 5. Chapter 6 develops four key streams of theorising. Firstly, it relates team states to different types of challenges, summarising in an updated framework from the literature review. Secondly, it brings our understanding of non-equilibrium thermodynamics in complexity into the discussion to flesh out a concept of “complex dissipative teams”. Thirdly, it reviews the implications of the first two streams for the practice of leadership teams. Finally, it explores the learnings that might be applied from this study to the academic practice of studying and researching complex team dynamics.

Chapter 7 presents the thesis’ conclusions, summarising the contribution of this study to both theory and practice, and suggesting some future directions for further research in this area.

2. Literature review

The state of the field

2.1 Locating this study in the literature

Miles and Watkins (2007, p. 90) argue that leadership teams have been described, discussed and debated as far back as Homer's *Iliad*:

> Though the Greeks were led in their quest for retribution against Troy by the powerful King Agamemnon, their victory would not have been possible without Achilles, the mighty warrior; Odysseus, the wily tactician; and Nestor, the wise elder… No one of them could have played all the varied roles necessary to guide the enterprise to victory; collectively they prevailed and won their place in history.

This study is focused on the behaviour of leadership teams in corporate organisations. A leadership team in an organisation is a special type of team, a team tasked with providing direction (where are we going?) and governance or order (how will we get there?) to a wider group of individuals who generally (but not always) report into that team. In Miles and Watson's (2007) quote above, Agamemnon, Achilles, Odysseus and Nestor are each kings (leaders) in their own right, but they come together (with others) to provide direction and order to the greater Greek hosts. Some twenty-nine centuries later, leaders in a modern organisation come together into leadership teams to provide direction and order to those who report into them.

Leadership teams exist at different levels of organisations and may variously be termed Executive Leadership Team (ELT – the most senior team in an organisation) or Top Management Team (TMT), Senior Leadership or Management Team (SLT or SMT), Extended Leadership Group (ELG) or simply Leadership or Management Team (LT or MT). This study will examine leadership teams at different levels within organisations.

In determining which theoretical lens to employ in this study, I begin by considering some key characteristics of the case presented in the Introduction above:

a) The leadership team dynamic was truly *dynamic*, shifting dramatically in real time in the room.
b) The dynamics and shifts or changes to be studied occurred over very short or *micro time scales*.
c) The dynamic spawned interesting behaviour at *both the individual and group level*, and the ways individuals related and interacted with each other drove changes in group-level behaviour.
d) The shifts and changes involved *uncertainty* and the group's assessment of it and reaction to it.

a) Leadership team "dynamics", not "statics"

Carlo Rovelli is a celebrated theoretical physicist working in the area of space and time. He directs the quantum gravity research group in Marseille, France. In his book on the nature of time he notes that the theoretical descriptions of phenomena that are most effective are "mathematical descriptions of precisely how things *change*, not of how they *are.* They will be about events, not things" (Rovelli, 2019, p. 90, author's emphases).

Rovelli is talking about our understanding of how the universe works, but he might also be describing organisational dynamics. Rumsey (2013) devotes an entire section of *The Oxford Handbook of Leadership* to "the dynamics of leadership", but also notes that these are "recently introduced theories" (p. 6). In this study I am interested in the dynamics of the leadership teams I propose to study; that is, how the teams change with time.

b) Short time scales

In the group dynamics literature a number of authors have built models that seek to describe how teams evolve or change over time, including Tuckman's (1965) group evolution model, Fisher's (1970) decision emergence model, Gersick's (1988) punctuated equilibrium model, Wheelan's (1990) integrated model of group development, McGrath's (1991) T.I.P. model, and Tubbs' (1995) system model. The majority of these models of team dynamics are developmental in their orientation – they describe a series of states or phases a team passes through on a longer journey, where each state is thought to contribute in some way to the team's development. By contrast, in this thesis I am not concerned with long-scale developmental changes, rather dynamic change in response to triggers in a single conversation. Although it will become clearer in the literature that the historical narrative arc in which a team finds itself is indeed a factor in how teams behave, for this study I need a theoretical lens that can operate over the timespan of minutes and hours rather than weeks, months or years. Such a time scale is considerably shorter than the more traditional studies outlined above.

c) Individual and team-level analysis

In his 2003 paper, Hackman introduces three levels of analysis for group dynamics:

- a micro level, focused on characteristics of individual group members;
- a meso level, focused on the characteristics of the group as a whole; and
- a macro level, focused on the group and its embedding context (for example the wider organisation within which it is located).

Hackman argues that group analysis is best done at more than a single level. Gorman et al. (2017, p. 1053) agree:

> We argue that many approaches aimed at studying interpersonal dynamics, such as social psychology, tend to locate explanations of psychological phenomena within the individual, rather than actual interactions… Because

> so much of the human condition is based on interacting with other people, we argue [for] a shift toward interaction- and systems-based psychology… In this article, we advocate a dynamical systems approach for answering this type of question. In this light, teams are viewed as a system of coupled elements that interact over time to produce patterns that are themselves not contained within the team's members.

This study is focused on the micro and meso levels of Hackman's schema, the interplay between individual team members, what that does to team-level behaviour, and then how that meso-level behaviour in turn influences individuals. According to Gorman et al. (2017), dynamical systems might be an appropriate theoretical framework in which to locate this thesis. But what of uncertainty?

d) The influence and impact of uncertainty

Mowles (2016) argues that contemporary leadership education and development tends to place the leader as an actor with high agency, with tools, frameworks and mindsets to deploy and levers to pull to change, direct or influence situations in which they find themselves. Plowman and Duchon (2008) describe the expectation that "leaders eliminate disorder" and uncertainty as a myth (p. 141). Houglum (2012) agrees, as do Uhl-Bien et al. (2007) and Hazy et al. (2007).

However, these contemporary/conventional views of Mowles (2016), Plowman and Duchon (2008) and others are deeply ingrained in leaders who feel pressure to "know". This is perhaps best summarised in a line delivered by the incomparable Harvey Keitel in the otherwise forgettable movie *U-571*:

> This is the navy, where a commanding officer is a mighty and terrible thing… a man to be feared and respected. All knowing, all powerful. Don't you dare say what you said to the boys back there again… "I don't know." Those three words will kill a crew, dead as a depth charge. You're the

> skipper now, and the skipper always knows what to do, whether he does or not.[1]

Voltaire famously summarised it as follows: “Doubt is not a pleasant condition, but certainty is absurd.”[2] The charge of Keitel’s character to not show uncertainty combined with its unpleasant nature (according to Voltaire) result in what Stacey (2010, p. 1) calls a fundamental contradiction:

> Contradiction: experiencing the reality of uncertainty but still believing that executives choose an organisation’s “direction”.

This pressure on leaders to know “what to do”, to reduce uncertainty for those around them, makes the impact of uncertainty in leadership discussions more complex. In the scenario presented in the Introduction, the change from task-focused activity to group-focused paralysis was driven by the sudden onset of uncertainty, but this uncertainty was multi-layered. Not only was the team unsure how to proceed or where they might end up, they were also unsure about how this uncertainty would play into the group dynamic shifting in real time.

Locating this study

In order to study shifting leadership team dynamics, over short time scales, at multiple levels, and incorporating uncertainty as a central feature, I will locate this study in the field of organisational complexity. In their meta-analyses of the application of complexity to organisations, authors such as Cilliers (1998), Anderson (1999) and, more recently, Mowles (2022) list characteristics of complexity theory that meet these four needs. I will delve into these characteristics in greater detail in the literature review below.

---

[1] Viewable at https://www.youtube.com/watch?v=IV79EIZVuHQ (retrieved Jan 2022).

[2] From Voltaire’s *“Oeuvres complètes de Voltaire*, Volume 12, Part 1”, p. 703, in a letter dated November 1770.

The remainder of this chapter will:

- introduce the field of organisational complexity, including its history;
- outline the differences between complex and non-complex organisational states, and the role uncertainty plays in both;
- explore how teams might transition from non-complex to complex states and back; and
- consider a core disagreement in the field about how to apply complexity theory to organisations, and what that means for this study.

2.1.1 An introduction to complexity

Organisational complexity is underpinned by the science of complex adaptive systems. This theoretical lens is relatively new to social and organisational studies (Brown, 2011; Byrne & Callaghan, 2013). Whilst complexity has been known in the physical sciences since the dawn of systems thinking, it has only been applied to social systems since the 1990s (eg Cilliers, 1998; Goldstein, 1995; McKelvey, 1997), to organisations at the turn of the century (Anderson, 1999; Stacey, 1996), and was first applied to leadership thinking by Russ Marion and Mary Uhl-Bien at the start of this century (Marion & Uhl-Bien, 2001). It has been applied to *groups* by Arrow et al. (2000), by Stacey (2001) and more recently Mowles (2017, 2022), but not yet to leadership teams. Before delving into the modern application of complexity thinking to organisational contexts, let us first consider its history.

2.1.2 Why talk about people "systems"? A brief history of systems thinking

Pre 1900

Organisational systems thinking may owe its earliest origins to Newton's calculus and the thermodynamics of Carnot (Meadows, 2008). Although not actual systems thinkers themselves in the way we might understand the term today (Capra & Luisi, 2014), nevertheless Carnot's (1824) heat engine was the first real analysis of a system and system efficiency, and Newton gave the world the mathematical language to understand how system states might evolve over time.

Mechanistic systems

In 1911, mechanical engineer Frederick Taylor published his *Principles of Scientific Management*, a revolutionary approach to managing people and tasks which would evolve into Ford's mechanised production lines (Ford & Crowther, 1924). The emphasis of Taylor's work was on the efficiency of production systems. In Taylor's systems the role of the agent (or human worker) was limited to the performance of tasks, hence Taylor's systems are described as simply *mechanistic* (Buchanan & Huczynski, 2004). Taylor explicitly sought to keep workers from interacting with one another as far as possible, limiting the scope for agent networks to form and reducing the complexity of the *mechanistic* system.

From mechanistic to human systems

In the 1930s, Elton Mayo redefined the role of workers in the workplace and signalled a strong alternative to Taylorism. Mayo arguably founded the human relations movement in response to Taylor's mechanised workplace (Bruce & Nylan, 2011). His pioneering work in the Hawthorne studies (Mayo, 1945) elevated group behaviour in organisational thinking and so placed the agent at the centre of the organisational system.

Mayo's work was built on by scholars of the Tavistock Institute of Human Relations, formed in 1946. Eric Trist developed the concept of the *socio-technical system* (Trist & Bamforth, 1951), which describes the interaction between agents and structural components of the system. Eric Miller and Albert Rice coined the *organic analogy* for organisational systems, comparing them to the human body in the way they transport and transform food and air into energy, self-maintenance and waste (Miller & Rice, 1967). This work fixed organisational systems as *open* systems, and would provide a philosophical basis for Maturana and Varela's (1980) work on *autopoiesis*. Autopoiesis means "self-creation", and was originally applied to biological cells, which are open systems, exchanging resources with their environment and capable of self-creation and replication. Luhmann (1986, p. 174) applied the concept to social systems of people, describing how they might engage in co-creation of elements of the system including communication:

> Social systems use communications as their particular mode of autopoietic reproduction. Their elements are communications which are recursively produced and reproduced by a network of communications and which cannot exist outside of such a network.

During this time, Talcott Parsons contributed significantly to the understanding of the human agent's role in system dynamics, particularly through different evaluative orientations (see for example Parsons, 1951). Parsons' students included Luhmann (see above), and Harold Garfinkel, the founder of ethnomethodology.

The explosion of systems thinking

Outside organisational studies, systems thinking and theoretical development leapt ahead. In the late 1940s and early 1950s, the pillars of modern systems understanding were established.

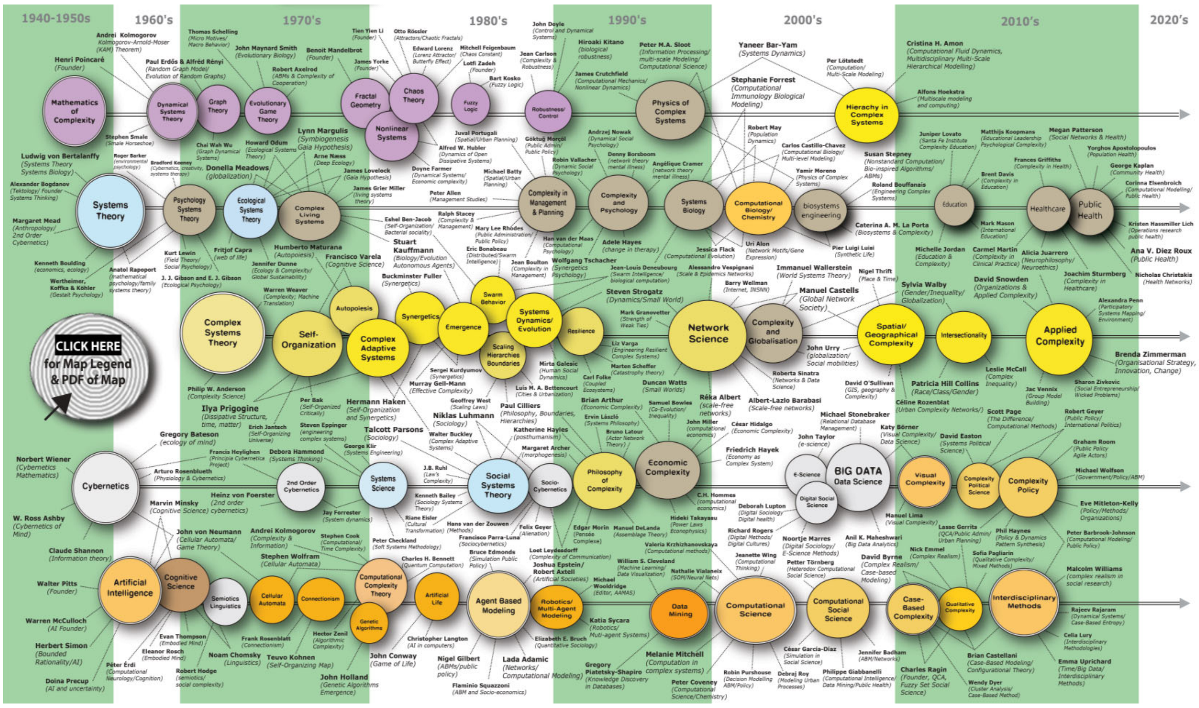

Figure 2.1: Map of the complexity sciences[3] (Castellani & Gerrits, 2021)

[3] Castellani, B and Gerrits, L (2021). Map of the complexity sciences. Art and Science Factory, LLC. Available in a larger, easier to read format. Retrieved October 28, 2021, from http://www.art-sciencefactory.com/complexity-map_feb09.html

Norbert Wiener (1948) and William Ashby (1956) started the *cybernetics* stream of systems thinking (see Figure 2.1, and below), a mechanistic, engineering and computational approach to systems. This stream would evolve artificial intelligence, computational modelling (John von Neumann) and agent-based modelling (Axelrod, 1997b; Gardner, 1970), social systems (Luhmann, 1982, 1995), complex philosophy (Cilliers et al., 2002), second order cybernetics and more.

Meanwhile, biologist Ludwig von Bertalanffy (1950) and mathematical psychologist/biologist Anatol Rapoport (1953) started the *general systems theory* approach to systems. More influenced by natural systems, this stream includes complex living systems (Bak, 1996), self-organisation (for which Ilya Prigogine [1997] received the Nobel Prize), Kauffman's (1995) biological systems, Maturana and Varela's (1980) autopoiesis, computational biology and more. The various streams of systems thinking are displayed in the map of the complexity sciences by Brian Castellani and Lasse Gerrits in Figure 2.1 above.

Dynamical systems are a subset of general systems theory. This purely mathematical approach to systems theory includes non-linear dynamics, Mandlebrot's (1983) fractal geometry, chaos (Gleick, 1987) and catastrophe theory (Zeeman, 1976). Together, elements of these two major streams would spawn a third stream: *complex adaptive systems* (see Figure 2.1). In recent times authors such as Derek and Laura Cabrera have sought to codify complex systems *thinking* into a series of fundamental strategies and tactics that can be used to tackle wicked problems (Cabrera, Cabrera and Powers, 2015).

Why does it matter here?

In formulating an understanding of organisational complexity, I draw on different aspects of systems theory from our discussion above. An understanding of the behaviour of teams that might be considered to be in a **complex** state is informed by (naturally enough) complex systems theory. It will become apparent that complexity theory caters for both the non-linearity and stochastic randomness that can characterise complex behaviour. On the other hand, what I will call **complicated** team states will draw more from cybernetics and general systems theory, dealing with relatively more linearity and determinism. This results in marked differences in the way teams behave in these two states, and it is to these distinctions that I will now turn.

2.2 Complicated vs complex

Upon reading the literature on organisational complexity it becomes apparent that complex systems are defined as much by what they are not as what they are. This is achieved by comparing and contrasting one set of challenges, situations or states that is not complex with another set that is complex. The first author to make this type of distinction was Ralph Stacey with his “Stacey Matrix” (Stacey, 1996).

The Stacey Matrix

The Stacey Matrix has been heavily cited in the literature (see for example Beckham, 2001; Eliat & Noble, 1999; Guzman & Wilson, 2005; Lane & Down, 2010; Zimmerman & Hayday, 1999).

In its original formulation, Stacey intended the matrix to be interpreted from a complex adaptive systems perspective (Stacey, 2012). It is intended to be of assistance to leaders, and presumes they operate in a team environment (hence the agreement axis). The matrix (see Figure 2.2 above) has one axis representing uncertainty and the other agreement. In Stacey’s matrix the uncertainty axis is presented as the environment the leader finds itself in, and the agreement axis is the inverse of the amount of conflict (value judgement free) within the team. Hence, one axis is external and the other internal to the team.

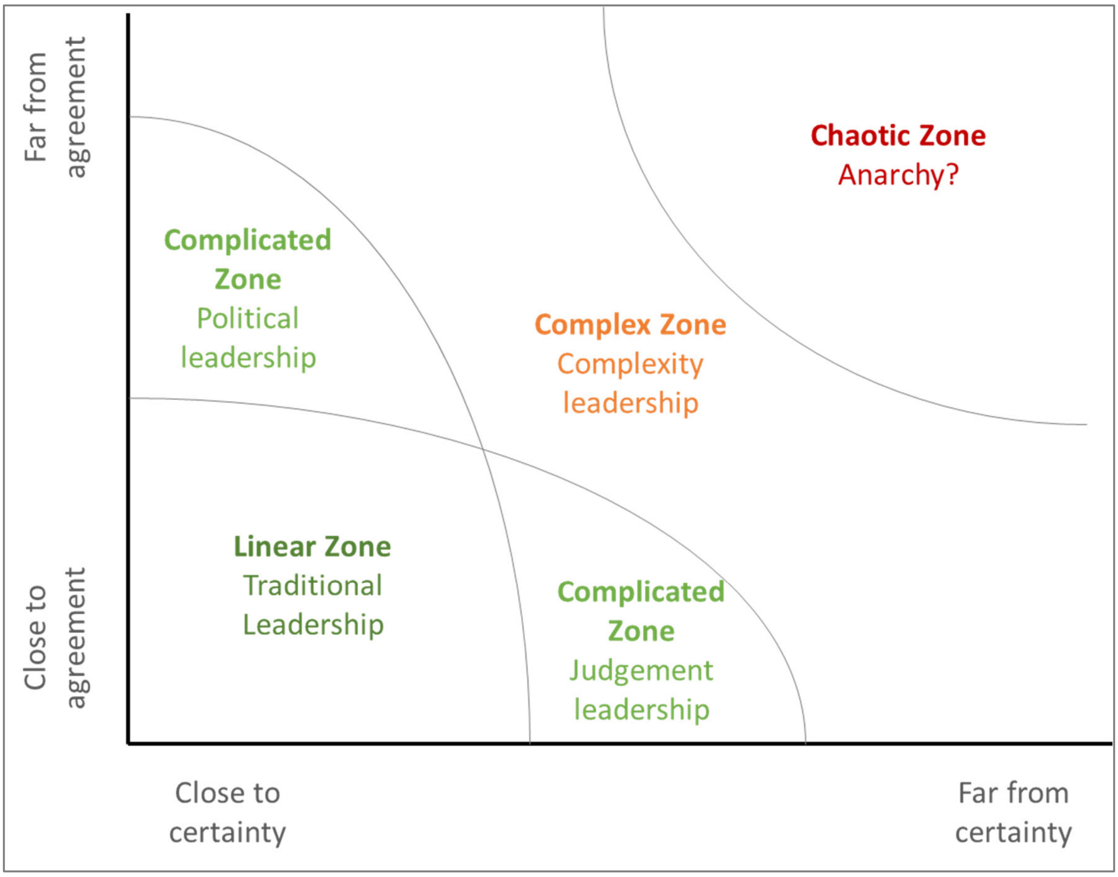

Figure 2.2: The Stacey Matrix, adapted from Stacey (1996)

Stacey then distinguishes between different regions or zones within the matrix. Like Plowman and Duchon (2008) and Mowles (2016) above, he regards traditional leadership as operating in low uncertainty and with little conflict. He uses the term “complicated” to refer to leadership that has uncertainty but low conflict (“judgement” is required) and also leadership that has certainty but disagreement (“political” influencing is required). In the centre is the complex zone, characterised by both uncertainty and conflict, and then the extreme state he calls “Chaos”.

As one of the earlier pioneers of introducing complexity thinking into management and organisational discourse, Stacey deliberately positioned his work to distinguish between more orthodox management theory and complexity. The Stacey Matrix embodies this distinction, with the “traditional” and “complicated” zones catering for more traditional management and leadership discourse, while his ideas on complexity operate in a separate zone. Implicit in this type of distinction is an important approach which is picked up by authors to follow: that complexity theory sits alongside and *extends* traditional discourse; it doesn’t seek to supplant traditional thinking. The matrix axes then describe the conditions under which that traditional thinking begins to fail, and complexity theory becomes more useful.

The Stacey Matrix first appeared in the 2nd edition of Stacey’s text *Strategic Management and Organisational Dynamics* (Stacey, 1996). By the 3rd edition of the text, published in 2000, the matrix had disappeared. This is curious, given how widely adopted and referenced the matrix has been. Stacey (2012) himself provides the explanation in a critique of an article which uses the matrix. He introduced the matrix to highlight the need for leaders to work in more uncertain, complex ways, but lamented that the diagram was largely misinterpreted from a determinist perspective. Stacey decried the matrix being used as just another management tool: being used to illustrate a leader’s choices about which arena to play in, thus in effect playing down the complexity perspective in favour of a traditional management discourse focused on high control, rational choice and easily understood causal links. In my review of complexity below it will become clearer as to why this perspective is incompatible with complex leadership. For now, suffice to say that Stacey no longer uses the matrix.

Adaptive and technical problems

Ronald Heifetz and Marty Linsky (2002a, 2002b) built on this distinction of “complicated” vs “complex”. They extended Stacey’s work into describing types of change or types of challenges a leader might face. Heifetz and Linsky labelled Stacey’s “complicated” as “technical” problems or changes, and “complex” as “adaptive” challenges or change. Heifetz and Linsky (2002a, p. 67) distinguish the two in this way:

> When your car has problems, you go to a mechanic. Most of the time, the mechanic can fix the car. But if your car troubles stem from the way a family member drives, the problems are likely to recur.

Introducing the human element to an otherwise technical problem (in this case the way the family member drives) makes the problem complex. Heifetz and Linsky (2002a) argue that issues arise when managers and leaders try to attack adaptive problems with technical tools. In this way, their argument mirrors Stacey's of six years earlier: that the traditional tools of leadership that work in the complicated zones of his matrix don't work in the complex zone.

Heifetz and Linsky's (2002a) distinction is still very much in use today, in areas such as counterterrorism (Ihatsu, 2021), leading in a pandemic context (Bagwell, 2020), educational leadership (Muluneh & Gedifew, 2018) and managing global virtual teams (Bilal, 2021).

The Cynefin framework

Developed by Kurtz and Snowden (2003), the Cynefin framework is named for the Welsh word for "habitat". According to McLeod and Childs (2013, p. 299), the framework "has been used in a range of contexts to support decision-making and strategy development in dynamic and challenging situations". The Cynefin framework uses the distinctions and language of the Stacey Matrix in naming its domains: simple, complicated, complex and chaotic (see Figure 2.3 below). Unlike Stacey's matrix, the framework has no axes. Instead, Kurtz and Snowden carve the framework canvas into "ordered" (the left-hand side) and "unordered" (the right-hand side), although in a later version of the landscape Snowden said that the distinction "has been dropped because complexity and chaos are as different from each other as they are from [the Ordered domains]" (Snowden, 2021, p. 59).

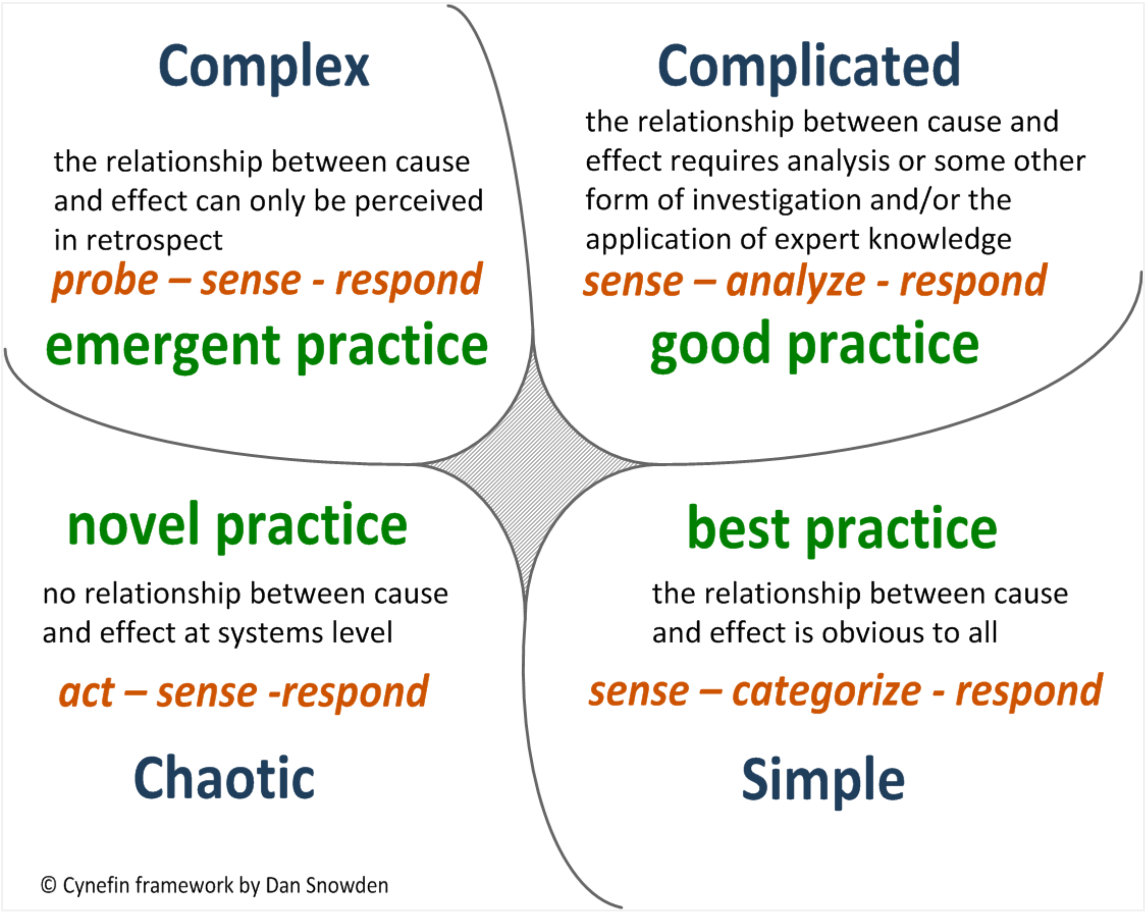

Figure 2.3: The Cynefin framework, from Kurtz and Snowden (2003)

Without the external axes of Stacey's matrix, the Cynefin domains are only weakly related, although Snowden insists that dynamic movement between the domains is possible. Kurtz and Snowden (2003) state that this weak relation is deliberate. The lack of axes and the associated ordering principles are a clear point of distinction from Stacey's matrix, although Kurtz and Snowden don't refer to Stacey in their paper. Snowden (2016, para. 1) explains that he does use an ordering philosophy to separate the domains in the Cynefin framework:

> I've long used a constraint based definition to understand the differences between order, complexity and chaos.

He references Juarrero's (2000) work on constraints in complex causality, without delving into far from equilibrium states and the implications for complexity. I will return to the impact of constraints on how one might investigate complexity below.

In his subsequent consulting work, Snowden (and others) have used the Cynefin framework in work with groups of organisational leaders. The framework has become a sensemaking tool (Browning & Boudès, 2005; Van Beurden et al., 2011), typically used with groups of leaders to help them understand the different types of problems they might face and how different problem types require different classes of solutions. In fact, French (2013) suggests the framework is effectively a challenge stocktaking tool. Kurtz and Snowden (2003) don't refer to team states or dynamical responses at all; rather, they suggest that a leader can determine the type of challenge they're facing using the framework, and then deploy the appropriate strategic response. Snowden (2016) refers to this approach as "sense-making", implying that the purpose of the framework is to help leaders understand the world they work within. However, there is still a flavour of traditional leader-as-actor in the framework, what Lichtenstein et al. (2006, p. 3) might label an "infatuation with leaders" or Plowman and Duchon (2008) might call "heroes" who can first make sense of what is around them, and then choose an appropriate strategy to respond to situations from simple to chaotic.

Despite its apparent popularity with organisational practitioners, the Cynefin framework has had its share of critics. Williams and Hummelbrunner (2010) devote a chapter of their text on systems concepts to a review of Cynefin. They found that many of the terms used in the model were ambiguous or poorly defined and that this limited its practical value. In their text on new knowledge management, Firestone and McElroy (2012) argue that the structure of the framework is confusing in that it looks like a 2 x 2 matrix and yet the author insists it is not supposed to be interpreted that way. They argue that this makes the framework difficult to use. The further find that the framework is too limited in its scoping, and that it lacks a rigorous academic or empirical foundation. This last point has been picked up by Derek Cabrera (Cabrera, Cabrera, and Gibson, 2020; Cabrera and Cabrera, 2019), who argues that Cynefin has little empirical support. Cabrera suggests the Cynefin is "often mistaken for [an] adequate differentiation of complexity and associated terms (chaotic, simple, complicated, etc.)"[4] whereas its intent is about sensemaking.

Administrative and adaptive leaders

Mary Uhl-Bien, Russ Marion and Bill McKelvey (2007) build on Stacey's original distinction between "complicated" and "complex" situations, suggesting that a different type of leader is required for the two different situations' categories, what they call an "administrative leader" for *complicated* situations and an "adaptive leader" for *complex* situations.

Like Stacey, Uhl-Bien et al. (p. 190) position their approach as a challenge to traditional leadership theory:

> Despite the needs of the Knowledge Era, much of leadership theory remains largely grounded in a bureaucratic framework more appropriate to the Industrial Age.

Instead, they propose a "complexity leadership theory", explicitly built on complex adaptive systems. In this theory "administrative leadership" is described in terms consistent with Stacey's and Kurtz and Snowden's complicated domain and with Heifetz and Linsky's technical problems, while "adaptive leadership" is described using the language of complexity. Uhl-Bien et al. seem most concerned with extending understanding into the complex (adaptive) area, introducing and explaining the various elements of complexity likely to be experienced in this area.

[4] https://help.cabreraresearch.org/effective-complexity, retrieved 2/05/2022

Effective Complexity

Hise Gibson, Derek and Laura Cabrera (2020) also compare and contrast the concepts of complicated and complex systems, but use a different framework:

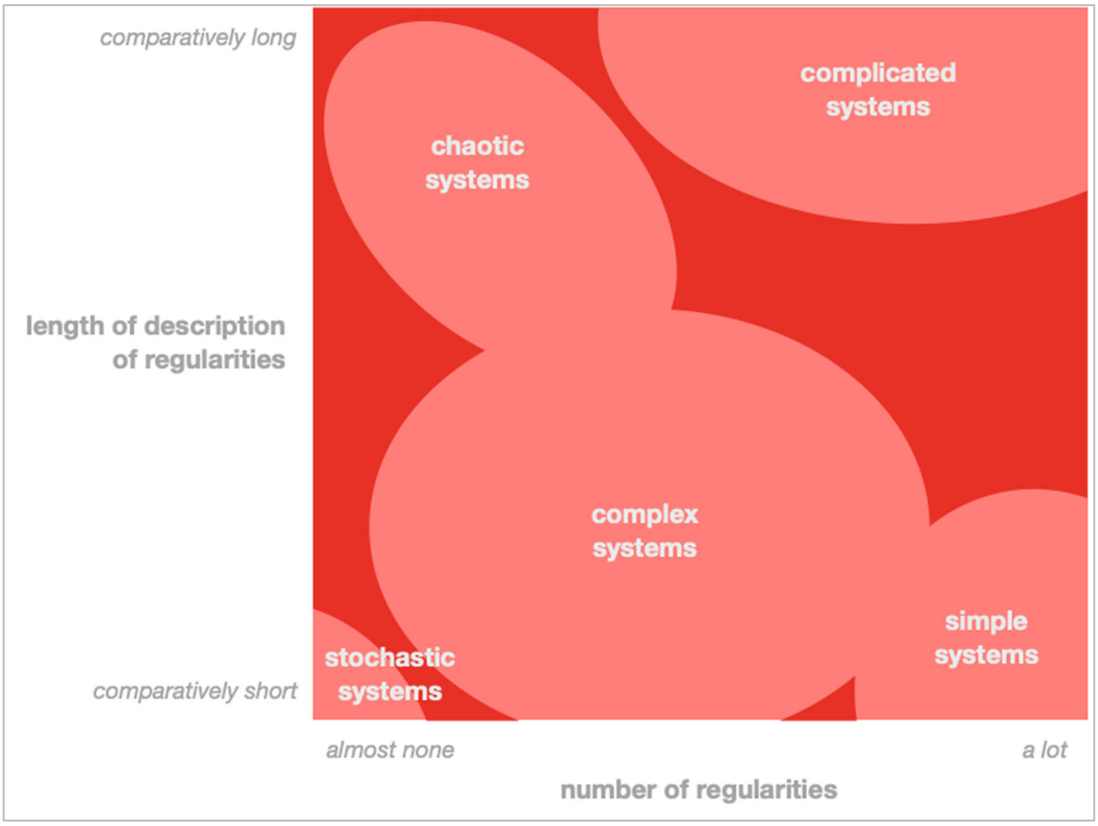

Figure 2.4: Effective Complexity, from Cabrera, Cabrera and Gibson (2020)[5]

The effective complexity framework is used by the Cabreras to support their *DSRP* theory of systems thinking. The details of systems thinking are beyond the scope of this thesis, but the model shown in figure 2.4 above is useful in the distinction it makes between complicated and complex systems.

[5] This image is an updated version of the image published in the referenced paper, retrieved from the author's website at https://help.cabreraresearch.org/effective-complexity, 2/05/2022

The authors use a cognitive perspective for categorising system types. The horizontal axis – "number of regularities" – describes how repetitive the system behaviour is. A highly regular system can be represented by a much smaller description and hence is highly compressible. The vertical axis is the information content or information "length" required to describe each regularity. Thus a simple system is very simply described with a short descriptor repeated a lot, whilst a chaotic system has very long descriptors that repeat very rarely.

In this framework complicated systems have long descriptors but a lot of regularity. That means complicated systems are generated from a proportionately complicated set of instructions. By contrast complex systems can generate novel (low repetition) behaviour from relatively simple instructions. This means complexity can be relatively easy to understand at the generative level, but much harder to adequately describe at the emergent level. An example of simple rules generating complex results is Reynolds' (1987) "Boids" agent-based models. These computer simulations model the flocking behaviour of birds, and enormously beautiful and complex flocking patterns can be generated from surprisingly simple rules, this is a feature of complex adaptive systems.

But what do they mean?

The challenge with the matrices, distinctions and frameworks above is to be clear about how to read them. What exactly are the domains trying to categorise? Whilst there is a consistent distinction between a "complicated" category and a "complex" category, it is less obvious what to do with them. Stacey's (1996) matrix categorises organisational or group states: a leader uses the matrix to discover which state his or her team is in and then works with that state accordingly. On the other hand, Heifetz and Linsky's (2002b) distinction and Kurtz and Snowden's (2003) Cynefin framework are used by leaders to categorise problems or challenges – and then provide hints about how to tackle problems in each region. Uhl-Bien et al. (2007) talk about types of leadership, and Gibson et al. (2020) apply it to cognitive capacity of leaders. Figure 2.5 below compares and contrasts how each approach tackles complexity.

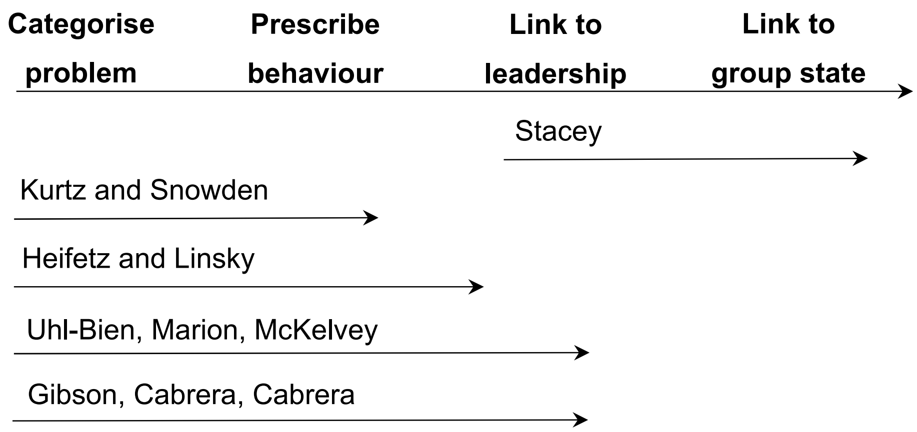

Figure 2.5: Problem or challenge categorisation

This creates potential confusion in the reader's mind: are we talking about types of problems here or are we talking about team "states"? It is my thesis that these two lenses are not completely discrete – they are fundamentally linked. I wish to explore whether certain types of challenges trigger certain states in the teams that face them. Like the flipping bits in Bar-Yam's (2004) simple thought experiment, do teams self-organise into states related to the challenge they are currently facing? Are team states and types of problems just linked or are they interdependent? Is the causality linked, as Juarrero (2000) or Stacey et al. (2000) suggest? And if they are linked, how does the sensemaking of the team in understanding their own state frame how they might characterise the challenge they are facing (or indeed vice versa)? These are questions I hope to address in the primary research described in this thesis (below). For the moment, let us delve more deeply into the distinction between "complicated" and "complex".

2.2.1 “Complicated”

Recall that the complicated domains in Stacey’s matrix above are characterised by some uncertainty on both axes. This means there are unknowns about where the team is, but these unknowns are discoverable. The uncertainty is reduced by the addition of information to the system, and much of the dominant discourse on leadership theory (as we saw described by Marion and Uhl-Bien (2007) Uhl-Bien et al. (2007), Stacey (1996) and Mowles (2014, 2016) above) might suggest that it is the role of the leader to arrange for the addition of this information. For this reason, a large part of the leader’s traditional toolkit includes tools for obtaining, sorting and analysing information to make strategic decisions (Buchanan & Huczynski, 2004; Eisenhardt & Piezunka, 2011; Stacey, 2011), effectively tools of prediction and control. Could leadership teams in **complicated** states display characteristics of cybernetic or general systems?

Cybernetic systems

Cybernetic systems use *negative feedback loops* to constantly seek *equilibrium states*. The archetypal example of a cybernetic system is central heating in a room. The heating unit contains a temperature sensor which takes feedback about the room’s temperature. Based on the feedback, the unit then pumps heat into the room until the desired (set) temperature is reached, at which point the heat pump cuts out. If the room temperature is disturbed, then the system will act to restore the equilibrium state (the desired temperature). In effect, the system interprets and represents the environment, then responds to its interpretation.

Cybernetic-type organisational systems are simple and common (Stacey, 2011). Such systems are goal oriented; the goal is set as the system’s equilibrium state. The system is then homeostatic: it only has negative feedback loops driving back towards the equilibrium state. An organisational team with a regular business-as-usual target might be considered cybernetic.

Interestingly, true cybernetic systems possess the *Markov property* – they are memoryless. This means that the future behaviour of the system at any time is a function only of its current state (how far it is from equilibrium), not a function of the system's history. However, cybernetic organisational systems contain human agents, and humans have memories. The human agents are not only the key mechanism by which the system achieves equilibrium, they can also disturb the system from equilibrium.

Could team members in a team that is in a complicated state act as the "control mechanism" between the sensing and interpretation of the environment and the response of the team? Do team members sense how the team is working and then intervene to drive the team back to equilibrium: for example by downplaying conflict, or attempting to relieve or avoid tension and anxiety where possible? Most team members measure how the team is progressing towards its goals and then intervene – for example speeding up or slowing down work – to remain on track. In each of these cases, is the team displaying behaviour consistent with the description of a cybernetic system?

General systems theory

General systems theory owes its beginnings to Ludwig von Bertalanffy (1950) and Anatol Rapoport (1953). It is a theory of open systems. As an example in an organisational context, a business imports people, goods, resources, ideas and knowledge, changes them, and then exports them. Classic examples of general systems include factories and processing plants. General systems thinking can be seen in the value chain analysis of Porter (1985). Such systems are homeostatic, but the homeostasis is not about goal seeking because the system focus is on the transport and transformation of resources.

Negative or equilibrium seeking feedback loops dominate in this type of system, driving the system to preferred production states. However, because causality in the system is more linear than the circular causality of cybernetic systems, general systems can occasionally be prone to positive feedback loops resulting in wild divergence and far more dynamic or complex behaviour (Meadows, 2008).

It would seem that human agents might have slightly higher degrees of freedom in this type of system, meaning the system is more dependent on the behaviour of agents than in a goal-directed cybernetic system. The openness of the system means that homeostasis is not guaranteed; it would have to be managed if the system were to remain stable. Additionally, the system depends on its interfaces with the external environment for the resources it will transport and transform, so some form of boundary maintenance is required for stability.

This systems-based description of team behaviour in complicated states is not revolutionary. Any experienced team member will be familiar with setting goals, managing disturbances, directing behaviour and managing external interfaces. But authors such as Eisenhardt (1989), Uhl-Bien et al. (2007) and Stacey (2011) in their discussions of complex leadership argue that these types of systems, being essentially homeostatic and equilibrium seeking, are not the environment in which leadership is truly tested. Instead, they suggest leadership shines when dealing with systems and situations in what Anderson (1999) describes as *far from equilibrium* states. This is the domain of complex adaptive systems.

2.2.2 "Complex"

Whilst the complicated domain rests on a century of management and strategy theory, the complex domain is underpinned by the science of complex adaptive systems.

A complex system is a system in which the components can't be simply decomposed. For example one might consider that a jumbo jet engine (exempt of any human interaction) is not a complex system – its mechanical operations are a complicated (but not complex) sum of its constituent components. On the other hand, the human brain is a complex network; its function can't be linearly decomposed into the simple firings of individual neurons (Cilliers et al., 2002; Uhl-Bien & Marion, 2008). In essence, the difference between a complex system and a merely complicated one is that the elements of a complex system (called "agents") have *conditional instructions*; that is, the instructions that determine how an agent A behaves explicitly reference the behaviour of other agents in its local vicinity. In a complicated system the majority of the elements or agents' instructions are independent or not conditional.

Complex adaptive systems contain elements of both non-determinism and non-linearity (for more detail, see the next section on types of uncertainty). A number of key researchers and authors in the field have sought to provide overviews of complex systems, including Cilliers (1998), Anderson (1999), Hazy et al. (2007), Miller and Page (2007), Marion (2008), Merali and Allen (2011), Stacey (2011) and Mowles (2022). Across these authors some core characteristics of complexity emerge. Defining these core characteristics will help us develop an understanding of what a complex system might be, and what we might expect to see in such a system.

Basic definition: agents

The individuals that interact with one another in a complex system are generally referred to as agents. Agents might be cellular automata or "bots" in computer models, individual insects in a swarm or hive, birds or fish in a flock or school, or in this study individual humans in a team.

Features of complex systems: open systems

Complex systems are open systems: they freely interchange information and energy (resources) with the environment. The agent population is not fixed: the system imports, transforms and exports agents ("recombination"). As a result, complex systems are embedded in their environmental context: they don't operate as closed systems and can't be evaluated in isolation. Further, complex systems operate far from equilibrium, meaning they require energy to be sustained in that state.

Features of complex systems: locality

In complex systems, the interactions between agents are short range (agents usually interact with neighbours, but not across systems). Complexity scholars call these interactions "local". In larger organisational groups of humans, locality is network locality rather than spatial or physical locality. For instance my "local" neighbours may be part of a leadership team that works at a similar senior level within an organisation, but may sit on different floors in a building (or in a pandemic world, we may sit in different cities or countries!). Furthermore, each agent usually responds to its understanding of its own locality (in organisations this means its local group's sensemaking) rather than an understanding of the system as a whole.

Features of complex systems: conditional behaviour

In a complex system, the behaviour of any individual agent is conditional on the behaviour of those nearby. That means that the individual agents pay attention to those around them, and modify their own behaviour based on their perception of the behaviour of those around them. This is a key transitional feature for complex systems: when the behaviour of agents is conditional, the system can exhibit complex behaviour; when it is not conditional (for example if agents are not paying attention to one another), it cannot.

Features of complex systems: simple rules generate complex behaviour

The agents in complex adaptive systems do not need complex (or even complicated!) instructions to generate complex systems level behaviour. In fact surprisingly simple agent level instructions can generate very complex system level behaviour, *provided the instructions are conditional* (see conditional behaviour, above). A readily accessible example is in John Conway's artificial *Game of Life* simulation, which can be played online. In this game individual agents are squares in a large matrix array. Each agent is instructed to change state (either "alive" or "dead") based on the states of some nearby neighbours. Note that the instruction is (a) *simple* to describe and execute, (b) *conditional* on its neighbours' states (and nothing else), and (c) *local* – conditional only on its neighbours' states. The patterns that emerge as the game evolves over time (successive updated iterations) are quite beautiful, complex and *emergent* (see next item).

Consequences of conditional behaviour: emergence

Group or system level behaviour *emerges* from the interactions of the agents. Emergent behaviour is not a simple sum of individual interactions, and can't be located in any single individual agent – it emerges from the interactions. Lichtenstein and McKelvey (2011) find that emergence can happen at multiple levels of interaction, including group level, and can provide for novel and unexpected behaviour.

Consequences of conditional behaviour: non-linearity

A consequence of conditional behaviour, the interactions between agents can be non-linear; that is, they can drive system behaviour that can be extremely sensitive to initial conditions and not necessarily proportional. There are feedback loops in the interactions between agent and agent (agent behaviour is modified by their perception of other agents' behaviour) and between agent and local system (agent behaviour is modified by their perception of the local group emergent behaviours; that is, local norms or local cultures).

Humans in complex systems: noise

Researchers, particularly those who come from a computer-based or agent-based modelling perspective, use the term "noise" to describe unpredictability in the behaviour of individual agents. This noise can result from random behaviour, errors made by individual agents, or the exercise of free will, and it has the effect of making complex systems non-deterministic. Whilst non-linearity drives system or team level behavioural uncertainty, random noise introduces uncertainty into individual behaviour.

Features of complex systems: memory and the Markov property

The complex interplay of agents and systems is dynamic; they co-evolve over time. This means agents and systems do not have the Markov property, a "memoryless" property exhibited by stochastic processes where each event in the process is discrete and disconnected from the others. By contrast, agents in complex systems, and the systems themselves, have history trajectories and "memory"; their future is always (at least partly) a function of the collective past.

Features of complex systems: far from equilibrium, dissipative

An "equilibrium" system is steady or stable with respect to its local environment; by contrast, complex systems operate away from equilibrium. As a consequence, complex systems require energy to be sustained; that is, they are "dissipative": they use or dissipate energy, and require more to stay steadily away from equilibrium.

Features of complex systems: attractors and attractor states

Attractors are features of complex or chaotic dynamical systems. An attractor is a state (or a set of states) towards which a complex system might spontaneously tend to evolve, despite the system's starting conditions. As an example, consider a system consisting of a ball set rolling in a smooth bowl or cup. This system has a single stable "point attractor": the ball at rest at the bottom of the bowl. Regardless of the initial position or velocity* of the ball in the bowl, the ball-and-bowl system will evolve over time towards the same fixed point attractor (*provided the velocity of the ball isn't sufficient for it to roll out of the bowl!). Attractors are discussed in greater detail in the Discussion chapter, in section 6.1.5.

Consequences of far from equilibrium: metastable

A metastable system is temporarily stable, but fluctuations might disturb that system away from its stability. An example is a ball perched at the top of a rounded, smooth hill. The ball can stay at the top of the hill (appear stable) provided it is not disturbed; if disturbed, it will roll down the hill. This is because the hill (the system) reinforces the disturbance: once the ball starts rolling, the incline speeds it up. The ball can stay metastable at the top of the hill with the application of energy – working to nudge the ball back to the hilltop when it begins to roll away, or simply holding it there. In this way, the ball is away from its equilibrium state, which is obviously the bottom of the hill.

Consequences of far from equilibrium: adaptive, self-organising

In complex *adaptive* systems, agents learn from their interactions (creating more feedback loops). As a result, complex adaptive systems tend to self-organise, evolving towards local order characterised by locally low entropy (which in turn is why they must operate far from equilibrium).

Most of these features will be expanded on in greater detail throughout this thesis. In summary, complex systems are open, containing agents with local, noisy, conditional behaviour. The system's environment and its history must be taken into consideration. It can exhibit non-linear dynamics which drive emergent, novel, unpredictable and adaptive behaviour, and it operates far from equilibrium in a dissipative metastable fashion. Complex systems also process, and are a source of, uncertainty, and it is to this uncertainty that we now turn.

2.3 Uncertainty: reducible vs fundamental

The literature around uncertainty seems to approach the subject from two different but complementary perspectives. Reichl (2005), in his exploration of fundamental uncertainty in the sciences, encapsulates this well, suggesting that uncertainty can be divided into those uncertainties that are a function of our incomplete understanding of a system or situation and those that are fundamental to a system or situation (see also Driebe & McDaniel, 2005). We might call this a distinction between *reducible* and *fundamental* uncertainty.

Such a distinction is important. Traditional approaches to management and leadership such as those outlined in the sections above presume and then work largely with reducible uncertainty, those uncertainties that can be reduced by the addition of knowledge or information. An early definition of the concept of organisational leadership was expressed by Stogdill (1950, p. 3):

> Leadership may be considered as the process (act) of influencing the activities of an organized group in its efforts towards goal setting and goal achievement.

Plowman and Duchon (2008, p. 129) express much the same sentiment thus:

> Conventional views of leadership are based on the assumption that the world is knowable and that effective leaders can rely on planning and control mechanisms to bring about desired organisational futures.

Separated by nearly sixty years, these authors agree that it is the role of leadership to provide direction (where should we go?) and control/management (how should we get there?). In this paradigm and more specifically, one might say that the role of leadership with regard to uncertainty is thought to be about prediction (remove future oriented uncertainty) and control (remove current state uncertainty). I will return to the importance of these two aspects of role in Chapter 3 below. Marion and Uhl-Bien (2007) call this traditional conceptualisation of leadership the “bureaucratic paradigm”, and Mowles (2014) calls it the “dominant discourse”, but both agree that traditional treatment of uncertainty is incomplete.

In his examination of the critical role of uncertainty in games, Costikyan (2013) discusses examples of uncertainties that arise directly from incomplete information, these are summarised in Table 2.1 below.

Type of removable uncertainty	**Strategy for reducing uncertainty**
novelty (we haven't experienced this situation before)	consult someone with experience of the situation
unknown or hidden information (we don't know part or all of that)	seek out a source with information about the unknown, or conduct analysis using tools to remove the hidden, or improve technology to measure with more precision
"fog of war" – perception limited to a horizon in space, time or capability, beyond which is a "fog"	bring together and encourage information sharing in a group with non-overlapping perception boundaries, or consult someone with radically different perception boundaries, or use wide field technology to increase your view
capability uncertainty, either physical or mental (I don't know how I – or someone else – will do at this task)	improve performance through practice or focused development, bring together a group with varied performance capabilities, introduce performance measurement and control mechanisms
scheduling uncertainty (we don't know when these things will happen)	plan, and plan contingencies, mitigate risks
ambiguity of perception (we see these things differently)	share, triangulate and align perceptions

Table 2.1: Removable uncertainties and strategies for reducing them

In each case, the uncertainty in the situation can be "remedied" by the addition of information of some form. In fact, an analysis of the tools taught in the typical MBA program shows that they are mostly concerned with prediction and control, and have been found by Rubin and Dierdorff’s (2009) analysis to be incomplete in a leader’s education. Mowles (2022) agrees: something may be missing here.

2.3.1 Fundamental uncertainty

What may be missing is an acknowledgement and some understanding of fundamental uncertainty. Reichl (2005) argues from first principles that there are uncertainties that are irremovable or fundamental. One obvious example is the Heisenberg Uncertainty Principle (Heisenberg, 1927) of quantum physics. The Uncertainty Principle places fundamental limits on the certainty with which complementary physical variables (eg momentum and position or energy and time) might be known. Note it is not a limit of measurement capability (such as might be removed by increased technological precision) but a fundamental limit on knowability.

It could be argued that in human systems fundamental uncertainty arises in two main ways:

Non-linear fundamental uncertainty

The first is when the system begins to display a sensitivity to initial conditions. The sensitivity is driven by non-linear interactions amongst the components – in this case the people in the human system (Anderson, 1999; Andriani & McKelvey, 2009; Arrow et al., 2000; De Landa, 1997; Goldstein, 2008; Helbing, 2010; Prigogine & Lefever, 1973). Non-linear interactions generally involve feedback loops that drive systems away from equilibrium. The simplest “feedback loop” is when the output of one iteration of an equation forms the input for the next iteration. For example:

$$x_{(n+1)} = x_{(n)}^{y} + y$$

In this case the output of each iteration of the equation – $x_{(n+1)}$ – becomes the input to the next iteration – $x_{(n)}$. The evolution of the equation depends critically on the value of y: even for values of y close to 1, the equation rapidly blows out.

Non-linear dynamical systems display behaviour that is very sensitive to their initial parameters or conditions. The classic example is the flapping of a butterfly's wings in New York causing a hurricane in Tokyo (Lorenz, 1972). In general we might say that systems with linear interactions display more readily understandable causality and lead to greater possible degrees of prediction and control, whereas in systems built on non-linear interactions causality is more obscured, and hence there is much more uncertainty in predictability.

Non-deterministic fundamental uncertainty

The second main way fundamental uncertainty might arise in human systems is non-determinism. Non-deterministic systems involve randomness. Randomness in human systems arises through the irrationality or unpredictability of agent (human) behaviour (Andrade & Ariely, 2009; Boschetti, 2011; McKelvey, 2002; Nowak & Sigmund, 1992). It is outside the scope of this thesis to delve deeply into the libertarian debates about free will. I simply note here that regardless of whether randomness shows up in human systems as free will or merely as luck or chance (Franklin, 2018; Shabo, 2018), either way it increases uncertainty in human systems.

In fact, complex human system modellers regularly include randomness in human behaviour modelling since Rob Axelrod's "noise" factors in his famous iterative prisoner's dilemma virtual tournaments (Wu & Axelrod, 1995). In the virtual tournament, Axelrod set up a series of programs that would play the archetypal prisoner's dilemma (Flood, Dresher, Tucker & Device, 1950) in a repeated iterative fashion. Theorists were invited to submit ideal strategies to be tested in the virtual tournament over a thousand iterations. In each iteration the program would respond in the way predicted by the strategies, but with the addition of a random “noise” element. In the program this a probability of a random “error”, built in to simulate human error, or the exercise of free will (unexpected choice). The randomness of “noise” (whether truly random or a result of free will) introduces further unpredictability and uncertainty into the system.

In the distinction between fundamental and reducible uncertainty we see echoes of the earlier distinctions between complicated and complex systems, between technical and adaptive challenges, between administrative and adaptive leadership. Tsoukas (2017) argues that the application of a “reduce-the-uncertainty” strategy to a complex problem is – again – a serious error. Instead, he concludes that the only way to deal with complexity is to ensure our representations of it are commensurately complex rather than simplified.

2.3.2 An uncertainty landscape

The uncertainty discussed above might be synthesised as shown in Figure 2.6 below.

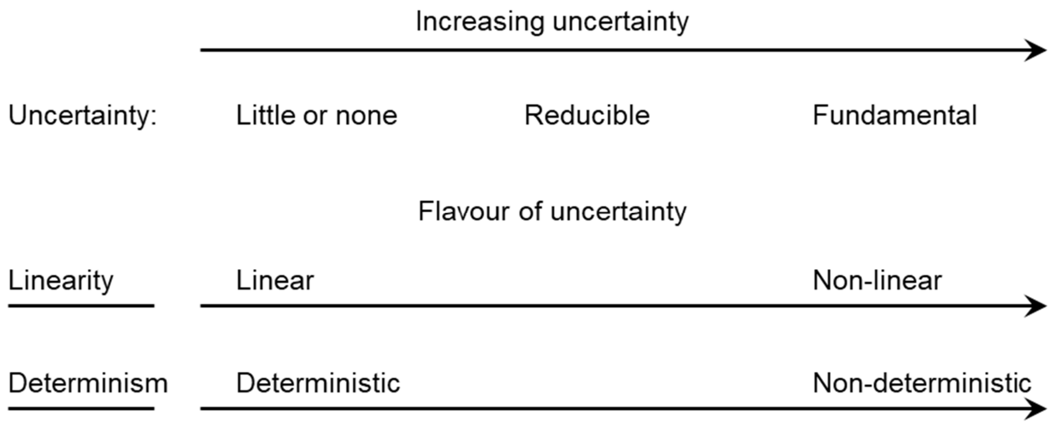

Figure 2.6: Determinism and linearity

Little or no uncertainty means that causality is readily seen and understood – we can immediately see that *if X, then Y*. The next level of uncertainty is the reducible uncertainty discussed in the section above. As we saw above, uncertainties of this type result from incomplete understanding of a situation and can be reduced by the addition of information. The last level is fundamental or irreducible uncertainty, resulting from non-linearity or non-determinism.

Suppose we separate the Linearity and Determinism into two axes: we might then use these to synthesise our understanding into a new landscape to frame our tension between complicated and complex states, and understand how different types and levels of uncertainties affect the challenges leadership teams face and the team states they consequentially enter.

2.3.3 The vertical axis: linear to chaos

In the understanding of uncertainty I develop in this thesis, I will build the work of Stacey (1996), Heifetz and Linsky (2002b), Kurtz and Snowden (2003), Uhl-Bien et al. (2007), and Gibson et al. (2020) discussed in section 2.2 above. In that section three diagrams were presented: Stacey's matrix, Kurtz and Snowden's Cynefin framework, and Gibson et al's (2020) Effective Complexity model. This section incorporates some elements from each while at the same time distinguishing my thinking from theirs. Like the Stacey Matrix and the Effective Complexity model (and unlike Kurtz and Snowden), I use horizontal and vertical axes to root my thinking in the above discussion of two types of uncertainty (non-linearity and non-determinism). The axes add extra information to the Uncertainty Landscape. I will begin to populate my Landscape with similar domain names to those used by Stacey, Kurtz and Snowden and Gibson et al; however, the axes and their relative positioning will provide more nuance to the domains and their relationship to each other.

Let us first consider the y (vertical) axis in Figure 2.7 below. The domain in the top is labelled "Chaos". Unlike the Stacey Matrix, the chaotic domain is not an extension of complexity but separated from complexity by relative determinism. In this way it is more similar to the Effective Complexity model in that complex is separate from complicated.

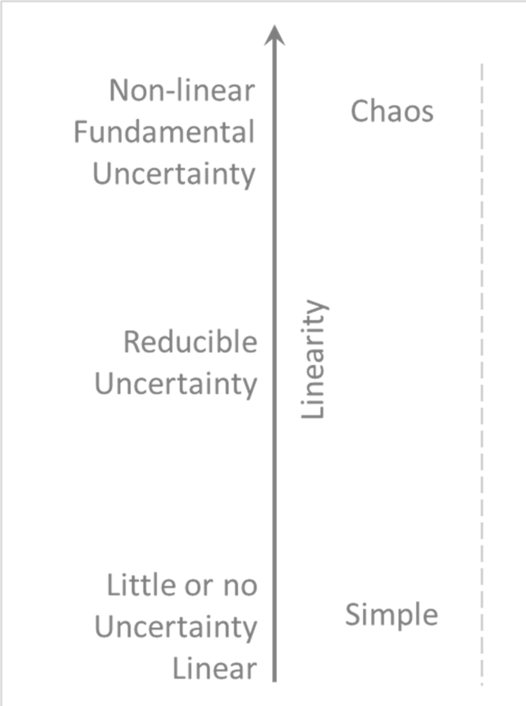

Figure 2.7: The vertical axis, non-linearity and chaos

Chaotic systems are deterministic (Gleick, 2011; Lorenz, 1963; Timofeeva, 2013) but not linear. The determinism of chaotic systems means we typically understand *how* they work: if we were able to know precisely everything about the current state of a chaotic system, then it would evolve entirely predictably. In practice, prediction is possible in chaotic systems either over relatively small time scales, or within stable regions (Devaney, 1989; Gleick, 2011) using sophisticated modelling. However, the tiniest error in initial conditions is magnified by the feedback loops that occur in non-linear systems, driving the outcome away from the expected (Devaney, 1989), colloquially known as the “butterfly effect” (Lorenz, 1972). Lorenz posited that the flapping of a butterfly’s wings (a tiny disturbance) might overwhelm and significantly change the potential outcome of the weather weeks later (for example what might otherwise have been a fine day might instead experience a hurricane). In the account related in the Chapter 1 above, the interjection of the CD

AU might be regarded as a butterfly event, in that it changed the course of the afternoon session unpredictably.

Exploring the chaotic domain helps us better understand the uncertainty associated with the vertical axis. Chaotic systems are deterministic, so we know how they work. In fact, some chaotic systems are simply described mathematically. The uncertainty is in the outcome, since tiny fluctuations can be magnified by the non-linearity of the system. So our vertical axis can be described as *uncertainty in outcome,* or *uncertainty about where we'll end up.* In practice human interactions are not chaotic, because they are not strictly deterministic. They include some elements of randomness.

2.3.4 The horizontal axis: determinism to randomness

Let us now consider the x (horizontal) axis as shown in Figure 2.8 below.

The domain in the bottom right is "randomness". "Randomness" is an intriguing concept. Helbing defines it nicely as "*Chance affectedness"* (Helbing, 2010, p. 6), as states influenced by chance.

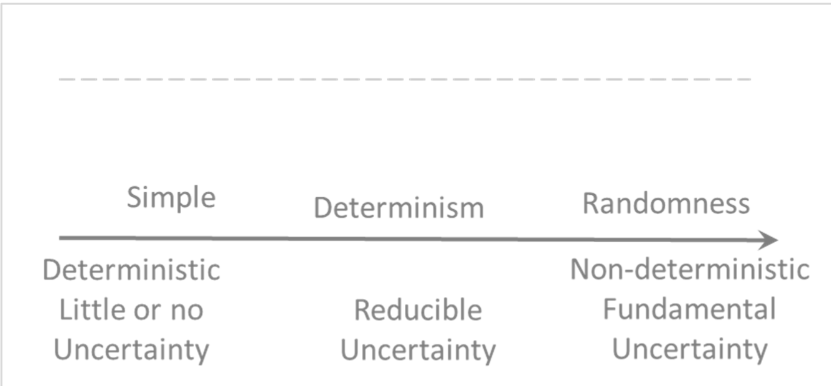

Figure 2.8: The horizontal axis, non-determinism and randomness

Everyday familiar examples of “random” include games of chance such as the roll of a six-sided die, toss of a coin or the spin of a roulette wheel.[6] Each of these examples has two properties we associate with randomness: each is a Markov process and can be modelled stochastically (using probabilities).

A Markov process is a memoryless process (Grosskinsky, 2013). This means the current state of the system is independent of – and hence can’t be determined by examining – the previous states. In the games of chance examples above, each roll of the die, toss of the coin and spin of the wheel is entirely independent of the previous ones. Suppose we know that the previous ten tosses of a coin have all landed on “heads”, this adds no information to the 11th toss: it is still a 50/50 chance of landing heads or tails. Interestingly, many people are unaware of the Markov property of games of chance (Tversky & Kahneman, 1974), which is why casinos track and display the results of previous spins or tosses to gullible patrons.

Despite the Markov property, random systems are still modellable, and in a sense predictable. They can be modelled stochastically (Helbing, 2010). Stochastic models are probabilistic; they tell us how the system will behave statistically over time, but not how any single step or event might happen. For example we know that over time the tossing of a coin will converge on a 50/50 probability, but not how the next coin toss will land. In nature we know the decay rates of radioactive elements and can use this information to calculate the half-life of a sample, but we can’t tell which atom will decay next or when a given atom will decay (it’s truly random). This stochastic order seems to “emerge” from the individual events despite their being unrelated. Humans similarly can generate random choices (Persaud, 2005; Warren et al., 2017). One simple example might be a series of

[6] A roulette wheel is not actually random; it is *pseudo-random*, or a mechanical approximation to randomness. The roulette wheel is itself a deterministic machine, but it is extremely sensitive to initial conditions. In fact, it is a non-linear deterministic system masquerading as random.

unweighted choices that are unrelated (whether to purchase shoes A or shoes B given that they are of equal utility). These choices are random for given individuals, but conform to patterns at a population level sufficiently enough for merchants to predict sales. In fact, Simonton (2003), in his analysis of the creative outputs of scientific research, found that scientific creativity could actually be modelled as a constrained stochastic behaviour. This means that the outputs over long periods of time might be predictable at a population level, but which scientist might produce which breakthrough at which point is more or less quasi-random.

Exploring the random domain helps us better understand the uncertainty associated with the horizontal axis. Random systems are linear and stochastically modellable, so we know what results they will produce over time: in fact, the probabilistic descriptions are often simple. The uncertainty is in how the outcome is achieved, since the Markov property means the individual cycles are unrelated. So the horizontal axis can be described as *uncertainty in process,* or *uncertainty in how we'll get there.*

We now can see how non-linearity and non-determinism might play into leadership group decision making and dynamics: they manifest as uncertainty about destination ("where we'll end up") and process ("how we'll get there") respectively. Human behavioural choice introduces random noise into the system (Miller & Page, 2007), meaning human systems are not entirely deterministic. In order for human systems to be deterministic, humans must have no free will (Baumeister, 2008). But groups of humans interacting together involve feedback loops – we modify our behaviour based on our interpretation of the behaviour around us (Nisbett et al., 1982) – so human systems are not linear. Thus it seems that both types of uncertainty most likely appear in human dynamics to some extent together. In Figure 2.9 below these two axes – linearity and determinism – have been connected into a single matrix showing the chaos and randomness just discussed.

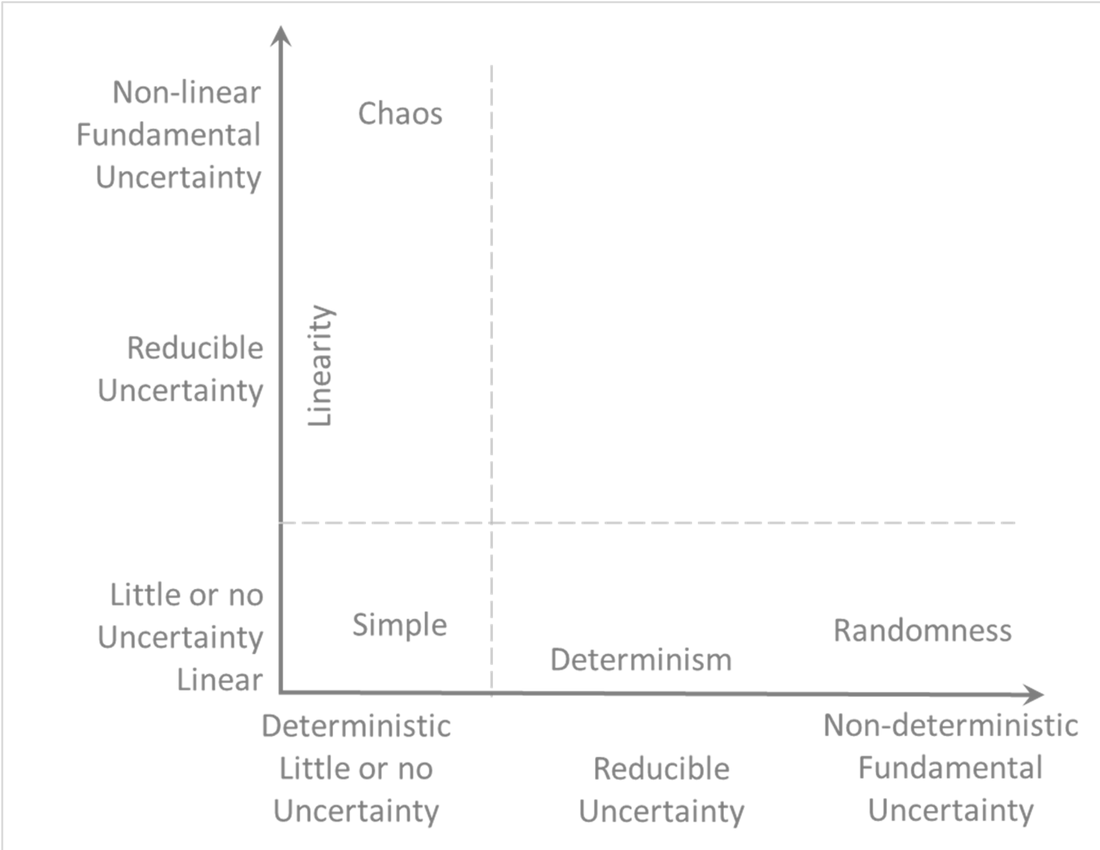

Figure 2.9: A single Landscape of Uncertainty: axes only

2.3.5 The human domains in the Uncertainty Landscape

As discussed above, human teams will always have some element of non-linear uncertainty and some element of non-determinism about them, and so they are unlikely to be in chaotic, random or simple states. The distinctions on the axes suggest two other domains on the map. Building on the Stacey Matrix and the Cynefin framework, I name them “complicated” and “complex”, as in Figure 2.10 below.

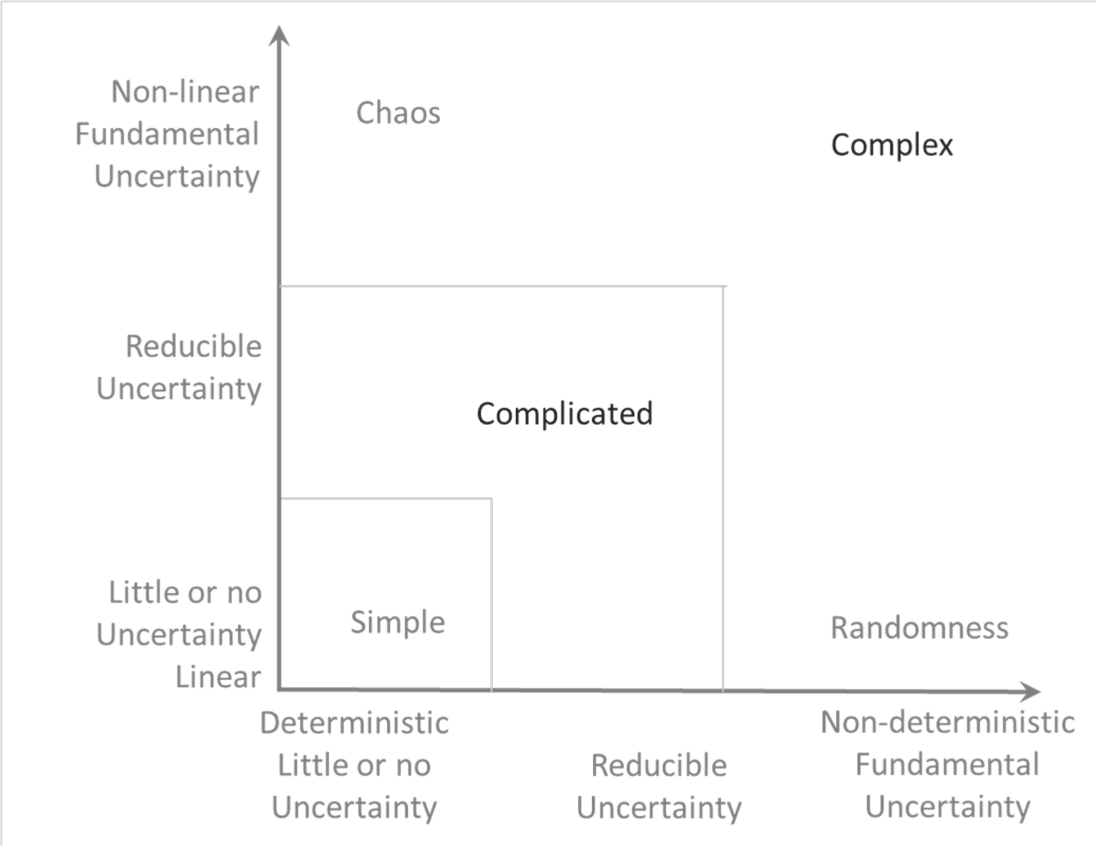

Figure 2.10: The human domains in the Uncertainty Landscape

The bottom left corner is characterised by low to zero uncertainty on both axes. Thus this corner is the intersection of the bottom of the vertical axis: linear relationships between cause and effect; and the bottom of the horizontal axis: a lack of random noise. In Figures 2.7 and 2.8 above I have labelled this corner of the Uncertainty Landscape “Simple”, referencing the simple relationships between cause and effect here. An organisational challenge fits this domain if it is known how to tackle it (low uncertainty about process) and it is known how it will end up (low uncertainty about outcome). Note that it is not possible to be definitive about what challenges go in this domain because they are going to be contextual. What is “simple” to a team of veterans of a field each with twenty years of experience may not be so to a team of novices. This is why it is not possible to do the “stocktaking” problem classification of Kurtz and Snowden’s Cynefin framework without taking into account the state of the team tackling the challenge. In fact, the types of team/challenge interaction we'd expect to see in the simple domain would be described by Frey and Osborne (2017) as likely to be undertaken by individuals acting alone or interacting singly with technology, or increasingly tackled by "robots". In this thesis I am most interested in the interaction of teams of leaders, and the state of leadership teams changes with different challenges they meet. For this reason I will not be further investigating the simple domain, but rather focusing on the distinctions between complicated and complex team challenges and team states. I have covered "complicated" and "complex" in some detail above.

2.4 Complicated to complex and back again? state changes in teams

> The music's between us…
>
> - *Duran Duran, "(Reach up for the) Sunrise", 2004*

Is it possible to move from a configuration with characteristics that are complex into a configuration that is not, and then back again? Such a change of configuration, with corresponding changes in characteristics, would be an example of a *state change*. Authors in the complexity space already employ the concepts and language of the physical sciences of state changes to describe how teams respond to complexity. For example Viejo et al. (2015) and Den Hartigh et al. (2014) talk about "phase" or "state" changes in teams.

Organisational culture theorist Edgar Schein (2010, p. 299) argued that if we want to understand thinking about state changes we have to begin with Kurt Lewin:

> The fundamental assumptions underlying any change in a human system are derived originally from Kurt Lewin (1947).

In 1947, Kurt Lewin published a paper on "Frontiers in Group Dynamics" (Lewin 1947). Section D of the paper discusses how "permanent" or at least "quasistationary" changes might be made in organisational groups. In section D, subsection 6 mentions the challenges that might arise in stabilising change and introduces Lewin's famous "Unfreeze – Move – Freeze" model for change. Schein (2010) argues that this unassuming subsection has become the basis for our understanding of change management. In their meta-analysis on the influence of Lewin's thinking, Cummings et al. (2016, p.34) report that this idea has come to be "regarded as the 'fundamental' or classic approach to, or classic 'paradigm' for, managing change".

Cummings et al. (2016) argue that Lewin has been misinterpreted, and that the initial idea has taken on a life of its own, commonly now described as Lewin's three-step model, or "Change as Three Steps" (CATS). Lewin's names for steps two and three have evolved in common usage (see Figure 2.11, below). It is the "refreeze" step that is most relevant to this discussion.

UNFREEZE ⇨ CHANGE ⇨ REFREEZE

Figure 2.11: Lewin's CATS model as it is now commonly described

According to Cummings et al. (2016), Lewin's "refreeze" appears in:

- Lippit et al.'s 1958 change model as "stabilize change" and "achieve terminal relations";
- Kolb and Frohman's 1970 Planned Change Model as "Evaluate and Terminate";
- Tichy and Devanna's 1986 3 Acts of Transformation in "Act 3: Institutionalising Change";
- Kotter's 1995 Eight Steps of Change as "Consolidate" and "Institutionalise"; and
- Schein's 2010 Model of Change and Learning as "Institutionalising new concepts".

Notice the use of the words “terminate” and “institutionalise” (and derivatives) for the final state of each model. Yet Lewin himself in his original paper says that “A change towards a higher level of group performance is frequently short lived” (Lewin, 1947, p. 34). I argue that the suggestion of change as something that can be done and finished, as if new equilibrium states in groups can be reached and sustained, is an idea that despite its pervasiveness is fundamentally flawed. This idea of change as a transition between two “fixed” states has found some opposition in the process organisational studies field, for example Helin et al. (2014), Hernes (2007) and Langley and Tsoukas (2017), although it is still a remarkably persistent idea. In order to challenge it, it may be necessary to go further back than Lewin and consider the “physics envy” in the social sciences.

2.4.1 We’re envying the wrong physics

> I always envy the physicists and mathematicians who can stand on firm ground. (Freud, 1961, p. 451)

The so-called “science wars” of the social sciences are perhaps best described by Flyvbjerg (2002): the ongoing battle as to whether the social sciences should maintain an empirical and quantitative approach to understanding and describing how people interrelate, or whether to discard this approach as “physics envy” and let other more qualitative ways of understanding human interaction dominate the discourse and research. In this context “physics envy”, or more broadly “natural science envy”, is generally regarded as an envy of the positivism, rationalism and mathematical empiricism of the natural sciences. The science wars still rage, though the balance is shifting in a modern “post-truth” world (Babich, 2017). It is not the intent in this thesis to further prosecute the war itself, rather to question whether we are envying the right physics.

Jeremy Rifkin, in his seminal work *The Third Industrial Revolution*, laments the educational basis of economists:

> It wasn't until the second half of the nineteenth century, when physicists articulated the first and second laws of thermodynamics – the energy laws – that economists had a scientific basis to accurately describe economic activity. But by that time, economic philosophy was so mired in Newtonian mechanical metaphors that its practitioners were unable to part with these theories, even though they were based on scientific assumptions that were largely inapplicable to economic practice. (Rifkin, 2011, p. 195)

Although Rifkin is speaking of economists, the same might be applied to management education. In particular one can see the "Newtonian mechanical metaphors" in the change management models of Lewin and others in the section above. For instance, Newton's first law of motion is about sustainable stability:

> Law I: Every body persists in its state of being at rest or of moving uniformly straight forward, except insofar as it is compelled to change its state by force impressed. (Newton, 1687).

In other words, once you change the state (of motion) of an object or system, it will continue in the new state until acted upon again. When rephrased in this way, one can see how the "unfreeze, change, refreeze" thinking is conceptually similar. Newton's second law explains how a net force on an object produces a change in momentum (how to make things move), whilst the third law describes equilibrium systems as being those in which pairs or arrays of forces are finely balanced. Put together, these imply that it is only action (a net force) that produces change between different equilibrium states. It is not so far from this thinking to the idea that action on an organisational group will produce a change, which then results in a new state for the organisational group in a new equilibrium. By way of analogy, imagine a group situated on one step of a large staircase. The group is stable on this step. The group is then acted upon by an external force that lifts the group to a higher step. The force then stops, and the group rests stable on its new step. Unfreeze, change in response to an external action, then refreeze: Lewin's model. The post-change refrozen state is sustainable for ever if group state changes operate along the lines of Newton's first law.

But this is not how groups work. Recall Lewin's comment from above: "A change towards a higher level of group performance is frequently short lived" (Lewin, 1947, p. 34). Jantsch (1980) also argues that a universe composed of deterministic and equilibrium-based transformation models is incomplete, as do Gemmill and Smith (1985, p. 751:

> Transformation processes are not understandable through the equilibrium models we most often use to describe system dynamics.

What is missing from Lewin/Newtonian state change models is the impact of time and decay.

2.4.2 Metastable, but not in equilibrium

If the idealised equilibrium systems of Newton's mechanical metaphors no longer work for my purposes, I will have to turn to a more complex understanding of how group states change. Our understanding of complex dynamics in human systems draws heavily on Ilya Prigogine's work in thermodynamics: the branch of physics concerned with the relationships between energy, work, entropy and heat. Of particular interest to me here, Prigogine and Lefever (1973) explored "far from equilibrium stable states". Equilibrium states describe systems tending towards a stable balance with their environment, whereas Prigogine found that complex states tend to operate out of equilibrium with their environment, and can even reach a metastability away from equilibrium. Let us try an analogy to explore this difference between "equilibrium states", "far from equilibrium states" and "metastability".

Consider an open saucepan filled with water sitting on a stovetop. Left alone for long enough, the saucepan, water, and unlit stove will eventually reach thermal equilibrium with the surrounding air – they will all be at the same temperature. Let's call this state A. Now let us turn on the stove and begin applying heat to the saucepan. The saucepan and the water will increase in temperature, and will move out of equilibrium with the environment. As we apply more heat, the temperature will eventually reach the boiling point for the water. At this point a new "stable state" can be reached – a roiling boil. Further heat doesn't significantly raise the temperature, it just turns liquid water to gaseous water vapour. Let's call this state B. It is a "metastable" state; it stays stable so long as we supply it with steady heat and resources (water to replace the lost water vapour). State B is also called a dissipative structure: a dissipative structure operates far from equilibrium, and is in steady exchange of energy, information and resources with its environment (Prigogine, 1978).

Suppose we now step back from the analogy of the saucepan-water system to a human group. Prigogine, in discussing his work in far from equilibrium systems and structures, used this very example of boiling water as "a simple example of a dissipative structure in a complex system" (Prigogine, 2005, p. 14), and in social systems (Prigogine, 1997; Prigogine & Lefever, 1973). Numerous authors in the complexity space, including Stacey (2011), Stacey et al. (2000), Uhl-Bien et al. (2007), Anderson (1999), Ball (2005) and Miller and Page (2007), make strong cases for organisational groups behaving as complex systems, leaving them open for operating far from equilibrium.

We now have two different states for human groups to be in, an equilibrium state, and a far from equilibrium or dissipative state. They are not symmetrical states; they are very different. The difference between the two is in the energy required to maintain them and the entropy associated with them.

2.4.3 Concepts from thermodynamics: energy, work and entropy

Central to our modern understanding of thermodynamics is the concept of entropy. Entropy can be challenging to define to the non-physicist (Penrose, 2004; Sears & Salinger, 1975), and a number of potentially unhelpful lay explanations further cloud its meaning. It is most commonly applied in the natural sciences of physics and chemistry, but is also a critical consideration in cosmology (Hawking, 1988), climate science and earth systems (Kleidon & Lorenz, 2005; Pauluis, 2005), ecology (Ulanowicz & Zickel, 2005), biogenesis, evolution of the biosphere (Schwartzman & Lineweaver, 2005), and even economics (Rifkin, 2014; Ruth, 2005). As best as we can tell, it has not yet been applied to our understanding of organisational change.

To help understand how entropy works and how it might be applied, consider the analogy of a garden. Left untended over time, the state of the garden will decay – weeds will grow, flowers will be attacked by pests, grass will become unkempt, detritus will accrue, and pots and structures will rust and break down. According to thermodynamics, these are symptoms of the garden slowly increasing in entropy, and there are three things we can learn from it to apply to how we understand change in groups.

Firstly, the second law of thermodynamics uses entropy to ascribe an asymmetry to the universe. The law says that in our universe, entropy in closed systems never decreases over time. As a consequence, the “arrow of time” (past to future) points always in the direction of increasing entropy (see for example Hawking, 1985; Zeh & Page, 1990). This means we can unequivocally tell past from future by watching (for example) an untended garden over time: untended but tidy gardens evolve into unkempt gardens, never the reverse. By extension, group states are not reversible. We saw earlier that humans and human groups do not have the Markov property; they retain histories, and this accumulation of “information” over the course of time is a characteristic of the separation of a group’s “past” from its “future”.

Secondly, in order for an unkempt garden to evolve into a tidy one, “work” is required. In thermodynamics, work has an energy cost. So if we use energy to do work on the garden, we can locally reduce its entropy. There is always an energy cost in reducing local entropy. We can apply this understanding to our saucepan of water analogy from above. The roiling boil is achieved and then maintained by the addition of energy (heat). When we stop adding energy, the heat in the water and saucepan slowly flows into the surrounding environment. From our understanding above, we can now tell that the roiling boil is at a lower entropy state. In general we might say that the movement of some part of a system out of equilibrium with its environment (tidying the garden, heating the water) is equivalent to moving it to a lower entropy state.

Thirdly, and following on from the previous two points, “order” has less entropy than “disorder”. One can immediately see how this might apply to our garden analogy: there are simply fewer microstates associated with the macrostate “tidy garden” and far, far more associated with the macrostate “untidy garden”. In simpler language, there are many more ways for a garden to be untidy than tidy. Hence the untidy garden has more entropy. This is how we connect “order” and “disorder” with entropy. It costs energy to tidy the garden and reduce entropy, and hence it costs energy for order to arise from disorder.

But this thesis is not about gardens and boiling water: can what we’ve learned be applied to more complex biological systems, and ultimately to human teams? Beekman et al. (2001) argue that it can – they observed and described phase transitions between ordered and disordered (or lower and higher entropy) states in foraging Pharoah ants. How might such a concept as entropy be applied to human teams?

What does entropy mean for teams?

To this juncture I have established the following points:

1. There is an inverse relationship between energy and entropy: systems or objects that are in equilibrium with their environment have high (in fact, maximal) entropy, whereas systems that are operating far from equilibrium have lower entropy.
2. Complex systems operate far from equilibrium, and hence have lower entropy.
3. Complex systems, operating far from equilibrium, are dissipative. This means they require energy to be sustained away from equilibrium.
4. Complex dissipative systems can use available energy to reduce their local entropy, that is to self-organise.

As a direct consequence of the above, when a team is in a complex state:

1. It is operating away from equilibrium.
2. It is dissipative.
3. It has lower entropy than when in complicated or equilibrium states.

Points 1 and 2 above are relatively accessible and understandable. When teams are in a complex state they require energy/work to remain there. But what could it mean for a team to have “low” or “high” entropy?

To understand the application of entropy to human domains, I begin by going back to Claude Shannon (1948) and his work on entropy content of information. Shannon’s work showed that entropy might be connected to the uncertainty around given events, and hence inversely correlated with information. This should intuitively make sense, in that entropy is generally popularly correlated with disorder. It is a small leap from there to realise that ordered systems are more information rich (and hence of lower entropy) than disordered ones.

Whilst Shannon’s work has become one of the foundations of information technology, it has also been used as a springboard for taking the concept of entropy into human domains. For example, Ruth (2005) has pushed entropy into discussions on economics, while Hirsh et al. (2012) have used Shannon's entropy as a basis for formulating a "Psychological Entropy", defined as "uncertainty in perception and action" (p. 3), and quantified it in an analogous way to Shannon's original formula. Most useful for the purposes of this thesis is William Lawless' (2017) work on "the physics of teams".

Lawless approaches his subject from a strong physics perspective, beginning with Shannon's (1948) entropy and Wissner-Gross and Freer's (2013) work on causal entropy. He splits the focus of a team's work into (a) work done by a team on itself, managing or fixing or otherwise working on its own structure, and (b) work done in solving problems or addressing issues the team has been formed to address. This split is similar to the distinction made in Wilfred Bion's (1961) "basic assumption group" (a) and "work group" (b) that we will explore in more detail in Section 4.1 below. Lawless next defines a maximum entropy production (MEP) and least entropy production (LEP) possible state for (a) and (b), and then proceeds largely mathematically to derive this interesting equation:

$$S = \lim_{\sigma_{LEP} \to 0} \sigma_{MEP} \to \infty$$

(Lawless, 2017, p. 7, equation 13)

The equation says that the entropy production for a team (S) is composed of two competing factors: the entropy produced (and hence energy consumed) in working on itself (a) and the entropy produced (and hence energy consumed) in working on problems (b). In this case, when the entropy produced (and hence energy consumed) in working on itself (a) tends towards 0 (LEP tends to 0), then the entropy produced (and hence energy consumed) in working on problems (a) is potentially infinite. Lawless' equation 14 shows the opposite state:

$$S = \lim_{\sigma_{MEP} \to 0} \; {}^{\sigma}LEP \to \infty$$

(Lawless, 2017, p7, equation 14)

This time, when entropy production on working on itself is maximised, little entropy production is available for working on the problem at hand.

As an outcome, Lawless suggests that his equation 13 above represents a high-performing team (able to do more productive work), whereas his equation 14 represents “what happens when a team fails, splits apart, or implodes” or even “a couple undergoing divorce” (Lawless, 2017, p. 7). Lawless has built some simplifying assumptions into his maths (for example that energy usage is lossless and can be split into the two broad categories given; also that all work on problems is productive and all internal work is unproductive), but his application of entropy is still insightful.

This provides a workable useful definition of entropy in a team context: a team’s entropy level measures the availability of energy for it to use to do productive work. A low entropy state correlates with high energy consumption (highly dissipative) and hence high entropy production. Furthermore, that energy consumption and entropy production might be split into different tasks and activities, and some of these might be in tension.

2.4.4 Consequences for complex state teams: are they sustainable?

What have we learned so far? Firstly, teams that are in complex states are in relatively low entropy states. Secondly, these team states operate out of – and potentially far from – equilibrium. Thirdly, such team states are dissipative structures (Prigogine, 1978), meaning they require energy and resources to be sustained, just like the roiling boil in the examples above. Fourthly, left unsustained they decay to equilibrium states, like the unkept garden. I will now apply this to switching between complicated and complex team states.

Per Bak's work on critical state dynamics (Bak, 1996; Bak et al., 1989; Paczuski et al., 1996) and the collapsing sandpile model are instructive of how quickly state transitions can happen. To revisit what is meant by complicated and complex states and how teams might switch between them, I start by considering a more constrained human example: traffic flow. Ball (2005) describes three states of traffic based on traffic flow: stable flow (what we would call complicated state), complex or metastable flow, and system collapse into gridlock.

Stable traffic flow is where the flow rate is light. You might meet this type of flow when driving on a six-lane highway late at night with little other traffic around. Now let us increase the density of traffic by adding more cars to our highway. For a while the flow rate (number of cars passing a fixed point per unit time) increases uniformly with density – the system stays in its first stable state. However, at or around some critical point the system changes into a complex state. In this state the behaviour of the traffic system becomes complex, the flow rate could continue to increase with density, or it could suddenly collapse into gridlock. The possibility of sudden collapse leads to the complex state being described as metastable: the system can behave in a non-linear fashion due to its sensitive dependence on the behaviour of individual drivers and the road system. A single driver breaking down, or a dog suddenly darting into traffic could cause a collapse of the system into the third state: gridlock. Richard Solé provides the modelling to show the phase transition from what he calls "fluid" to "congested" states, and then shows that the same transitions happen in internet networks (Solé 2011; Solé & Valverde, 2001). In either case, the human feedback loop (driver in the traffic, computer/phone user in the internet) is a crucial feature in the complexity of the phase transition.
In the traffic example the key distinction between stable complicated state and complex state can be found in the responses of the drivers. In a complicated state,

drivers' behaviour is largely determined by their focus on the road structures (the traffic signals, lanes, corners, inclines, etc). In a complex state the drivers' behaviour is more dependent on their focus on the behaviour of other drivers than on the system structures. In the complex state the emergent behaviour is a function of the links between the agents rather than the agents themselves: it really is the case that "the music's between us".

Is it possible to use the language of state changes to explain what happened in the case described in the Introduction to this thesis? There are a number of indicators we should be able to detect if a system has evolved from a complicated state into a complex state:

1. The interdependence of the agents in the system increases as the focus on agent interactions increases (Hazy et al., 2007; Marion, 2008) – in a human team, team members should increasingly focus on each other's reactions.
2. As a result, the dynamics of the system become non-linear, extremely sensitive to initial conditions and small changes, and complex patterns begin to emerge at the system level (Anderson, 1999; Ball, 2005; Helbing, 2010; Marion, 2008; etc). In human teams this means small, otherwise inconsequential acts or utterances by team members might have unpredictable consequences.
3. The system evolves towards a new order (this new order is called an "attractor"), far from equilibrium, and with characteristics of a dissipative structure (Anderson 1999; Marion 2008; Prigogine & Lefever, 1973). In this context, "dissipative" refers to the system using (and hence requiring) energy to be sustained. In human teams this could result in the team reaching an "in-the-zone" state of increased pace of work and increased productive output (or, per Lawless [2017] above, increasingly energetic floundering!).

4. The system begins to adapt, learn and self-organise (Hazy et al., 2007; Marion, 2008); a team organises itself into new roles or patterns adapting to the circumstances at hand without centralised authoritative direction.

Let us reconsider the narrative in the opening section of this thesis in light of the above. In the narrative we can see all four of these things happened rapidly following the interjection of the CD AU:

1. The focus of team members in the room visibly shifted from the task (dominated by interaction with the whiteboard timeline) to one another; they turned from the whiteboard and began scanning other team members' reactions.
2. Comments by single team members at this point drove the conversation (and the shifting dynamic) rapidly in different directions.
3. The team looked for a new "order" to deal with this new state, increasingly looking to perceived authority figures (me as the facilitator, the CEO, the CD AU) as order attractors. More energy was being used as the "energy level" in the room (focus, attention, discomfort and anxiety) increased.
4. Factions coalesced rapidly around key figures as the team self-organised and took new norming cues for how to respond.

If the team in the introductory narrative underwent a state change, how do we explain what triggered it?

Different problems trigger different responses

Several authors in the field of applying complex adaptive systems thinking to organisations define different classes of problems that leaders might face. As we saw above, Kurtz and Snowden (2003) distinguish between the *complex* problems and the merely *complicated* problems in their Cynefin framework. Complicated challenges are challenges we face for which we have – or could construct – patterns of response. Conversely, a complex challenge is one for which we can't know ahead of time how it will evolve, and hence we can only plan for very short horizons. Snowden (2002) compares restructuring an organisation (complex) with restructuring an aircraft (complicated): as soon as an organisation of people gets the merest sense that a restructure is imminent, it will begin “to mutate and change in unknowable ways; new patterns form in anticipation of the event. On the other hand, if you walk up to an aircraft with a box of tools in your hand, nothing changes” (p. 105) until you start working.

Heifetz and Linsky (2002a, 2002b) use the labels *technical challenge* and *adaptive challenge* in place of *complicated* and *complex* problems respectively. They argue that a different style of leadership (rather than Snowden’s prescriptive process) is required for each type of problem. Uhl-Bien, et al. (2007) take a similar approach, suggesting that an *administrative leader* is required for technical problems and an *adaptive leader* for adaptive challenges. Stacey’s (1996) matrix categorises problems into complicated and complex by the responses of people to uncertainty inherent in the problem.

What these approaches have in common is that they distinguish what we might call *technical* problems from *adaptive* problems. In each case above, the key distinguishing factor between technical and adaptive problems is the level of uncertainty (Heifetz & Linsky, 2002a; Snowden, 2002; Stacey, 1996; Uhl-Bien et al., 2007). Technical problems are ones for which a solution might be planned, for a given current problem state A, one can define an optimal solution state B, and a path from A to B. Adaptive problems are ones for which there might be some ambiguity about the current state A, the future state might be unknowable and the path from A to that future state (let us call it “Not A”) is also uncertain.

In the narrative in the Introduction, the team begins in a complicated state dealing with the challenging but technical problem of planning its strategy. This is treated as a technical problem by the team because there is agreement about how to tackle it: an agreed process and agreement about what would constitute success at the end. The team members had tackled such problems previously. After the interjection of the CD AU, it seemed the problem changed – new information (about the opinions, preferences and perspectives of team members) was rapidly made available to the team. In this case, has the problem become adaptive? Has the combined uncertainty about how to proceed, and uncertainty about what a resolution might look like triggered the team to change into a complex state, with the resulting behavioural characteristic changes?

There is a question here about how the problem changed. How did the interjection of a single opinion change the problem and hence the team state? In my experience, leaders respond in generalised ways to state shifts in their team dynamic. Stacey (2011) suggests this is because they experience the phase change as *discomfort or anxiety*. The uncertainty in complexity could be felt by team members as discomfort. Because humans will generally attempt to reduce discomfort when they can (Abramson et al., 1978), teams might, as a general rule, try to reduce the uncertainty and discomfort by returning the group state to the complicated region of the state map. But before considering what happens next, I will delve a little deeper into what might trigger the discomfort.

2.4.5 Power in complex dynamics

Leadership team dynamics cannot be explored without considering the power dynamics that may exist in the team. As Clegg et al. (2006) wrote, “power is to organization as oxygen is to breathing” (p. 3). Clegg et al.’s book concentrates on the exercise of organisational power, as does Fleming and Spicer’s (2014) review of the organisational power literature, and concepts from each are useful to consider in any complex dynamics.

In their seminal book *Reframing Organizations*, Lee Bolman and Terrence Deal (2017, pp. 192–193) note eight sources of power used in organisations:

i. Positional power or authority
ii. Information or expertise power
iii. Control of rewards
iv. Coercive power ("the ability to constrain, block, interfere or punish")
v. Alliance or network power (sometimes called relationship power)
vi. Access and control of agendas (or access to decision making)
vii. Framing: control of meaning or symbols
viii. Personal power (charisma, energy, stamina, political or verbal skills).

Of these, numbers i and iii (and to an extent vi) are formal power types; that is, power sources with a positional structural component. Formal power sources are accessible only to certain people in a leadership team: each team studied will have a team leader (power source i), in some cases a head of Human Resources or Operations (access to power source iii) and often a team assistant or chief of staff (controls power source vi). The others are informal sources of power, available to various members of the team. It is possible for any person in any of the teams to be studied to attempt to use one or more types of power in order to sway others to their opinion or position during the exercises. How might one account for such power utilisation?

Commenting on Fleming and Spicer (2014), Mowles (2022) extracts three themes from the power literature that can be applied to complex dynamics:

1. Power in organisations is usually exercised informally, despite the focus in the leadership literature on more formal or authoritative power forms.
2. There is a link between power and the management of uncertainty.
3. The ongoing negotiation of the use of informal power adds more uncertainty to individuals' sense of agency.

Let us consider each theme in light of leadership teams.

Informal use of power

One reason why informal power is more common in teams might be found in the way more formal types of power are exercised. As noted above in comments on Bolman and Deal's list (2017), formal power types are usually located in and associated with an individual's position – they are not for anyone to use. This means their exercise in a group is associated with an individual and a deliberate act. Zimbardo (2011) argues that this type of power is more easily exercised in a depersonalised manner; that is, at a distance. In a team setting it is difficult to do that. Any exercise of formal power is going to be right in the team's faces, available for view, when the team is in a complex state and hence paying attention to one another. Stewart Clegg (1993) established a strong link between power usage and conflict, and it may be the intuitive anticipation of potential conflict that constrains the use of formal power in complex team states.

Stacey (2003) and Mowles (2022) argue that complex group settings both constrain and enable the behaviour of participants. I will develop the impact of constraints on the group further in section 3.5 below. Suffice to say here, the group's attention when the team is in a complex state could provide a constraint on the exercise of formal power, something that will be relevant the empirical research.

Power and uncertainty

Mowles (2022) contends that "most literature assumes that organisations abhor uncertainty and power is a way of alleviating it" (p. 52). This establishes the use of power as having a reducing effect on uncertainty. It is possible that we may see some people in teams using information/expertise power, framing power or charismatic power to attempt to reduce uncertainty in the team exercises, and that this power would then be accretive: reducing uncertainty in the group makes some team members happier/more comfortable, which then increases relational/network power. However, this is only half the story. Sometimes, Mowles (2022) argues, increasing uncertainty can be a source of power. Some team members may resist or be dissatisfied with simplification or reduction in uncertainty and so be drawn to those who increase it. Further, Mowles suggests that creation of uncertainty can increase the power associated with uncertainty – for example if one has resource power over a particular resource, then creating uncertainty about that resource increases ones power.

Negotiated power

Arrow et al. (2000) concur that informal power in complex groups is constantly being negotiated, while Stacey (2001) goes a step further to suggest that the power relations are generated and re-created in the process of the group's agents relating to one another.

In fact, Stacey (2001, 2003), Mowles (2022) and authors from the "complex responsive processes" school of complex dynamics would argue that most things in a group are constantly being negotiated, including power, risk, disclosure and "authenticity", standing, relationships to each other and the group, group norms and culture, and even individuals' social identity. Many of these "negotiations" happen informally, at Wilfred Bion's (1961) "basic assumption group" level, where the group is working on its own dynamic even as it discusses other things.

It seems there is at the very least a virtuous circle here, possibly even a feedback loop. The apprehension of uncertainty in a conversation may lead to group members sensemaking or negotiating about how power might be used to manage that uncertainty, which then adds more uncertainty to the dynamic. Secondly, the flux of informal power in the group adds extra dimensions to the agents in the group, making them more complex themselves. For the purposes of this thesis, it seems that the recognition of power within the group will tend to add to its complexity, when group members are paying attention to it.

Returning to the vignette presented in the Introduction, the interjection of the Australian Commercial Director (CD AU) can’t be understood without taking power into some consideration. There is formal power in the CD AU’s title and position, which impacts how others in the group might respond to it/him, particularly those in the room who reported to him. There is the deliberate public negotiation of informal power embedded in the remark – a power grab for the Australian commercial business over the emerging American business. And there is the power negotiation (or challenge) between the CD AU and CEO. Each of these power vectors added to the uncertainty in the group, but, as Arrow et al. (2000), Stacey (2001) and Mowles (2022) would argue, the dynamic shift can’t be understood in terms of power alone.

3. To model or not to model?

The challenge with researching complexity

3.1 Two broad approaches to studying complexity

In order to decide on an approach to conducting research into complexity in teams, I first had to confront a central debate in the literature, aptly phrased by Peter Allen (2010, p. v):

> To model or not to model? That is the question.

The debate

There is an old physicists' joke that goes:

> Q: How does a physicist milk a cow?
>
> A: First let us consider a spherical cow in a vacuum…

The joke recognises that physics models tend to begin life as "a sphere in a vacuum" (Harte, 1988), removing the complicating details from problems so as to find analytical solutions. These solutions can then be modified computationally to describe real-life phenomena more realistically. So it is with the hard science approach to complexity modelling: the models tend to be simplified agents operating in bound spaces (vacua) according to very simple rules. The reason for this is itself "simple": even slightly complicated "agents" or "schema" (the rules agents follow) very quickly overwhelm the model, making the computations exponentially prohibitive (Miller & Page, 2007). To the researcher trained in the hard sciences, this is not a philosophical problem – such simplifications are a standard technique. However, to the researcher trained in qualitative social sciences, the simplifications in the agents, schema and system render the model pointlessly unrealistic. To those preferring the allegorical approach to complexity, the “agent” is a human being, and the “complexity” of that agent is irreducible. Figure 3.1 below illustrates the tension between narrative and scientific approaches to complexity. Richardson (2011, pp. 372–373) labels these two approaches the “Neo Reductionist School” and the “Metaphorical School” respectively. This tension deals with the way in which an understanding of complexity is applied to organisation studies. The scientific approach suggests that the tools of complexity science (agent-based modelling, etc) be applied directly to organisations. The allegorical approach argues that those scientific tools don’t work in human organisations, and instead we should apply understanding of complexity qualitatively to the organisational narratives around leadership, teams, change, and so on. At the heart of this tension is the concept of the “agent”. Recall from section 2.2.2 above that agents were defined as “the individuals that interact with one another in a complex system”.

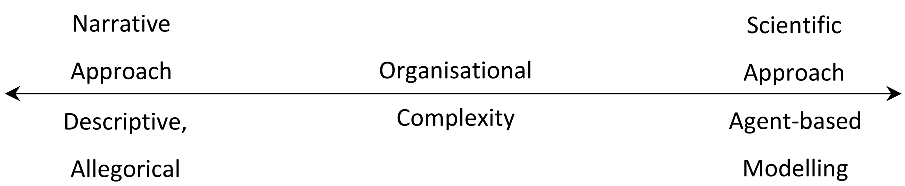

Figure 3.1: Narrative vs scientific application of complexity

In the complexity literature, the agent is a source of debate. Vallacher and Nowak (2008) call the subject of this debate *dynamic minimalism*, the debate over whether the agent in a human system can be simplified in order to make a human system modellable. On the one hand are researchers steeped in the traditions of complex adaptive systems modelling, who attempt to model human dynamical systems with simplified human agents. Examples include Hazy et al. (2007), Helbing (2010), Hollingshad et al. (2013), McKelvey (1997) and Miller & Page (2007). On the other hand, authors including Stacey (2011), Anderson (1999), Cilliers et al. (2002) and

Tsekeris (2015) use a narrative approach to complex human systems that preserves the “complexity” of the human agent and its social context.

It is tempting to see this debate in the same light as the so-called “science wars” described by Flyvbjerg (2002) – the ongoing battle as to whether the social sciences should maintain an empirical and quantitative approach to understanding and describing how people interrelate, or whether to discard this approach as “physics envy” and let other more qualitative ways of understanding human interaction dominate the discourse and research. However, in the case of complexity the two sides aren’t always so readily separated. For some authors in the field, it is difficult to definitively determine which “side” of the debate they are on. Those authors approaching complexity from the metaphorical/narrative approach (see above), including Anderson (1999), Eisenhardt (1989), Morgan (1997) and Nonaka (1988), regularly and readily acknowledge that their analogies are built on the work of the computational modellers and hard scientists. On the other hand, McKelvey’s most cited paper is Uhl-Bien, Marion, McKelvey (2007), with 740 citations, and it fits the metaphorical/narrative approach to complexity that is more consistent with Uhl-Bien’s work on complexity and leadership (see Uhl-Bien & Marion, 2008) than McKelvey’s more usual scientific approach.

3.2 “To model”

One approach to overcoming the predictive challenges with complex systems is to use agent-based models to forecast the system’s behaviour computationally (Miller & Page, 2007). John Conway’s artificial *Game of Life* simulation (Gardner, 1970) was the first serious agent-based model, and can still be “played” online today. Schelling’s (1971) dynamic segregation model and Axelrod’s mass iterative prisoner’s dilemma tournaments of the 1980s are early examples of agent-based models. The success of such simulations was in their ability to generate complex and beautiful emergent behaviour at the system level from extremely simple agent-level behavioural rules (Axelrod, 1997). One consequence of this approach is the philosophical “dumbing down” of the human agents in the system, to the extent that human agents in models can be replaced by simple cellular automata, or even virtual insects (Dorigo & Gambardella, 1997). In this type of system the human agents are absolved of judgement or determination, much like David Chalmers’ (1996) philosophical zombies or *p-zombie*.

However, prediction is not the only reason to model. Epstein (2008, section 1.9) highlights sixteen reasons to model *other than prediction*:

1. To explain or elucidate
2. Guide data collection
3. Illuminate core dynamics
4. Suggest dynamical analogies
5. Discover new questions
6. Promote a scientific habit of mind
7. Bound outcomes to plausible ranges
8. Illuminate core uncertainties
9. Offer crisis options in near real time
10. Demonstrate trade-offs and suggest efficiencies
11. Challenge robustness of prevailing theory through perturbative analysis
12. Expose prevailing wisdom as incompatible with available data
13. Train practitioners
14. Discipline policy debate
15. Educate general public
16. Reveal the apparently simple to be complex (or vice versa)

Many of Epstein’s alternative reasons to model concern learning more about the system. This undermines one key misunderstanding in the critique of agent-based modelling: the assumption that the models are intended to provide complete or final descriptions of the systems to which they are applied. Mathematicians call such final or complete solutions analytical solutions; they are generally formalised equations of state, encoding the state of the system at any time as well as a description of how it will evolve over time. On the other hand, computational solutions are solutions to problems which are arrived at through a succession of approximations in a feedback loop. As an example, consider the equation:

$$x^2 - 16 = 0$$

This equation can be solved analytically by adding 16 to both sides of the equation and taking the square root of both sides:

$$x^2 - 16 = 0$$
$$x^2 = 16$$
$$x = 4$$

We discover the analytical solution that x = 4. To attack the same problem computationally, we first guess what x might be. Suppose we guess $x = 2$:

$$x^2 - 16 \text{ for } x = 2$$
$$2^2 - 16 = -8$$

The result is less than zero, so we now know our original guess was too small. We might guess $x = 6$ next, obtaining a result of 20, which tells us this guess is too high. But now we know x lies between 2 and 6. We might guess next 3, then 5, narrowing in on the correct answer, which is 4. In this case, the computational approach is more unwieldy than the more direct analytical approach, but then our problem is simple and linear. For more complex problems, analytical solutions are harder to find, or indeed may not even exist. For this reason, agent-based models – which model complex situations – have shifted from analytical to computational approaches (Helbing, 2012; Maguire et al., 2006). Computational models are by nature learning models: the test-and-learn approach of modellers suits action in complexity perfectly, which is why Farmer and Foley (2009) have recommended it as a more effective methodology for economics.

3.3 "Not to model"

Helbing (2010) suggests that what works well in the physical sciences doesn't always translate into the social sciences. He can almost match Epstein's list above, cataloguing fifteen challenges that make modelling social systems harder than physical systems:

1. High number of variables
2. Relevant variables may be unknown and/or hard to measure
3. Statistical variation of measurements is considerable and can swamp any relations or laws of social behaviour
4. The time scales on which variables evolve are interdependent, not easily separated
5. Any rules or laws governing interaction or behaviour can change over time, fundamental physical laws are assumed to be constant over time
6. Systems are not reducible: can't be sub-divided into simple non-interacting sub-systems for reductive analysis
7. Non-linear and/or network dependence of variables leads to complex dynamics and structures, obscures cause and effect relationships
8. Interaction effects are strong and so emergent phenomena dominate
9. The observer participates in the system and modifies the reality
10. Information plays a more integrated and interconnected role than in purely physical systems
11. Analysis is complicated by factors such as: heterogeneity of variables, consciousness, decision making, memory and anticipation, intention, interpretation variation, communication and even randomness

12. Human interaction bases such as emotion, creativity, innovation, etc are complicating factors
13. Social systems are influenced by normative (eg moral) factors which can be subjective and variable
14. Frequently realized through a single human history
15. Empirical studies limited by technical, financial and ethical issues (Helbing, 2010, p. 3)

As a result, Helbing – and many other practitioners – say modelling is too inaccurate. Helbing agrees with Richardson (2011) that the field is divided into those who prefer a modelling approach and those who eschew it, preferring a narrative approach instead.

The narrative approach, its proponents argue, preserves the complex concept of "self" for human agents in complex adaptive systems (eg Cilliers et al., 2002; Tsekeris, 2015). This complex self is at odds with the "dumb agents" of models, and it can get very complex. For instance, biologists Maturana and Varela (1980) introduced the concept of *autopoiesis* to explain cognition in complex systems. An autopoietic system is one which generates copies of itself. The archetypal autopoietic system is a living cell, and the cell produces copies of itself through the process of *mitosis* (cell division). Contrast this with a factory or production line which produces goods other than copies of itself: Maturana and Varela call this type of system *allopoietic*. Luhmann (1995) takes their work further, suggesting the autopoiesis of social systems is not physical, but cognitive. Luhmann proposes that social systems engage in the self-production of *meaning*, which meaning is then self-organising in complex systems. Information autopoiesis in complex systems has familiar examples: a traffic "knot" or snarl can persist on a motorway long after the cars involved in the original accident have moved on. In such an example the information in the system (the configuration of the cars) is independent of the individual agents (the cars). Similar emergent patterns can be seen in hive insects and swarming animals. Luhmann argues they also happen in organisational systems where meaning in the system can endure beyond the membership of individual human agents in the group.

Whilst we can model the traffic snarls and the insect swarming behaviour in the paragraph above, the “No-Modelling” school suggests there is a whole different level of complexity once the system agents become human. Mowles (2014, 2016) argues that all human–human interactions are inherently complex and sufficiently so to be beyond what Cillers (1998) might call reducible representation.

This is a genuine conundrum: the interactions of real human agents cannot yet be feasibly modelled, but simplified agents in models can’t convincingly represent humans. The difficulties with the modelling approach are to be expected, sensitivity of output to fine details of the model is a key feature of the non-linear systems that are the trademark of complexity. On the other hand, the complexity of the interaction of real humans makes it very difficult to isolate key causal issues, forcing the allegorical approach to be non-predictive and non-specific.

3.4 A question of scale?

Richardson (2011) is scathing of both sides of the debate outlined above, arguing they are “overly simplistic” (p. 374). He calls the modellers the “Neo Reductionist School”, suggesting they make the false promise of “a neat package of coherent knowledge that can apparently be easily transferred into any context” (p. 374). He labels those who eschew modelling as the “Metaphorical School”, saying they could produce “an incoherent mish mash of unrelated ideas and philosophies” (p. 374). Instead, he suggests a middle ground, a “Critical Pluralist School” which has no further real insights to offer, but chooses critically from the first two schools. My approach in this thesis is certainly pluralistic in that it will borrow from both ends of the complexity spectrum, although it is far less critical than Richardson's positioning!

Returning to the continuum of narrative to modelling presented in Figure 3.1 above, then modifying it with a scale factor, might reveal where a middle ground could exist (Figure 3.2 below).

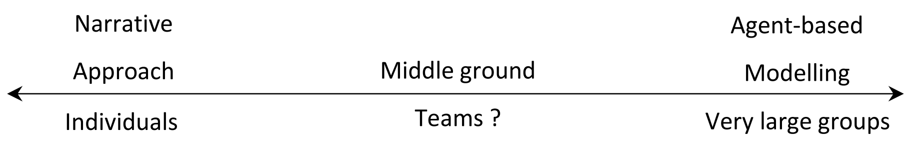

Figure 3.2: The space for a middle ground

Modelling seems to work best, and is most commonly applied, at large group or population level. For example, all the applications of model-based decision making in NECSI's (the New England Complex Systems Institute) handbook on complex decision making are at the level of societies, supply chains, markets and populations (Qudrat-Ullah et al., 2007). Galam's (2012) treatise on Sociophysics operates at the same scale. At this scale, the emergent behaviours at the group level dominate individuals through the sheer number of agents (whether "Bob" or "Barbara" wake up anxious this morning has little bearing on the way the economy will function today – at least for most Bobs and Barbaras). This means dumbing the agents down isn't a problem for the model.

At the other end of the scale, one-to-one human interactions are not modellable. At this scale, individual whims and randomness dominate the emergent behaviour (how Bob and Barbara happened to wake up today absolutely affects how their date goes this evening, despite the matchmaking computer saying they are a good fit). But what about the middle ground?

Leadership teams have characteristics of both ends, and tantalisingly suggest they might be modellable: teams often behave in repeatable ways, and yet can diverge rapidly. Can they be represented, in Cilliers' (1998) terms?

Part of the challenge is that Allen's original question above, "To model or not to model?" (2010, p. v), is not merely a question about practical application or of scale; it has metastasised into a question of epistemology and ontology. Adherents to either end of the narrative-to-modelling scale see the world of complexity differently, make sense of it differently, and apply that sensemaking differently. More than twenty years ago, Anderson (1999) noted that there is no single theory of organisational complexity, and Mowles (2022) finds that is still true today. It is outside the scope (and the capability!) of this thesis to attempt to construct such a unifying theory, but perhaps some progress can indeed be made in moving the two ends a little closer to each other by exploring some of the "grey" between them.

3.5 Moving the Narratives a little towards the middle

Recall that the central challenge of narrative scholars to modellers is that the models are necessarily overly simplified, and hence do account for the full complexity of human behaviour. The assumption here is that human behaviour is of an order of complexity greater than simulated agents, or even social swarming insects or flocking birds.

Humans *are* different to simple agents or swarming insects. Edward O. Wilson, dubbed "Lord of the Ants", explains that ants have distributed intelligence, they lack a super-order driving thinking (Hölldobler and Wilson, 2009). Döring and Chittka (2011) agree, arguing the difference is in human cognition and personality, while Nowak and Highfield (2011) argue that the richness of human communication is what separates us from insects and flocking or swarming animals. However, this doesn't stop us applying some learning from the analysis of such animal systems, which is the thesis of Peter Miller's (2010) book *The Smart Swarm*. Miller makes the application connection at the scale of crowds (the acknowledged scale of the models), as does Surowiecki (2005), but can it apply at smaller scales?

Mowles (2022) argues that modelling is about trade-offs and constraints. All models make assumptions or simplifications about either the agents involved or the system or environment in which they interact. Some of these simplifications will inevitably reduce the model's descriptive or predictive accuracy, but not if the behaviour being modelled is itself constrained. Consider some situations in which human behaviour *is* obviously constrained. We have already met such a situation above – Rob Axelrod's prisoner's dilemma virtual tournaments (Wu & Axelrod, 1995). The prisoner's dilemma is a *game*, and games are classes of human behaviour that are constrained by design. The rules of games constrain behaviour, sometimes heavily, sometimes lightly – there are things you can do and things you can't do in games. In some games the rules dominate players' interactions so that effectively players are playing side by side with little interaction, for example in a sprint race. Such a game is largely linear, there is relatively minimal player-to-player direct interaction. On the other hand, chess is a game in which the human interactions dominate the rules – the game is highly interactive with each move being dominated by the opponent's previous moves and the pattern recognition and capability of the players (Connors et al., 2011). The pattern recognition is important, because it suggests that the behaviour of players is sufficiently constrained so as to be recognisable, and further that playing is itself modellable (Ferilli & Angelastro, 2016).

Games are domains of artificially or deliberately constrained human behaviour, but there are other examples of constrained behaviour that are less deliberately contrived. One example discussed earlier in this chapter was Ball's (2005) traffic flow. When driving in a car, one's behaviour is constrained, and it is, again, these constraints that make the traffic flow (of human behaviour) modellable at any scale.

Finally, to bring this argument into the context of this thesis, Stacey (2003) and Arrow et al. (2000) argue that our behaviour in groups is also constrained. Mowles (2022, p. 21) summarises it in this way:

> We might think of these constraints in the sense that we can't behave in just any way: we are all acculturated, enabled and constrained by rules of politeness, turn-taking and what is socially acceptable for "us".

Mowles adds that power and political relationships within the team dynamic are an additional source of behavioural constraints, these potential sources of political power in the groups were covered above. In summary, what Mowles is describing here is the essence of "conditional behaviour": our interactions in groups contributes to group norms, and these norms then constrain or enable our behaviour. This has the effect of reducing the accessible degrees of freedom of potential human behaviour in leadership teams significantly – but is it reduced sufficiently to be modellable?

3.6 Moving the Modellers a little towards the middle

The challenge of resisting over-simplification is a key one for modellers: in a domain that displays non-linear sensitivity to small details, how do we choose which initial settings to simplify or ignore?

In their book *Complex Adaptive Systems: An Introduction to Computational Models of Social Life*, John Miller and Scott Page (2007) ask the critical question: "How sophisticated must agents be before they are interesting?" (p. 237). They characterised this as an open question in complex agent-based modelling, arguing that "agent sophistication may not even be well defined" (p. 237), Intelligence, or a capacity to display cognition (assess surroundings and make decisions), is, they argue, multi-dimensional, and not easily modelled. They begin to address the question by wondering how smooth the spectrum is from a "dumb" agent to a hyper-sophisticated one, and note that it is not true that complex group behaviour requires high levels of individual sophistication. In fact, as they point out, it is possible even for “dumb” agents to accomplish “smart” things, using the amusing example of the film character Forrest Gump. Despite being possessed of little fluid intelligence, Gump’s “intelligence” is what Döring and Chittka (2011) would describe as highly contextual – he reacts to his local environment, making largely local decisions, which have unpredictable consequences.

Another question raised by Miller and Page (2007) is to what extent does agent heterogeneity matter? This is another argument often made against computer-based models: that the agents are too self-similar, they are insufficiently heterogenous to represent the differences in the people they are supposed to characterise. Again, this is an open question. Miller and Page find that model precision doesn’t necessarily scale linearly with agent heterogeneity.

However, at the scale of this study into leadership team behaviour, it would seem that we would require agents that are sufficiently heterogenous to encode the differing personalities within and amongst various leadership teams. We are also operating at a scale at which individual agent proclivities might suddenly swing the group’s trajectory in unexpected directions. If we are to model, how might we encode each team’s agents with enough sophistication and heterogeneity, particularly if we are not sure how much is “enough”?

Recall the discussion of autopoiesis of group cognition above. Fernández et al. (2014, Abstract) describe this type of autopoiesis of meaning as:

> …self-producing not in terms of [the system’s] physical components, but in terms of its organization, which can be measured in terms of information and complexity. In other words, we can describe autopoietic systems as those producing more of their own complexity than the one produced by their environment.

If a system is capable of self-replicating its complexity, then an extension of Ashby's (1956) law of requisite variety might apply. Requisite variety requires a control system to have at least as much variety (complexity) as the regulated environment. Cilliers (1998, p. 58) extends similar thinking into complex systems: "Models of complex systems will have to be as complex as the systems themselves.". Boisot and McKelvey (2011) recast Ashby's law as a Law of Requisite Complexity, connecting it to a human's ability to make representations or schema of the complexity they find themselves in. Mahmoodi, West and Grigolini (2019) connect requisite variety or complexity with the complexity matching effect, wherein interacting complex systems tend to fine-tune complexities to enhance information exchange.

At this point a sage reminder from Miller and Scott (2007) might be appropriate: a good practice for computational modelling is to "focus on the science, not the computer" (p. 246). Recall in section 3.2 above that I defined the meaning of "computational" as an iterative approach to problem solving rather than "using a computer". In modelling a team's complex behaviour, we should do precisely this: toss the computer aside and get the team to be its own model. In other words, we might suppose that a leadership team's behaviour *is* modellable, but only if the model is of a similar level of complexity as the team itself. It might follow that one possible model of a leadership team is the team itself. If we use a team to simulate itself (for example in a sandbox-style challenge), then all the complexity of the individual team members, their relationship dynamics, the group's history and its power dynamics are *already encoded in our model*, and the sophistication and heterogeneity problems are resolved.

3.7 The middle ground

This will be my approach for this study: using simulated challenges with real teams to get them to model their own complex behaviour, and then interrogate the observed behaviour to see if the phase changes I have theorised above actually appear. Importantly, this will affect the generalisability of the results uncovered, which is a typical objective of agent-based modelling approaches (Elsenbroich & Verhagen, 2016; Galam, 2012; Helbing, 2010). This generalisability is built around the predictive nature of the models, but prediction is not what this thesis is trying to do. Helbing (2012) offers an alternative – insights might be gleaned from models, and then applied in narrative form (which can encode greater contextual nuance) to more general situations. Panovska-Griffiths (2020) makes a similar point in discussing the benefits of computer modelling for public health policy in the Covid-19 pandemic of 2020 – there are insights to be gleaned from the modelling even when its accuracy and hence predictive power are constrained or limited. Mowles (2022) offers an example of this when he extracts narrative learnings from Reynolds' (1987) "Boids" agent-based models (ultra-simplified but beautiful models of bird flocking behaviour) to apply to humans in organisational life.

So this study will take learnings from either end of the complexity "spectrum". It will sit between the population scale of social agent-based models and the individual leader scale of narrative, at the scale of teams. I will use simulation exercises to get each team to be its own model. I will then look for conceptual learnings from the behaviour of the individual teams and the cross comparison between teams, and apply these insights in a narrative fashion back to how leadership teams might respond to complex challenges.

3.8 Positioning the researcher in the research

Having situated this study within the field of complexity, what of the researcher?

Eoyang (2011) positions the study of complexity as *necessarily* both an epistemological and ontological study. Yaneer Bar-Yam (2017) pithily phrases this as "complexity is different". Sentient agents in complex networks are constantly engaged in making representations or schema of their environment to help understand it (Boisot & McKelvey, 2011; Cilliers, 1998; Eoyang, 2011), and because of the contextuality and uncertainty in the systems those schema are necessarily imperfect and/or incomplete (Bar-Yam, 2017). But complex systems are also non-linear, the representations made by any given agent at any point can have an unpredictable effect on how the agent and then the system behaves. Hence I am interested in both how the leadership team system behaves and also what representations are being made of how it behaves; in other words, there is interest in both observed behaviour and sensemaking about that behaviour. The study will be both ontological and epistemological.

There are implications of the sensemaking for the research design. Firstly, it is difficult – Stacey and Griffin (2005) would suggest it is *impossible* – to study complex human systems from the traditional positivist scientific perspective. The researcher can't be wholly objectively separate from the teams being studied (since researcher and research subjects will be co-creating meaning). Inevitably, the researcher will be involved in the research, hence the epistemological positioning of the research is constructivism. Each work group will co-create meaning for the experimental experience with the researcher, and the language used to do so will also be of interest. Thus communication and sensemaking are key elements of the methodology: the dynamic links between the agents in the system are communicative ones (verbal and non-verbal communication), and it is these links that are expected to change as the phase changes; hence they are key to observation.

However, complexity theory suggests that from these co-created experiences we would expect some repeated and repeatable group-level behaviours to *emerge*, this emergence being a feature of complex dynamics. In a sense, then, we should be able to adopt (perhaps paradoxically) a postpositivist ontological stance. That is, we should expect to see patterns emerge in the group behaviour as they transition into complex phases, these patterns being suggestive of an objective reality. In fact, for the sample groups, I will deliberately choose different types of leadership teams in different organisations and different industries such that if consistent behaviour emerges it is not a function of similar sampling. However, this is not positivism. I will label the ontological positioning post-positivism to account for the manner in which complexity authors (see for example Cilliers, 1998; Hazy et al., 2007; Lichtenstein & McKelvey, 2011; Mowles, 2016, 2022; Stacey, 2011; Stacey et al., 2000; Uhl-Bien et al., 2007) adopt a critical perspective with respect to the more traditional discourse on leadership and leadership team dynamics.

The apparent “paradox” of a subjective constructivist epistemology married with a critical/ postpositivist ontology mirrors the wider debate in the field discussed in this chapter. The subjective narrative sensemaking at the scale of the individual from the narrative approach to complexity could be considered subjective constructivism, while the quantitative modelling at the scale of the groups adopted by the quantitative approach to complexity is more akin to positivism or post-positivism. In a sense, this study could be considered a test of the extent to which these two approaches need to be so separate, their adherents so rancorous. By melding elements of either approach into the methodology for this study, I hope to provide something of a middle ground where the two approaches can meet.

3.9 Summary of Chapters 2 and 3

There are three main gaps in the literature this study hopes to address.

Complicated vs complex and the impact of uncertainty

The literature on organisational complexity from the narrative school talks about “complicated” and “complex”, but there is no agreement on what is being discussed. Kurtz and Snowden (2003) and Heifetz and Linsky (2002a, 2002b) apply these broad distinctions to types of challenges or issues leaders face, Uhl-

Bien et al. (2007) apply them to types of leadership, and Stacey (1996) applies them to team states. This creates potential confusion in the reader's mind: are we talking about types of problems here or are we talking about team "states"? In response, I have synthesised these various understandings into a single Uncertainty Landscape incorporating levels and types of uncertainty, which seeks to link team state to problem type. The hypothesis is that the two are interdependent, and this will be tested in the empirical research.

State transitions, energy and entropy

Literature on the integration of thermodynamics concepts into complexity theory further illuminates how and why leadership teams might change states from complicated to complex and back again, what might trigger the transitions, and what the energy costs and entropy consequences might be. This study will further investigate these concepts by focusing on the state changes in the teams under investigation.

Agent-based modelling vs narrative or allegorical approach

There is a significant debate in the field about how to apply complexity concepts to organisational contexts: "To model or not to model? That is the question." (Allen, 2010, p. v). One key discovery is that each operates best at a different scale: modelling works best in large populations where individuals can be simplified without overly affecting behaviour, whereas narrative approaches work at the smallest scale where individual complexity can be appreciated but aggregation of multiple agents is not required. The scale factor leads to a hint as to where a middle ground might be found – at the scale of teams, in the case of this study of leadership teams. The law of requisite complexity points to a way to "model" at this scale without losing the glorious complexity of individual agents: let the team be its own model. This informs how this study will be conducted.

4. Methodology

An approach to researching complex leadership teams

4.1 Research questions

The research study undertaken had two levels of focus, in rough analogy to Wilfred Bion's (1961) "work group" and "basic assumption group". The first level of focus in the research corresponded with the *primary task* of Bion's work group; in this case, it was a study of how complex dynamics show up in leadership teams, and how we might make sense of it when it does. At the second level of the study, inspired by the debate above, the focus was on how the study was being done, in the same way Bion's basic assumption group pays attention to how the group itself is operating.

Building on the summary in section 3.9 above, the questions driving the research were:

Focus level 1:

a) How might leadership teams shift or jump between **complicated** and **complex** states? How are these state shifts related to the challenges or situations the teams are facing?
b) Why do those state shifts occur? What triggers and drivers propel these changes in either direction?

Focus level 2:

c) How might we study complex dynamics at the level of organisational leadership teams? How could elements of both the narrative and modelling approaches to complexity be integrated into a single study?

I aimed to address these questions with a coherent series of quasi-experiments and discussions run across a number of leadership teams.

4.2 Research design

Because I was not starting the study with a blank slate, this was an abductive study. Abductive thinking is used when constructing technical or theoretical descriptions of social life from lay accounts. Having observed “b”, we will see how effective an explanation “a” is for it. (Charmaz, 2006; Josephson & Josephson, 1995). In this case, “b” was the phase shift in the team dynamic and “a” was complexity.

Since emergence is a natural feature of complex networks, understanding, meaning and knowledge will be co-created by the researcher and subject teams through the process of the research – this is in keeping with the approach of grounded theory (Charmaz, 2006; Glaser, 1992). Importantly, however, this was not a strictly Grounded Theory study – pure Grounded Theory is a process of exploration and discovery from a more or less blank slate. In this study I was starting from a reasonably solid grounding in how complex networks work and how we might expect complex groups to behave. Nevertheless, it is important to recognise that findings in earlier groups in this study may well influence how I will work with later groups – at the very least because my own sensemaking was part of the research and will evolve over the course of the study.

In designing this study I adopted a stance of epistemological pluralism (Kellert et al., 2006; Miller et al., 2008), deliberately drawing from different ends of the complexity field with very different ways of understanding and investigating the world. Consequently, I undertook a mixed methods (Lingard et al., 2008) approach to the research. Three “methods” were employed:

1. a series of quasi-experiments with a series of teams;

2. a group debrief discussion with the team that had just undertaken the experiments, these discussions in the style of focus groups (as per Sarantakos, 2005); and
3. a personal reflexive narrative.

4.2.1 Quasi-experiments

Recall from Chapter 3 above that the purpose of this section was to treat each group as a model of itself. By doing this, I encoded all of the details of each participant and the group relationships and history into the "model", giving me the most accurate model initial state I could get. Each group was then asked to undertake a series of simulated challenges in an artificial or "sandbox" environment. This meant I was not undertaking an observational or ethnographic study of teams in their own real-time context. Nor was this an action research piece – the objective was not to improve the functioning of the teams (although it is possible they may learn from the experience). The simulation exercises were more like *quasi-experiments*.

Campbell and Riecken (1968), and more recently Cook (2015), distinguish a quasi-experiment from an experiment in two main ways: firstly, unlike a true experiment, a quasi-experiment does not have randomised selection; and secondly, quasi-experiments either don't have the same control groups as true experiments, or don't have control groups at all. In this study, participant selection at the group level was purposive (see section 4.4 below), and there was no control group (although there was cross-group analysis). Thus quasi-experiments were an apt choice for this study.

Reichardt (2009) defines four different archetypal quasi-experimental designs, of which "nonequivalent-group design" (p. 54) is the one that most closely matches my research design. In a nonequivalent-group design, analysis is across participants (in the case of this study, across groups) rather than single longitudinal analysis of participants over some time.

It should be noted that these authors are defining quasi-experimental design in a clinical context, the context in which it is most often applied. In my organisational context, “individual participants” became “leadership teams” as the units selected for analysis, and social experimentation – especially qualitative social experimentation – is a very different beast from clinical experimentation. For instance Sarantakos (2005), in his instructive text on how to conduct social research, argues that experiments within a qualitative research framework are “still in their infancy” (p. 190). He goes further, arguing that in fact:

> Neither the theorists, the methodologists, nor the practitioners have made an effort to demonstrate that qualitative experiments are possible. (p. 190)

In coming to this conclusion, Sarantakos is arguing from a typically positivist understanding of experiments in keeping with a natural sciences tradition (from which they came). He later suggests that should experiments be used in a qualitative study, the researcher should be clear that their intent is not to test a well-defined hypothesis but to help develop or evolve a proposition. This is closer to the abductive approach of this study. Coming from a different perspective, Benini (2000) loosens definitional constraints from experiments completely, proposing that qualitative researchers who use “experiments” necessarily use their own definition of what an “experiment” is.

So what is a quasi-experiment for my purposes in this study, and why do one?

Dooley et al. (2003) suggest that *micro-scale interactions* in complex networks (peer to peer) are best studied with real-time observations rather than asking the group to report on how they worked in the past. This is significant: the greater proportion of research methodologies are built on asking people about things:

surveys, questionnaires, interviews, focus groups, etc. Yet Dooley et al. argue above that this is not an effective study mechanism for complex groups. Since the group's sensemaking is part of the study, I wanted to compare what they think they were doing/had done with what I actually saw them do.

However, I was not looking to undertake an ethnographic study – observing and recording the groups in their real organisational life. Instead, the experimental exercises were simulations – sandbox challenges the group tackled in a closed environment. Arrow et al. (2000) argue that when working with complex groups, "experimental simulations overcome some of the difficulties posed by both field study and laboratory experiment[s]" (p. 269). In an experimental simulation, the researcher creates the context and system they want to study. In this thesis, I wanted to study leadership teams undergoing phase shifts, so those were the conditions I deliberately attempted to create. In doing this, I was squarely locating the study in the middle ground between single narrative and population modelling described in the literature review above.

4.2.2 Focus group debriefs

After each experiment/simulation, I debriefed with the group about what just happened. These group discussions were what Sarantakos (2005, p. 194) calls focus groups, "a loosely constructed discussion with a group of people brought together for the purpose of the study".

This group discussion was semi-structured: it started with the same two questions asking the group to consider the exercise they had just engaged in. The questions were: "How easy or difficult did you find the exercise?" and "Did anyone feel any discomfort in tackling that exercise?" In this way, each group had two similar reflections that I could use for comparative coding in the data analysis. The discussion then proceeded based on how the group responded: this was the unstructured part. The discussions were all focused on the group and researcher engaging in sensemaking together. Combined with the experiment, each team ended up made two representations (Cilliers, 1998) of itself: one in real time during the simulation exercise, and one through guided reflection, sensemaking and self-organised meaning construction (Luhman, 1995) in the focus group.

4.2.3 The researcher's reflection

Most authors writing about methodology for studying complexity (eg Arrow et al., 2000; Byrne & Callaghan, 2013; Cilliers, 1998; Mowles, 2016, 2017; Stacey 2010; Stacey & Griffin, 2005) include the concept of *reflexive narrative* in their work. Ralph Stacey included it as a central assessment item in the complexity oriented *Doctor of Management* program he designed and directed for the University of Hertfordshire (Stacey, 2010). The reflection of the researcher is important because complex systems are very difficult (if impossible) to study from an objective detached perspective, hence the researcher co-creates the outcomes. The narrative structure of the reflection (and the data analysis, see below) is important in complexity because complex systems are not Markov systems (that is, they are not memoryless), therefore histories and trajectories matter. This study was designed with the researcher creating the simulation sandbox for the team, and then co-creating meaning with the team in the focus group.

4.3 Research process in detail

I did the research with a number of (5) leadership teams for validity/reliability and insurance (Kirk & Miller, 1985), in simple, complicated states, and complex states. The choice of senior leadership teams was purposive (Charmaz, 2006; Morse & Richards, 2002; Neumann, 2003) rather than random. Teams selected for the study were senior leadership teams deliberately chosen from different industries

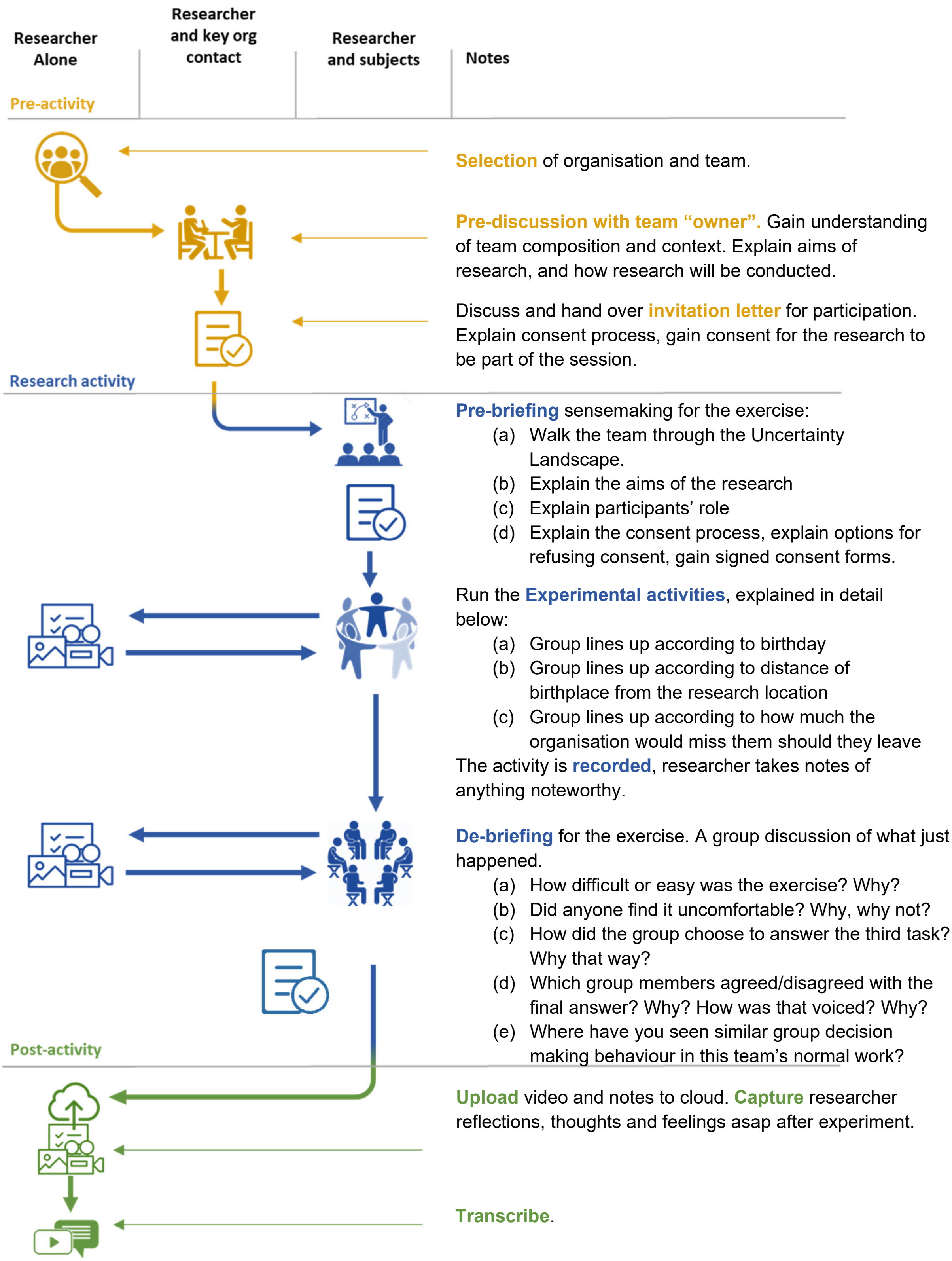

Figure 4.1: Primary Research Process Map

and representing different organisational functions. Figure 4.1 above is a process map showing how the research proceeded.

4.3.1 Quasi-experimental component

In the quasi-experiment, I ran a group process using the team as its own simulation (Arrow et al., 2000). The purpose of the simulation quasi-experiments was to trigger state changes in the various teams and then to observe the state changes and their consequences for individual and group behaviour. To do this, ideally each team would be faced with a complicated challenge (that is, one that can be completed with the team in a complicated state) followed by a complex challenge (one that triggers a team to shift into a complex state). So what would a complicated or complex challenge look like?

Recall from the literature review that some authors have tried to make such distinctions. Heifetz and Linsky (2002a) distinguish their technical (complicated) from adaptive (complex) challenges along the lines of task orientation versus people orientation of the problem at hand. Kurtz and Snowden (2003) and Uhl-Bien et al. (2007) use features of complex systems (such as emergence, adaptation, interdependence) to distinguish between the two. At its heart, the essence of a complex system is conditional instructions; that is, that the behaviour of individual agents or team members is conditional on the behaviour of those around them. So to trigger a shift into a complex state, what we need to do is ensure that participants are *really* paying attention to what their fellow participants are saying or how others are behaving as part of the decision making process about how they behave or contribute.

Uncertainty and anxiety

There is a significant body of literature in the behavioural and psychological sciences fields that connects people's experience of uncertainty with anything from mild discomfort to full anxiety. In 1994, Freeston et al. introduced the "Intolerance of Uncertainty Scale" (IUS), which connects responses to uncertainty to propensity for feelings of discomfort and anxiety. The IUS has since been well tested and validated (see for example Buhr & Dugas, 2002; Carleton et al., 2012). In their study, Chen et al. (2018) sought to investigate the links in the IUS beyond the clinical trait propensity understanding into more generalised contexts, and found uncertainty to be a more general trigger for worry:

> while IU [Intolerance of Uncertainty] is an important cognitive vulnerability factor of anxiety and related symptoms…uncertainty could be regarded as a trigger of worrying thoughts. (Chen et al., 2018, p. 60)

In particular, the finding "when under imminent threat, uncertainty provoked increased worry" from Chen et al. (2018, p. 60) was of use to this study. I was not so much interested in trait-based dispositional tendency to anxiety as I was in triggering states in which people pay more attention to one another, and it seems at this stage that if I could construct challenges with uncertainty in them, that would trigger some worry or anxiety in participants. Would that result in further conditional behaviour?

Hazy and Boyatzis (2015) use the term "emotional contagion" to describe the tendency of emotional states in individuals to spread in agent-based populations. They found this was true of emotional states characterised by either a positive or a negative affect. In either case local emotional contagion created positive or negative "emotional attractors" (PEAs and NEAs), local basins of attraction for either affect state:

> "Individuals in groups experience rapid, localized feedback about the emotional states of others. This influences their own emotional states, which influences the emotions of others, and so on, creating a collective, synchronized emotional state among a subset of individuals within the population." (p806)

Mahmoodi, Grigolini and West (2018) further explained how this “collective synchronized emotional state” might evolve. In their study they looked at how likely it might be that extreme behaviours of “zealots” or “fanatics” might be noticed by agents in heterogenous populations. They found that in populations in complex states “social sensitivity” increased, allowing zealotry or fanaticism to flourish. “Social sensitivity” is a well defined concept in social psychology, being one of three types of social skills in Riggio’s Social Skills Inventory (SSI). Riggio (2014) defines it as the second skill class in the inventory: “skill in decoding or *sensitivity*” (p26). Guastello, Pincus and Gunderson (2006) correlated social sensitivity with “empathy”, finding in their empirical study that “empathy acted as a moderator of the nonlinear process” of social connection in dyads. (p365)

This represents a solid basis for the expectation that the more individuals in a social system pay attention to other local individuals (social sensitivity), the more emotional contagion, or “rapid, localized feedback about the emotional states of others” (Hazy and Boyatzis, 2015: p806) we should expect to see. But in this case I am interested in a particular emotional correlation: the NEA (negative emotional attractor) associated with uncertainty-related anxiety or discomfort.

Hirsh et al. (2012) provide the connection I was looking for in their paper linking uncertainty, information theory, information oriented entropy, self-organising systems and anxiety. In formulating their “entropy model of uncertainty (EMU)”, they propose the following tenets:

(a) Uncertainty poses a critical adaptive challenge for any organism, so individuals are motivated to keep it at a manageable level;
(b) uncertainty emerges as a function of the conflict between competing perceptual and behavioral affordances:
(c) adopting clear goals and belief structures helps to constrain the experience of uncertainty by reducing the spread of competing affordances; and

(d) uncertainty is experienced subjectively as anxiety. (Hirsh et al., 2012, p. 1)

Of these tenets, (b) and (d) were of particular use to this study: that uncertainty is experienced as anxiety (this matches the findings from other authors above), and that uncertainty emerges from conflict of perceptions and behaviours. Put together, this suggests that some things people might do and/or say in a group setting might be perceived as "risky".

According to Stokes et al. (1983), risk-taking in group settings "by definition involves the possibility of loss or harm" (p. 63). At risk are relationships with others in the room (what we might term a social risk) and standing within the group formal or informal power structures (political risk). Stokes, et al. (p. 64) I find that: "Group behaviours that are thought to be risky include self-disclosure, interpersonal feedback, and group confrontation."

Faced with this uncertainty and potential for risk, Hirsh et al. (2012) suggest people will respond by trying to minimise the uncertainty, or at least restrict it to "a manageable level" (point (a) in the quote above). Heifetz and Linsky (2002a, p. 66) add more detail to the avoidance of uncertainty tactics:

> Each one of these thwarting tactics – whether done consciously or not – grows out of people's aversion to organizational disequilibrium…people strive to restore order, maintain what is familiar to them, and protect themselves from the pains of adaptive [complex] change. They want to be comfortable again, and you're in the way.

The exercises

I now had enough to be able to construct the exercises in the quasi-experiment. The exercise that trips the team into a complex state should be one that involves sufficient uncertainty, and the uncertainty should be fundamental (as defined in the literature review above) in order to trigger some discomfort or risk in the group through “self-disclosure, interpersonal feedback, and group confrontation” (Stokes et al., 1983, p. 63). This should be contrasted with exercises that have more reducible uncertainty, and do not trigger disclosure, feedback or confrontation.

To that end, each leadership team was asked to undertake three short challenges as a group. Each challenge was a type of forced ranking in which the team would organise itself. The challenges were organised along the human domains on the diagonal line in the Uncertainty Landscape. Exercises 1 and 2 involved challenges with reducible uncertainty, only minimal disclosure, and no real need for feedback or conflict. These first two exercises also framed the group as to how to respond (that is, stand in a line), and formed a baseline for each group to use in the discussion/debrief section.

i) In the simple challenge, I asked the team to line up in order of birth date, from Jan 1 to Dec 31 (no years). This was simple because any one person in the team could execute for the entire team; there were likely no feedback loops. All the information to complete the challenge was known in the team, so there was no uncertainty.
ii) In the complicated challenge, I asked the team to line up according to a metric they each had to calculate involving data not known within the group (eg your latitude of birthplace, distance of their last place of work from this room, etc). The answer was interesting but not practically useful, so again no feedback loops. There was some reducible uncertainty in how to calculate the metric and unknowns in the data inputs.
iii) In the complex challenge, I introduced feedback loops. The team had to rank themselves (and each other) according to the value they add to the organisation. There was uncertainty about how to proceed, how others would react, what the outcome should be.

The third exercise *required* disclosure and public interpersonal feedback in order to complete it, and had some scope for conflict. All of these were likely to be experienced as risky (both socially and politically) for the group members, and so could trigger discomfort and anxiety, and change people’s behaviour. At the minimum, attention in the group should increase as individuals focus more on how others are behaving, and hence switch on the conditional behaviour that is a signature of complex networks.

4.3.2 De-briefing: qualitative discussion component

After the completion of the challenges, I debriefed each team on what they did, why they did it, and how they felt during the challenge, capturing the group discussion. The discussions were reflexive and unstructured (as suggested by De Jager et al., 2003; Mowles, 2016), responding to the group’s actions in the simulated exercises and their understanding of what they did.

4.3.3 Researcher reflection component

I recorded my own reflections on how the exercise proceeded after each simulation and discussion. These reflections included my observations of things people in the various teams said or did throughout their exercises and their debriefs, along with some of my own sensemaking as to why I thought they were saying or doing what they did. I noted when the groups might have surprised me either in the exercises or the debriefs.

4.4 Data collection: recruitment/selection of participants

The scope and setting for this study were determined as a consequence of the literature review above, the gap identified, and the consequent research questions. The study was limited to leadership teams in business organisations within Australia. The limits were arrived at for these reasons:

- *Leadership* was specifically part of the domain of my inquiry, the literature review was specifically chosen for the intersection of complexity theory and its impact on leadership. Not only is this a (relatively) emerging domain of inquiry in the literature, it is also useful and relevant for industry.
- *Leadership teams* was a limiting scope for this study. I was not interested in individuals who lead; rather, I was interested specifically in the dynamics within established teams with a leadership function.
- *Within business organisations*; I chose to limit the study to business leadership teams because of the relevance and applicability of any findings to industry, and the lack of similar studies in this space.
- *Within Australia* was a convenience factor.

Within this setting and scope, I decided that sampling would be purposive (Morse & Richards, 2002) in that I would “choose subjects who, in [my] opinion, are relevant to the project” (Sarantakos, 2005, p. 164). I deliberately chose leadership teams that led different functions within different organisations in different industries. This choice was to facilitate the meeting of two validity criteria set out by Arrow et al. (2000), that the teams be of a similar kind but in different contexts (see section on validity below).

Importantly, selection occurred at the level of the team. When a team leader agreed to participate with their team, individual team members were afforded the opportunity to consent (or not) to participating in the research on an individual basis.

In setting the sample size, I considered Connie Gersick’s (1988) study of team dynamics. A reprint of this paper has since been published in Frost and Stablein’s (1992) text on the conduct of “exemplary research”, a standard in PhD preparatory courses. Gersick originally studied four teams in case study and comparative fashion. Gersick then chose to study a further four teams in a second tranch because:

> The results were rewarding, but since three of the four groups were from the same setting, it seemed important to continue to expand the data base. (1988, p. 12)

Gersick approached her study from a grounded theory perspective (Glaser, 1992; Glaser & Strauss, 1967) and so, as she says:

> In line with Glaser and Strauss's suggestion, I stopped after observing the second set of groups because all the results were highly consistent. (1988, p. 12)

Effectively, Gersick's study consisted of three groups of graduate students working on a group assignment, and five groups in an organisational context working on a group task. In this study, I learnt from Gersick's experience, beginning with disparate teams in different settings, and focusing on real organisational leadership teams rather than students in a learning context. Hence I chose to study five different teams. This sample size also matched the five case studies chosen by Hannah and Eisenhardt (2018) in their study of competition and cooperation in ventures, although the methodology did not match the so-called Eisenhardt Method (Eisenhardt, 2021; Langley & Abdallah, 2011).

4.4.1 Data collection and analysis: data generation

Morse and Richards (2002) describe the process of data generation in qualitative studies as "data making", arguing that terms such as "data collection" cast the qualitative researcher in a more passive role. By contrast, they argue, "making data is not a passive process; rather, it is a cognitive process that requires tremendous investment on the part of the researcher" (p. 89).

This tremendous effort includes concentration, active listening, orchestrating the conversations in real time, observing as well as listening, and actively exploring how the research subjects are interacting with the task, with each other, and with the researcher themself.

Those three levels of interaction – with the task, with each other, and with the researcher – correspond to how data will be generated in the experiment. At the first level, I generated data in the interaction of team members with the task. These data were verbal and physical, and were generated in each task section and in the reflective discussion following each task. Subjects within each team took in the instructions from the researcher and then took action to complete each of the three tasks, talking to each other as they did so, and then reflected together on what they had just done. At the second level, I generated data in the interaction of team members with each other. These data were both physical and verbal too, and were generated in the task section and in the group debrief discussion at the end. The verbal data included discussions of each tasks and reflections in the debrief, the physical in this case was more body language and non-verbal communication. At the third level, I also generated data in the interaction of the team members with the researcher, again physical and verbal as at the other levels. These data became most pronounced during the debrief sections following each task.

Arrow et al. (2000), in discussing data collection in complex groups, distinguish global and local data. Global data in a complex system is system-level behaviour ("the group did this", "the group did that") whilst local data are the micro-scale interactions between team members ("Mary said this", "Tom frowned"). In complexity, both levels of data *may be useful*, or may be not useful, the researcher can't know ahead of time. For this reason, I captured all the verbal and physical data I could (see below), without trying to make sense of it and hence be selective in real time. However, Arrow et al. argue that it is useful to keep in mind some global trajectories for the group to guide the data generation. In this case, I used an increasing task difficulty (simple to complicated to complex) as a trajectory guiding the group's interaction with task, and looking for an increase in local discomfort in attempting the tasks as a global trajectory associated with change of team phase or state. Those two questions – "How difficult did you find the exercise compared to the previous ones?" and "Did anyone feel any discomfort in attempting the task?" – kicked off each debrief discussion, signalling those global trajectories.

4.4.2 Data collection and analysis: data collection

Given the data generation described above, the collection of data was by two means.

The primary data collection was by video/audio recording each team's attempt at all three tasks and engagement in the debrief discussion. Video and audio recording was the most complete means for capturing all the physical and verbal data generated (see above). Secondary data was collected via a video/audio reflection piece in which the researcher reflected on the piece of research just conducted. These captured the researcher's observations and sensemaking, providing a more nuanced counterpoint to the raw data collected through the primary method. These were then used for comparative analysis.

4.4.3 Data collection and analysis: analysis

Structuring the researcher's relationship with data along a historied trajectory is important not only for data generation and capture, but also for data analysis. Since I was interested in the complexity of the leadership team dynamics, time and trajectory were critical for my sensemaking – I wanted to see how the team dynamics evolved in relation to different tasks. Accordingly, I chose *narrative sensemaking* as a key data analysis tool (Arrow et al., 2000; Morse & Richards, 2002). In this case, the data were analysed so as to construct a participatory narrative (Kurtz, 2014) of how dynamics shifted through state changes, in particular looking for the change in the agent interdependence and relational focus described above as a triggering feature of the complex state.

This brings me to my second key analysis tool: the narratives constructed above were then used as the basis for a *comparative case study* at the global level, looking for similarities and differences in the ways the various groups responded to and then made sense of the challenge tasks. It was from this global level analysis that I expected to see the bases for analytic coding to appear. Two codes had already been decided: how the groups and individuals perceived and responded to *difficulty* in the team task; and how individuals identified and communicated their *discomfort* and what the group did with that. Further codes emerged at this point, which were used to further analyse data at the local level (borrowing from the interaction between generative coding and analysis as suggested by Kathy Charmaz [2002]). This triggered a final analysis level, where discoveries made in the comparative case study prompted further local analysis of events or comments of interest.

4.5 Validity and reliability

Lincoln and Guba (1985), amongst others, have argued that the terms “validity” and “reliability” have their roots in the work of quantitative natural scientists, and as such have no place in qualitative research. They suggest “trustworthiness” and “applicability” in place of validity and “consistency” and “dependability” for reliability. Even as they disagree, Morse and Richards (2002, p. 168) note that “Replicating a qualitative study is sometimes impossible and always difficult, because the data are richly within a particular context.”

They remain reasonable questions to ask of a study: is it accurate/credible (valid), and is it consistent (reliable)? I needed to define what they meant for my work with leadership teams in the field of complex dynamics.

4.5.1 Validity

In the traditional natural sciences, and in particular in mathematics, learning proceeds by studying generally applicable rules and then applying them to specific circumstances. For example, by learning and understanding Einstein's field equations for general relativity, I might produce a set of solutions that describe specific instances of black holes, or another set of solutions that describe how the universe will evolve over time. Both of these categories of things (black holes and model universes) are generalisable, and the most generalised description of them is the single group of field equations. As a student, I learn the general rules in the abstract domain and then practise applying them to solve specific problems in the "real" domain. This is typical of a nomothetic approach to knowledge.

In working with complex systems, three things make nomothetic inquiry problematic:

i) the sensitivity of the system to original conditions (see the section on "non-linearity" in the literature review above) makes it hard to start all inquiries from the same position;
ii) the inclusion of randomness/free will in human complex systems as a feature (see the section on "non-determinism" in the literature review above) rather than as something to be systematically removed; and
iii) the fact that complex systems do not have the Markov property (see literature review above), meaning that the histories each agent (individual) in each team brings into the room for the experiment matter.

Arrow et al. (2000) argue that for these reasons the study of complex groups and teams can not be nomothetical, it being impossible to create a series of identical teams with identical initial conditions for a comparative study.

By contrast, complex systems resist simplification. This follows (Cilliers, 1998; Siegenfeld & Bar-Yam, 2019) from the application of Ashby's (1956) *law of* *requisite variety*. By implication, we best learn about complex human systems by studying specific practical examples and seeing if we might glean anything general from them. This is more suggestive of an idiographic study, taking into account the individual experiences of each group and group member to construct an explanatory account of what happens for leadership teams in complex phases.

Idiographic studies can present validity challenges. Tsoukas (1989, p. 555) suggests there is a strong view “within a positivistically inclined social science… [that idiographic] research design has low external validity (i.e., nongeneralisability of findings beyond the case(s) researched)”. However, Tsoukas disagrees with this view, finding instead that:

> comparative idiographic research, concerned with producing explanatory knowledge… is simultaneously active at two levels. First, such researchers seek to redescribe their object of explanation in a theory important way, postulating the existence of generative mechanisms that are potentially responsible for the occurrence of the events under study. These generative mechanisms are examined via abstract research. Second, these researchers look for the contingent ways in which the postulated mechanisms are intertwined, which will generate the flow of experienced events. And such a view is achieved only by concrete empirical research. (1989, p. 559)

To ensure validity for an idiographic study of complex teams, I return to Arrow et al. (2000), who, in their treatise on small groups as complex systems, outline the following steps to guarantee validity:

i) study each group as its own case study;
ii) study a number of groups with some connecting feature, that is of a similar kind;
iii) study a number groups in different contexts with respect to the connecting feature above; and

iv) "map the trajectory of each group over time". (p. 259)

In this study, I met those four steps above:

i) each group studied was explored individually and then comparatively;

ii) all groups were connected in that they were all leadership teams;

iii) the leadership teams under study had different contexts: they led different functions in different organisations in different industries; and

iv) I was specifically interested in how they changed over time as they tackled the three tasks outlined above.

4.5.2 Reliability

In the quantitative tradition, the essence of reliability is the replicability of results. Consider the following definition from Arrow et al. (2000, p. 261):

> A perfectly reliable measure is one that would give the exact same results if used to measure the same property of the same object twice at the same time and with the same measuring instrument (but independently).

This definition is impossible to meet for this study. It is impossible to measure "the same object" twice, the act of running the experiment with a single team once changes that team (their sensemaking changes), and no two teams are precisely alike. So how might I approach reliability for this study?

Morse and Richards (2002) provided a way forward in their discussion of "coding reliability" (p. 175). While acknowledging the challenge presented by the traditional view of reliability (above), they suggest that reliability might be met by ensuring that the coding of the study is the same across the groups under investigation. In this case, "coding" means the order and structure of activities and questions.

In this study, I took the Morse and Richards' view, ensuring that each group studied was introduced to the experiment in the same way, conducted the same three experiments in the same order and with the same instructions, and then began the reflective discussion in the same way with the same key questions.

4.6 Ethical considerations

The study has been approved to be conducted, HREC ETH18-3241. The study was deemed relatively high risk, since it involved experimenting with groups. The following risks were identified and mitigated as described below.

4.6.1 Ethical concerns and mitigation

How will the researcher manage any pre-existing issues that may be present between participants within these teams?

It is possible that pre-existing issues between participants may come up during the experiment. I have two strategies for dealing with this risk:

i) Relying upon researcher experience and expertise. I have been facilitating team discussions for nearly twenty years now in the course of my professional career. Over the course of acquiring that significant experience I have developed a number of tools, tactics and strategies for dealing with conflict in groups when it arises.

ii) This exercise is relatively mild in its capacity to trigger group conflict. However, in the case that something unexpected is triggered in the session, I would use my professional judgement to halt the exercise (if necessary) and debrief the participants in the same way I would when I have experienced conflict in groups in other scenarios.

This project initially involves limited disclosure to participants. How will the researcher manage participant responses?

The limits in initial disclosure are mainly centred on not telling participants that the exercise may involve some professional discomfort, because I do not want to pre-frame for participants that I'm expecting this – it may influence how the participants think they should respond to the task. Instead, I am conscious of the risks that entails, and am covering for those risks through my experience working with groups.

These specific tasks may cause significant discomfort to individual participants (including disclosure of personal information within a group setting). How will the researcher manage this?
These three tasks correspond to simple, complicated and complex group dynamics (respectively). In task 1 and 2 each participant has a primary relationship with the task, not with team-mates. In task 3 the team undergoes a phase change, the primary relationship becomes with other team-mates and behaviour becomes conditional on team-mate behaviour (a signal for complex networks).

In task 1 the personal information disclosed to the group (birthday without year) can be avoided if someone doesn't wish to fully disclose by simply inserting themselves between team members who have disclosed. This wouldn't affect the outcome of the task. In practice, team-mates are most concerned with sharing the year of their birth (and hence their age), which they are instructed not to do.

In task 2 the personal information disclosed to the group (distance of place of birth from this room) can be avoided if someone doesn't wish to fully disclose by approximating the distance, and then simply inserting themselves between team members who have disclosed. Again, this wouldn't affect the outcome of the task. In practice, teams enjoy celebrating the diversity they discover when team-mates are born in different places.

In task 3 the groups tend to use information which is commonly available to the group already (eg tenure in the group, number of direct reports, criticality of function, etc). The discomfort comes from the uncertainty about how to arrive at a metric to use, how to apply that metric to colleagues, and how colleagues might respond to their judgement.

These three tasks were chosen because they are forced ranking tasks, which leadership teams routinely do within the workplace.

The researcher is requested to explain how audio and video will be used during the project, and who will have access to these recordings.
Each series of exercises and the associated debrief will be filmed. They will be stored in a secure cloud location as described in my application. I will be the only person with direct access to the video and audio, and I will make it available to my supervisors.

The researcher is requested to clarify the consent process for individual team members.
The head of the team provides consent for the study to go ahead with that team. Each individual will be asked to provide their written consent to take part in the study. An individual participant will be informed they have the right to refuse to participate, and their decision to not be involved does not affect the rest of the study with that group. Should an individual choose not to participate, they will “sit out” of the exercises and the debrief. Because the study does not take the team’s longitudinal history into the analysis, their choice to sit out doesn’t affect the study of that team.

5. Results and analysis

What was discovered?

5.1 Structure of this chapter: data analysis approach

Data was collected from the following leadership teams:

When	Industry	Team
28/10/19	IT/Telco (top tier multi billion dollar Telco)	Chief Marketing Officer and LT
12/12/19	Construction (top tier multi billion dollar Construction firm)	Chief Financial Officer and LT
20/12/19	Agricultural production firm (Australian arm of large multi-national)	Australian MD and LT
10/03/20	IT/Telco (top tier multi billion dollar Telco)	Head of Content and LT
17/08/20	Travel/Software as a service (SAAS)	Executive LT

* “LT” = “Leadership Team”.

Table 5.1: Data sources: the teams that were investigated

My approach to analysing the data collected from the five groups is illustrated in the process map in Figure 5.1. The data collected in the participant exercises consisted of researcher’s notes on each session (number 1 in the diagram below) and video/audio recording of the exercises and debrief for each group (number 2).

The data were then subjected to a three phase process, each phase indicated by a different colour in the diagram below:

i) data preparation (the blue steps);

ii) analysis of the data for each group on its own (the yellow steps); and

iii) cross-group data analysis or comparative analysis (the red steps).

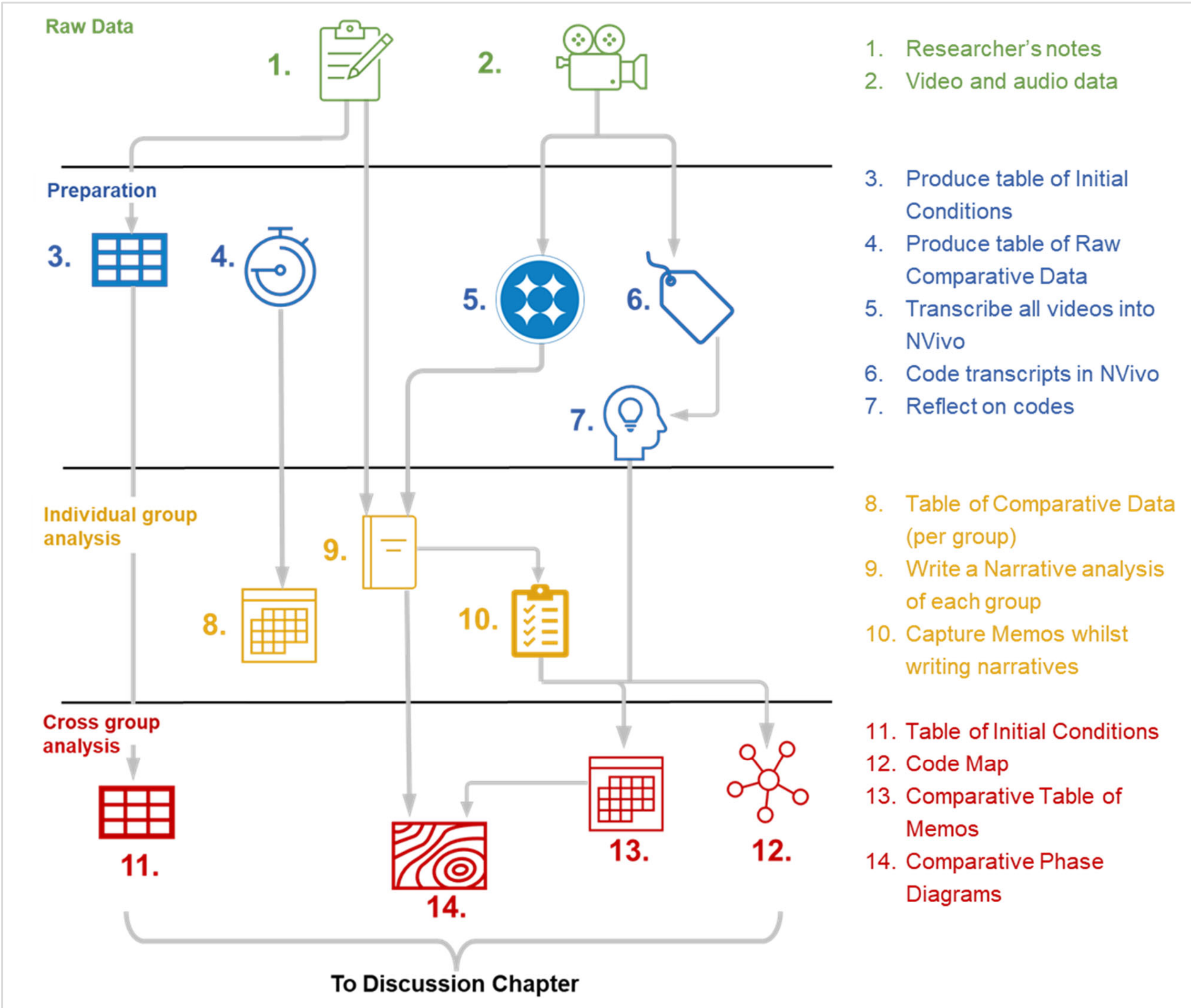

Figure 5.1: Data Analysis Process Map

Each phase and step in the process map is explained in more detail below.

5.1.1 Data preparation phase

Step 3: Table of initial conditions

Recall in Chapter 2 above it was found that in complex systems initial conditions matter. In this step, I pulled together some demographic details about each team in order to see to what extent these factors influence how the team performs. The following data was captured about each team:

Industry:	What industry the business is in. Do teams from one industry perform differently from those in others?
Business size:	Rough business turnover (revenue) and number of employees as two indicators of business size. Is size a factor in the approach or results?
Function:	The functional responsibility of the team (eg sales, technology, human resources, etc). Are some functions more adept than others?
Functional spread:	Functional spread is the span of the group. A narrow functional spread means the people in the team have closely aligned areas of responsibility. Broad means the responsibility areas are very different (eg finance, HR, IT, sales all in one team).
Seniority:	A measure of the number of reporting levels from the most senior executive team (executive team = seniority 1).
Time together:	How long has this group of people been working together?
Participant experience:	Participant experience is how long the individuals in the team have been working in leadership positions in their industry.
Composition:	Number of people identifying as females, males, or other in the team.

The initial conditions also included a short paragraph describing the context in which the group entered the room ready for the exercises, for example what else was happening on that day for that team, what they were expecting from the exercises, and if there were any influences on the group dynamic I may need to take into account.

Step 4: Table of raw comparative data

This is a table of largely uninterpreted data from each group extracted for the reference in the group narratives, for comparison between the various exercises for each group, and for comparison across the groups. Data extracted included:

Time taken:	Time taken to complete (or end) each task.
#Speakers:	Number of people who spoke during the exercise.
Avg. time:	Average speaking time per person.
Interaction:	The extent to which team members interacted with one another.
Discussion focus:	Main topic(s) of any discussion amongst team members.
Complete task:	What (if any) solution(s) the group reached for each of the exercises.
Physical positioning:	How the team members physically distributed themselves around the room during the exercises.
Eye contact:	Where participants were looking during the exercise.
Debate:	The level of debate in the team discussions, and the focus of any debate.
Difficulty:	How team members rated the relative difficulty of each exercise.
Discomfort:	The level of discomfort team members reported experiencing during the various exercises.

Of these data points, the last two (difficulty and discomfort) were planned ahead of the exercises based on the link between uncertainty and anxiety fleshed out in the methodology chapter above. The researcher deliberately asked each group to rate the difficulty of each exercise, and also to comment on whether or not any discomfort was felt during the exercise. The remaining ten headers emerged as potential points of interest during the conducting and reviewing of each exercise. This data was compiled into a single large table, and then the data relevant to each group was extracted and included in the group narrative.

Step 5: Transcription of video/audio

Each group video was laboriously transcribed into NVivo 12 Pro. Four files were produced for each group corresponding to exercise 1, exercise 2, exercise 3 and the group debrief.

Step 6: Coding of video/audio transcripts

The file was then coded in NVivo following an iterative process. This process is more time consuming, involving coding and recoding the data multiple times, and was used because the majority of the codes were arrived at abductively – only two codes were pre-defined before the coding began (discomfort and difficulty). The iterative process involved the following stages:

i) The first pass of coding involved marking all the text in each document with the subject of that text and any relational data (eg debate or disagreement, agreement, etc).

ii) After all text was coded, the codes were reviewed for similarity or connection. This sensemaking helps the researcher begin to understand what they are seeing and hearing in the transcripts and videos. Similar codes were clustered in NVivo.

iii) A second coding pass was then made with the new code clustering in mind. Some pieces of text attracted additional codes.

iv) A NVivo code map was produced relating the various codes and references.

Step 7: Reflection

The code map produced in the previous section became the subject of this reflection step. Section 3.8 above showed that this study would in a sense be both epistemological and ontological, and that sensemaking was a critical part of the analysis. This pause for reflection helps the researcher prepare for the narrative analysis in the next phase.

5.1.2 Individual group analysis phase

In this phase each group was treated as its own unit of analysis. The bulk of the analysis was a narrative of how the group responded to each task.

Step 8: Table of comparative data

The data from steps 3 and 4 were included at the beginning of each narrative to set the context prior to the group tackling each task.

Step 9: Narrative analysis

This study was interested in the complex interplay between how the group makes sense of the tasks it has been given and how that influences how the group behaves: the study was interested in sensemaking (Dervin, 1992: Klein et al., 2006; Pirolli & Russell, 2011; Weick, 1995).

Structuring the researcher's relationship with data along a historied trajectory is important not only for data generation and capture, but also for data analysis. Since I was interested in the complexity of the leadership team dynamics, time and trajectory was critical for my sensemaking (Arrow et al., 2000) – I wanted to see how the team dynamics evolved in relation to different tasks. Accordingly, I chose *narrative sensemaking* as a key data analysis tool (Morse & Richards, 2002). Stories or narratives are wonderful ways of encoding data: narrative structure naturally embeds causation (A happens before B before C) and salience (important details are included, unimportant details are edited out). In this case, the data were analysed so as to construct a participatory narrative (Kurtz, 2014) of how dynamics shift through state changes, in particular looking for the change in the agent interdependence and relational focus described above as a triggering feature of the complex state.

Each narrative weaves together verbatim excerpts from the transcripts with the researcher’s sensemaking to build an analysis of what happened in each exercise, as well as what meaning the group may have created whilst tackling the exercises.

Step 10: Memo capture

Whilst writing the narratives, potentially interesting ideas, observations or pieces of data were tagged and stored as memos (see Bazeley & Richards, 2000; Charmaz, 2006; Morse & Richards, 2002). The memos are at this stage short paragraphs capturing the essence of the idea or observation and its location in the group narrative(s). These memos were then collated and analysed with the codes in the cross-group analysis phase.

5.1.3 Cross-group analysis phase

In this phase data, observations, codes and memos were compared and contrasted across the various groups.

Step 11: Table of initial conditions

The data table assembled in step 3 above was analysed against the group performance to see to what extent the group performance was conditional upon who the group was.

Step 12 and Step 13: Code Map and comparative table of Memos

In light of all the analysis done so far, I returned to collating the memos and codes ahead of moving into the Discussion chapter. The memos were sorted into sensemaking clusters, and then placed into a final table which shows their relevance to the various groups. The codes were then revisited for a final pass, and clustered into a final map.

Step 14: Comparative dynamic phase diagrams

Phase diagrams are well known in physics and chemistry. To plot a phase diagram, one must first understand how the state of the system under investigation changes as the function of two or more variables. Possibly the most well-known phase diagram is that for water, which most of us met in high school science class. This diagram shows the state of water (solid, liquid or gas) as a function of temperature and pressure.

In this study, I was studying the evolution of various team states over time, hence my systems were *dynamical* systems and so the phase diagrams had to be *dynamical* too.

Such dynamical phase diagrams have been applied to complex systems before (Byrne & Callaghan, 2013; Sole, 2011); effectively, it means that one of my variables will be time. Therefore, I plotted the history or trajectory of each team through the exercises (this is the narrative sensemaking) in a phase diagram. But if “time” is one of the variables in the phase diagram, what will the other variable be?

Recall that each group was asked two standard questions after each exercise: “How difficult was that exercise?” and “Did anyone feel any discomfort doing the exercise?”. The reported difficulty of each exercise and the associated discomfort felt by the group represent a pressure (Arrow et al., 2000; Solé, 2011) against which the group trajectories may be plotted, hence “discomfort” (reported and observed) was the second variable in the phase diagrams.

To map each group’s trajectory through the phase space, I treated the group’s responses to exercises 1 and 2 – noting the relatively low reported discomfort and the way the group responded – as the group’s baseline state (Solé, 2011). This served as the basis for comparison for exercise 3. In this way, I could analyse whether or not a phase transition (Beekman et al., 2001; Prigogine, 2005; Solé, 2011) from a ground or complicated state into an elevated complex state occurred.

If such a transition did occur, it could be matched with the other data described above to create understanding about how it was triggered, how it might be recognised, and what the consequences might be.

5.1.4 Reading the rest of this chapter

The remainder of the chapter is laid out in this way:

Section 5.2	Individual team and narrative analysis for team 1
Section 5.3	Individual team and narrative analysis for team 2
Section 5.4	Individual team and narrative analysis for team 3
Section 5.5	Individual team and narrative analysis for team 4
Section 5.6	Individual team and narrative analysis for team 5
Section 5.7	Cross-group analysis: initial conditions
Section 5.8	Cross-group analysis: code mapping and analysis
Section 5.9	Cross-group analysis: memos and codes analysis
Section 5.10	Cross-group analysis: phase diagrams

5.2 Team 1

The following sections analyse data for team 1, the marketing leadership team from a top tier multi billion dollar Telco.

5.2.1 Team 1 – starting conditions

The starting conditions of the team.

Industry	Function	Functional spread	Seniority	Time together	Participant experience	Composition
IT/Telco	Marketing/ Product	Mid	2	2 years	Mid	5F/8M

Table 5.2.1: Team 1 initial conditions

Industry:	IT = Information technology, Telco = Telecommunications (phone and internet network provider)
Functional spread:	Functional spread is the span of the group. A narrow functional spread means the people in the team have closely aligned areas of responsibility. Broad means the responsibility areas are very different (eg finance, HR, IT, sales all in one team).
Seniority:	A measure of the number of reporting levels from the most senior executive team (executive team = seniority 1).
Participant	Participant experience is how long the individuals in the team have been
experience:	working in leadership positions in their industry.
Composition:	Number of females, males, and those identifying as other in the team.

The first team was the Chief Marketing Officer and his leadership team from an Australian Telecommunications Company. This company turns over multiple billions of dollars per financial year and employs thousands of people.

The marketing leadership team is responsible for setting the product, pricing and brand strategy for the business. The team has thirteen members, including the team leader (the Chief Marketing Officer). Five team members are female, the remaining eight are male.

5.2.2 Team 1 – analysis of the team's journey

I begin with a comparison of the three tasks for team 1. The table below compares raw data for how the team tackled each task. The headers are as follows:

- *Time Taken* is the time from the beginning of the exercise (the end of the instructions) to its conclusion (when the team agrees it is done).
- The *Beginning* headers refer to when the team begins to *speak* about the task or *act* on the task (timed from the end of the researcher instructions).
- *Interaction* describes how they physically interact with each other.
- *Discussion Focus* describes what the conversation between team members is about.

Task	Time taken	Speakers #	Avg time	Interaction	Discussion focus
1	0:42	13 (all)	1-2 s	Walked straight into a line. Some local interaction between members, most focus was on where to stand in the line.	Executing task – giving instructions to each other on what to do, checking with each other on what has been done.
2	1:10	13 (all)	2-3 s	Splintered into small groups, then assembled into line. Some interaction between members, most focus was on where to stand in the line.	Executing task – giving instructions to each other on what to do, debating relative distance of some places, checking with each other on what has been done.
3	7:00	9 (only 5 more than once)	~9 s	Stood in a circle to maximise eye contact with each other. No attempt to stand in a line to complete the task.	Significant wide-ranging conversation *about* the task, *without* the instruction oriented interactions of state 1 (how to *complete* the task). Discussions about how to approach the task, how to define task elements and what it might mean.

Observations	Exercises 1 and 2	Exercise 3
Complete the task	Tasks completed to group's satisfaction.	Did not attempt to stand in a line. Some attempts to describe the circle as an answer to the task, no group consensus on this.
Physical positioning	Quickly assembled into lines.	Stood in a circle to maximise eye contact with each other. No attempt to stand in a line to complete the task.
Eye contact	Some local eye contact between members, only when exchanging information. No eye contact with other members not speaking. Significant looking at floor or others' positioning so as to decide where to stand in the line.	Continuous eye contact with other team members. Eye contact both with those speaking (listening) and those not speaking (checking for how others are responding). This second type of eye contact is significant (see below).
Debate	Some debate about technical details of task (eg relative distances in exercise 2).	Significant and continued debate about the relative merits of various criteria and how to make sense of them.

Debrief Reported		
Difficulty	Little to none	Relatively high
Discomfort experienced by team members	None	High

Table 5.2.2: Team 1 task data

5.2.3 Team 1 narrative

This team attempted the three exercises in the morning session of a team offsite gathering. Prior to the start of these exercises, the team leader had offered an engaging and personal vision of where he thought this team could get to, including showing some vulnerability about how much this type of day together meant to him. Consequently, leading into this set of exercises the team members were in an open and up-beat frame of mind as could be evidenced by the smiles, laughter and chit-chat amongst the team.

In the first activity the team was asked to line up in order of their birthday (that is day and month only, not birth date). The team completed this first exercise in 42 seconds. There was very little discussion amongst team members, just announcing of birthdays to each other as they assembled into a line: the average speaking time was less than 2 seconds. Every team member spoke at least once; for most this consisted solely of announcing their own birthday to the room or to people nearby. There was little eye contact between team members, most of the time team members were looking at each other's relative positioning (focused on bodies) or looking at their own position relative to the room. Team members unanimously assessed this task as being *easy*, and no one reported any discomfort in completing the task.

In the second activity the team was asked to line up in order of the distance of their place of birth from this room in which the exercise takes place. The second task took this team one minute and ten seconds (1:10) to solve. This time the group at first splintered into clusters based on the geography of their answer: a "local" Sydney-based cluster, an interstate cluster, an Asia cluster and a Europe/UK cluster. Within each cluster there were brief exchanges for the purposes of ordering within each cluster – again, everybody spoke at least once and the average speak time was about 2 seconds. On reflection, team members agreed that this task was a little more difficult than the first task, but no one experienced any discomfort in completing the exercise.

Next, the team approached the third exercise. In the third activity the team was asked to line up in order of how much the business would miss them should they leave. As I explained the task there were incredulous exclamations and laughter from several team members. As soon as the instructions were finished two (tall, male) team members immediately walked to one end of the room away from the group to claim the “not missed” end of any future line. A third male member followed after them. Other team members looked at each other, nervously muttering. A fourth team member (female) asked the breakaway trio why they had left the group. They explained that they were commandeering the “easily replaced” and so she decided to join them. The remainder of the group began to slowly coalesce into a single group, moving towards the breakaways, who also began to move back towards the main group.

Let us pause to consider the spatial arrangement of the team. The team entered this third exercise standing in a straight line looking at me. The straight line was their solution to the previous exercise. Upon my completing the instructions for this exercise, that line immediately fragmented into small clusters as people began talking to people next to them, and the breakaway trio moved away from the group. At this stage the group was at its most disordered (spatially) and disconnected (small clusters of 2 or 3 people). Within 40 seconds of the exercise starting, the group had coalesced into a single circle, a much more highly ordered spatial arrangement and much more connected (a single conversation happening and all group members listening or contributing). It was interesting that no one suggested that the group organise itself in this way, this structure simply emerged. I discuss the implications of this emergent feature later.

By the 60 second mark, the group was in a sufficient state of discomfort that the team leader “cracked a joke” to reduce the tension in the group. This particular team leader is typically an empathic leader, having demonstrated in his previous interactions with the team his ability to discern how they are feeling along with some concern for them. The comment made was “Chris (researcher), can I just ask you? At the end of this, do you have the envelopes?” This was a reference to an old organisational practice of handing a severance envelope to someone about to be made redundant, and as such is rather a dark joke about the potential implication of this exercise. Despite the joke not being particularly funny, *all* team members laughed at it. This suggests that either:

i) there is some sycophancy in the group – team members are laughing to "please the boss"; or
ii) team members are laughing to relieve tension in the group; or
iii) the author of this thesis is not in possession of a sense of humour – the joke is actually very funny indeed!

It became evident in further interactions in this group that there wasn't much sycophancy in this group at all – participants were willing to speak their minds. This is in fact what Bloch et al. (1983) would describe as humour as tension-reduction. I return to this later as it showed up across multiple groups.

The reduction in tension did not last long, as the next speaker immediately took the group back into an uncomfortable discussion, asking the team, "What if you use that scale [of] who's effective and who's well liked?" The question prompted nervous laughter from the group. The conversation proceeded for another minute or so before this exchange took place:

Female speaker:	[This is] hard, maybe we should just stand in a circle?
Male speaker:	A circle?
Other speakers:	Yeah, a circle.
Male speaker:	Let's just do a big circle.

This is an interesting solution to the third exercise that emerged spontaneously in the majority of the groups, and has emerged in the vast majority of similar groups conducted by the author outside of this study. The "let's stand in a circle" is a solution to the exercise wherein all team members are nominally "equal". There are two possible reasons why this solution might be suggested:

i) Standing in a circle is a valid answer to the question as posed: all team members will be missed by the organisation to precisely the same degree; or

ii) Standing in a circle is a way to complete the exercise without having to engage in the uncomfortable work of judging each other and standing in a line.

Let us be clear – the likelihood of possibility (i) above is vanishingly small. It is *possible* that all 13 people would be equally missed, but extremely unlikely. This leaves us with option (ii) – the circle solution is a way of reducing discomfort. This group suggested the circle solution again at the 3 minute mark, this time preceded by these justifications:

Male speaker: I think not one of us should leave because we all form the picture, the jigsaw. I think jigsaw won't be complete without it. We are here for that reason. So I don't think we can place values on one another. So I think it's either complete or not.

Female speaker: Mm-hmm, yeah, I agree with that.

Male speaker: Yeah.

Male speaker: So does that mean we are in a circle?

Other speakers: Yeah back to the circle, we're in a circle. [laughter and crosstalk]

Notice the comment: "So I don't think we can place values on one another." This goes to the heart of the circle solution: not having to judge each other. This was followed by a rationalisation from another team member:

Female speaker: It's like the best example is U2. And they say one of the reasons they're still together is unlike many other bands where the lead singer gets a

	bigger cut or pay, they all agree from the outset we're U2 together and everyone is equal. It doesn't matter who gets more fame or not. Coldplay have done the same thing. And I think that just demonstrates there's not someone more or less valuable that they're not U2 without four of them.

This point became the centre of debate for the group for the rest of this exercise. On one side of the debate were those saying that the group was composed of individuals each with different strengths. For example:

Male speaker:	We all have unique strengths.
Male speaker:	(Recent additions to the team, names deleted) went straight over there. (points to one end of the room) Yeah, based on tenure, but at the end of the day we're here for a reason.
Male speaker:	But then (name deleted) volunteered for the other end of the line which I think is cool.

And then:

Female speaker:	What if though, you were asked to – I'm going to be provocative on purpose – if you were asked to deliver productivity by getting at least a third of this team reduced?
Team leader:	I'd just ask (the researcher) to hand some of you an envelope! [laughter].
Female speaker:	A team this size actually where people bring different skills … actually (name removed)'s superpower is superior leadership skills. That's really important for us as a team. You know, …

	(different person)'s superpower is just how considered and calm he is in moments of crisis… and I think we don't tend to, we don't tend to take that on board enough.

On the other hand, some were trying to justify the proposition that all team members are equal:

Male speaker:	It's interesting though cause there's the other side of it … the possibility that actually in some sense you'd like to think, well maybe it's as a group, we're successful for our organisation.
Team leader:	I think building on that, my personal ambition is to get to a point where our team is so strong and the capabilities are so good and we're so clear on our priorities that actually if I got hit by a bus, actually there's not that much difference

And then…

Female speaker:	I think if I look at things historically, and even just the way we lead, is we lead as individuals, not as a cohesive team. So I find it quite powerful that we're standing in this circle because I don't think our wider teams would see us standing in a circle.

The group stayed in their circle until the end. In the debrief, the group made sense of their result in this way:

Researcher:	Let me ask this question: Did anybody feel any discomfort at all doing that exercise?
Female speaker:	Yeah.
	(several people raise hands)

Researcher:	When was it concentrated? When was the discomfort at its highest?
Many speakers:	At the beginning.
Researcher:	Then what did we do to reduce the discomfort?
Male speaker:	We came together in a circle.
Male speaker:	Came together.
Male speaker:	Stood in a circle.
Researcher:	Let me ask you this question: Did you answer the task, which is line up in order of how much the business would miss you?
Many speakers:	No.
Male speaker:	No, we didn't.

When asked why the group stood in a circle, rather than insisting on forming an ordered line in answer, one team member summarised it this way:

Female speaker:	I was trying to go there and almost depersonalise it and just make it function.
Researcher:	Why were you trying to depersonalise it?
Female speaker:	To not hurt someone.

So the group completed the first two tasks quickly and to mutual consensus, in each case standing in an ordered line. However, they agreed they were unable to complete the third task, instead standing in a circle. Some of the group attempted at the time to justify the circle as a valid solution, but by the time of the group debrief, the majority view was that the circle solution was to avoid the discomfort and anticipated hurt of judging each other publicly.

Importantly, in the debrief some team members mentioned that they were unhappy or uncomfortable with the group's final result:

Female speaker: Me, I'm still slightly uncomfortable [with our circle result] because if we were picking a starting 11 I'd want to know I have the best forwards and the best mids and the best backs (a football metaphor). I immediately went "where's the sharpest team?"

This is important because this opinion was not voiced during the exercise, despite it being shared by four team members. There was no explicit or obvious exertion of power in the exercise to coerce team members into going along with the majority. In fact, it seemed that the refusal to share this unhappiness with the solution was less about trying to conform with the majority opinion, and more about a desire to stay away from pushing the group away from equilibrium. This is evidenced by the group falling into a cyclic pattern during their effort at exercise 3: someone would throw out a controversial opinion or a disagreement, the group would discuss it briefly and then rapidly move towards the appearance of agreement, usually followed by a tension-breaking joke. Then the cycle would repeat. This back-and-forward cycle happened five times during the exercise, and is a group-level behaviour that emerged in some form in all the groups. I return to this theme in more detail in the section comparing and contrasting the teams below.

5.3 Team 2

The following sections analyse data for Team 2, the financial/operations leadership team from a top tier multi billion dollar construction firm.

5.3.1 Team 2 – starting conditions

The starting conditions of the team.

Industry	Function	Functional spread	Seniority	Time together	Participant experience	Composition
Construction	Finance*	Broad	2	<1 yr**	Mid/Long	6F/5M

Table 5.3.1: Team 2 initial conditions

* This team is nominally a Finance team, in that the team leader is the Chief Financial Officer (CFO) of the company; however, it has a number of non-financial departments reporting into it (eg HR, project management office, etc).
** This team has been restructured into its current broad composition within the last year.

The second team was the Chief Financial Officer and his leadership team from an Australian Commercial Property Development company. This company turns over a billion dollars per financial year, has more than $30 billion in commercial assets, and employs more than 1400 people.

The "Financial" leadership team is in reality a hybrid composite team. It is not uncommon for some organisations to place a number of "back office" (not client facing) departments under the reporting stewardship of the CFO, and in this case the team includes a project management office, human resources, finance, communications and payroll. The team has eleven members, including the team leader (the Chief Financial Officer). Six team members are female, the remaining five are male (including the CFO).

5.3.2 Team 2 – analysis of the team's journey

Once again I begin with a comparison of the three tasks for team 2. The table below compares raw data for how the team tackled each task. The headers are as follows:

- *Time Taken* is the time from the beginning of the exercise (the end of the instructions) to its conclusion (when the team agrees it is done).
- The *Beginning* headers refer to when the team begins to *speak* about the task or *act* on the task (timed from the end of the researcher instructions).
- *Interaction* describes how they physically interact with each other.
- *Discussion Focus* describes what the conversation between team members is about.

Task	Time taken	Speakers #	Avg time	Interaction	Discussion focus
1	0:18	13 (all)	~1 s	Walked straight into a line. Some local interaction between members, most focus was on where to stand in the line.	Executing task – giving instructions to each other on what to do, checking with each other on what has been done.
2	1:12	13 (all)	2-3 s	Assembled into line. Two team members left the room to indicate a long distance from the rest of the group. Some interaction between members, most focus was on where to stand in the line.	Executing task – giving instructions to each other on what to do, joking about relative distances.
3	3:03	9 (only 5 more than once)	~10 s	Quickly moved into a circle to maximise eye contact with each other. Moved into a line at the suggestion/direction of the team leader, disagreed with final result.	Significant conversation about the task in the abstract. Some banter to lighten tension in the group. Eventually strong direction from leader.

Observations	Exercises 1 and 2	Exercise 3
Complete the task	Tasks completed to group's satisfaction.	Team stood in a line perpendicular to the ordered direction (we're all equal). On questioning, only 7 of 11 members agreed with this solution.
Physical positioning	Some local eye contact between members, most focus was on where to stand in the line.	Stood in a circle to maximise eye contact with each other. Stood in a line to complete the task.
Eye contact	Some local eye contact between members, only when exchanging information. No eye contact with other members not speaking. Significant looking at floor or others' positioning so as to decide where to stand in the line.	Continuous eye contact with other team members. Eye contact both with those speaking (listening) and those not speaking (checking for how others are responding). This second type of eye contact is significant (see below). Some dropping of eye contact when team leader was being directive.
Debate	Some debate about technical details of task (eg relative distances in exercise 2).	Significant debate cut short by team leader.

Debrief Reported		
Difficulty	Little to none	Relatively high
Discomfort experienced by team members	None	High

Table 5.3.2: Team 2 task data

5.3.3 Team 2 narrative

This team convened a special morning session specifically for the purposes of attempting the three exercises. After the exercises, the team was preparing to head out to a Christmas lunch together. This session represented the first time this team had met to do any work on themselves – all previous meetings for the team were solely to update their leader on and discuss task progress. Due to this lack of reflective time together, and their composite nature, the team operated in silos – each focused largely on their own area. Consequently, team members were in a mixed frame of mind leading into these exercises – nervous and awkward at the unusual nature of the meeting, yet buoyant about the following Christmas lunch together.

As can be seen from the table above, the team completed the first two exercises quickly and efficiently. The first exercise was completed in 18 seconds, and was described by the group as “simple”. The second exercise took slightly longer (1 minute 18 seconds), the extra time taken up with a brief discussion amongst four team members of how accurate the distances needed to be. Apart from this brief discussion, the team moved quickly into line with a minimum of interaction, and certainly no group-wide discussions. This exercise was described as easy by the group, and no team members reported experiencing any discomfort.

In the third activity the team was asked to line up in order of how much the business would miss them should they leave. The first two comments from team members indicate how the team regarded the challenge:

> Male speaker: That’s a real challenge.
> Female speaker: Wow. This is personal.

Interestingly, the group then immediately focused on how they would spatially arrange themselves:

> Male speaker: Well this is easy, I’m obviously down this end…
> Female speaker 1: You can’t be that self-deprecating!

The first male speaker tried to move into a position at the “I would not be missed” end of the line – a common early move in this type of exercise that I return to in the cross-group analysis below. This move was quickly curtailed by the first female speaker, which sent a strong message to the group to not move in that way. This was immediately followed by the following instructions to the group:

> Female speaker 2: I think we need to huddle.
> Female speaker 3: Yeah… huddle. (group moves into a circle)

The team moved into a circular shape even quicker than team 1 did. These early instructions are interesting for two reasons:

(i) Early suggestions to the groups seem to carry disproportionate weight – possibly because people within the group are unsure how to best proceed with the task, and so are looking for norming or instructive signals. I return to this theme in the cross-group analysis below.

(ii) The group has begun deciding how to approach the task by first deciding *where to stand*. This suggests that perhaps organising the physical layout of people in the room is an important component of tackling the task.

With the group standing in a rough circle, they were ready to begin debating and discussing the task, but the next voice into the group was the team leader's. His comment was significant:

Team leader: My gut reaction is that we all stand together, rather than line up. That's my gut reaction, that's what I think we should do, because I don't think you could lose anyone.

This is an early suggestion that the group move into a "solution" that avoids tackling the task. It is significant because it is early, and also because it is the team leader and, as the Chief Financial Officer, a senior figure in the organisation. The group initially attempted to debate the team leader's suggestion:

Female speaker 1: Or you could lose everybody.

Female speaker 2: This is always arguable.

However, a moment later the team leader put his point more forcefully:

Team leader: Yeah, I don't… if we do that, if we line up and do that we, we, we don't believe we are a team. So I don't wanna do it.

Finally, after another minute, the team leader became more directive:

Team leader: I reckon we do a line like that. (makes a gesture in a line perpendicular to the ordering direction)

At this point the team members began to move into a perpendicular line, signifying that they were all equal, in compliance with the team leader's suggestion. This means that this group completed the third exercise in just over three minutes, less than half the time taken by the next fastest group. However, not everyone agreed with the solution. The researcher asked the group to close their eyes and then raise their hands if they agreed with the solution the group reached: of the eleven team members, seven raised their hands.

This is a clear example of a person in a position of authority dominating a group decision making process. The team leader suggested a solution early on, and then reinforced the suggestion twice more. The result was a shortened process, less debate, compliance with the leader's suggestion despite (unvoiced) disagreement. What makes it interesting is the team's leader's reflection in the group debrief:

Team leader: I made a mistake. I spoke first. I shouldn't have spoken first.

Female speaker: But maybe you were being a leader!!

Team leader: No, I spoke out of self-interest because I spent a lot of time getting this team together. [general laughter] But I do believe what I said and I wanted to get it in and none of you are not important. You are all important so… [but] that was probably a mistake.

This unprompted reflection from the team leader shows his recognition that by speaking he directed the group response and process. His decision to speak up was not a rational calculated decision, it was driven by an anxiety about how doing the exercise might impact his team:

Researcher: Do you think so? Was it a mistake?

Team leader:	Well, because you asked us, we were all responsible, but I made it almost my decision by giving you a quick response and we were under a bit of, I felt a bit of pressure. And you're filming, but yeah, I shouldn't have spoken first.

This early commentary from the team leader again affected the group debrief. This time the team leader's reflection, disclosure and vulnerability encouraged other team members to share more of their thoughts about the task. In fact, this team then began to engage in the task discussion and sensemaking that the other groups all did in the actual task (as opposed to the debrief). For example:

Male speaker:	I think we as a team, I think we could have actually put some parameters or rules around it. Agreed those and done the exercise.
Male speaker:	We really have a problem that's complex, we have to solve it. I reckon we could have done.
Female speaker:	I really, reckon we put that in the "can't know".
Female speaker:	You can't know!
Female speaker:	It was about importance. That doesn't mean that we all are unreplaceable. I think it's that everybody is replaceable and it would be important if we all left or important if we all stayed. That anybody's role could be replaceable.
Male speaker:	[It's like] where we have to rank the value that people add to the organisation.
Female speaker:	Performance review time!
Team leader:	And the calibration!

Female speaker: Although you generally don't rank the people while they're in the room with you! [general laughter]

Male speaker: Well, that's the irony is that, and maybe you've explained that each of us in our roles make judgements about allocating capital, resources, KPIs across the business, remuneration, and we have roles where we work through those very allocations and judgements.

Male speaker: But this is a very personal one. This team, I think I made it hard.

These are examples of discussions that took place in the actual exercise for other groups: sensemaking about whether the exercise as posed is solvable, how it relates to other work tasks they undertake, what parameters or rules they could place around the task.

The group was also open about how difficult they thought the task was:

Male speaker: I think to me it was just… a shitty question to ask to be honest. [general laughter]

Researcher: Tell me more about that.

Female speaker: It was more shitty than the [others]. Your [phrasing] made it very personal. It became a who would I personally miss most in this room if they went, from a work and a personal—

Male speaker: No, who would *the business* miss.

Female speaker: You generally don't rank the people while they're in the room with you! [general laughter]

Male speaker: That makes it harder doesn't it?

Researcher: Compare [this exercise] with the previous two; easier or more difficult?

Female speaker: Much more difficult.

Female speaker: I still think it [was] difficult.

Female speaker: It's still personal.

Male speaker: It depends what you're rating.

Male speaker: I think I could give you an order, I don't know if it would be right.

Female speaker: I don't know enough about what all of you do.

Female speaker: But getting alignment in the room is difficult because everyone would have different views on that. That's why it becomes more … complex.

Female speaker: You [the researcher] made it personal but that's how it becomes harder.

Researcher: Ahhh – so it's all my fault? [general laughter]

Notice that the sources of difficulty reported by the team included incomplete information, subjectivity of judgement, the "personal" nature of the judgement, lack of an objective standard against which to measure, and the difficulty in getting consensus across that team.

The group also reported the exercise as making them feel uncomfortable. Clearly, the team leader felt some discomfort in anticipating what the exercise might do to the team. When asked if they felt any discomfort in attempting the exercise, the rest of the team agreed that they did. This prompted one team member to reflect on why their perpendicular line solution might actually have been a reasonable result:

Male speaker: I think what's interesting for me is we have a complex question, but the stakes of not solving it or the motivation to solve it is not significant enough to go

> through the pain as a group of solving it. Like if that was existential to [business name] … we might have gone harder.

This piece of reflection encapsulates precisely why most groups avoid completing the task as posed: the anticipation of the discomfort and effort (the “pain”) associated with completing the task seemingly isn’t justified by the expected return on invested effort. I return to this theme in the cross-group analysis below.

5.4 Team 3

The following sections analyse data for Team 3, the local executive leadership team from a the Australian arm of a large multi-national agricultural production firm.

5.4.1 Team 3 – starting conditions

The starting conditions of the team.

Industry	Function	Functional spread	Seniority	Time together	Participant experience	Composition
Agriculture	Executive*	Broad	1	5+ yrs**	Very Long	3F/7M

Table 5.4.1: Team 3 initial conditions

* This team is the Australia/New Zealand executive leadership team of a global company. The team leader is the country Managing Director, and reports directly to the global CEO. Like any executive team, the functional spread is broad – it spans the entire local organisation.
** The bulk of this team has been together for a long time, but the Managing Director is new – she joined the company and the executive team within the last two years.

The third team was the Australia/New Zealand executive leadership team from a global agricultural sciences business. The company produces chemical, biological and technological products to support primary producers. This company turns over more than five billion dollars per financial year and employs more than 7000 people globally.

The ANZ executive runs the business in Australia and New Zealand. This consists largely of local market sales, marketing, logistics and supply and support functions. Most of the R&D is done from head office. The team has ten members, including the team leader (the Managing Director). Three team members are female (including the MD), the remaining seven are male. The average age of team members is about 50 years.

5.4.2 Team 3 – analysis of the team's journey

Once again I begin with a comparison of the three tasks for team 3. The table below compares raw data for how the team tackled each task. The headers are as follows:

- *Time Taken* is the time from the beginning of the exercise (the end of the instructions) to its conclusion (when the team agrees it is done).
- The *Beginning* headers refer to when the team begins to *speak* about the task or *act* on the task (timed from the end of the researcher instructions).
- *Interaction* describes how they physically interact with each other.
- *Discussion Focus* describes what the conversation between team members is about.

Task	Time taken	Speakers #	Avg time	Interaction	Discussion focus
1	0:17	6	~2 s	Some local interaction between members, only when exchanging information.	Executing task – giving instructions to each other on what to do, checking with each other on what has been done.
2	1:58	10 (all)	2-3 s	Split into local and international groups, then organised within those groups. One person checked in on order.	Executing task – giving instructions to each other on what to do, some debate about scaling the distances in the result. Some joking.
3	6:43	10 (all spoke more than once)	~5 s	Group initially separated commercial and support functions. Placed two most powerful people at the top of the line. When checked, no one thought they had the right solution! Leader suggested that the solution was actually a circle.	Significant wide-ranging conversation about the task, and ways of moving forward on it.

Observations	Exercises 1 and 2	Exercise 3
Complete the task	Tasks completed to group's satisfaction.	Group stood in an order separating commercial and support functions. Placed two most powerful people at the top of the line. When checked, no one thought they had the right solution! Leader suggested that the solution was actually a circle.
Physical positioning	Moved into lines quickly.	Stood in a U-shape to maximise eye contact with each other. Moved into a line separating commercial and support functions at 5:40.
Eye contact	Some local eye contact between members, only when exchanging information. No eye contact with other members not speaking. Significant looking at floor or others' positioning so as to decide where to stand in the line.	Continuous eye contact with other team members. Eye contact both with those speaking (listening) and those not speaking (checking for how others are responding). Leader and sales leader made sparse comments but significantly shaped the group when they did.
Debate	Some debate about technical details of task (eg relative distances in exercise 2).	Significant debate about how to tackle the exercise until they moved into a line.
Debrief Reported		
Difficulty	Little to none	Most people agreed task was harder. One person suggested it couldn't be that hard because they came up with a solution (although no agreement on the solution).
Discomfort experienced by team members	None	High

Table 5.4.2: Team 3 task data

5.4.3 Team 3 narrative

This team tackled the exercises at the start of a team offsite gathering. There were good spirits amongst team members due to having time out of the office together.

There was also scepticism from some team members, a function of the day being organised and “owned” by the relatively new MD who has come from outside the industry. This team – despite the long time together for most team members – has some awkward internal power dynamics. Factors driving the power dynamics include:

i) the matrix structure of an executive team meaning support function leaders “serve two masters”: they report into the local MD and also into a global functional leader;
ii) the local sales leader has a long tenure with the company, has consistently performed very well, and is an alternate power centre somewhat opposed to the new MD; and
iii) the new MD has come into the business from an unrelated industry and is trying to shake things up locally.

The net effect of the above was a reduction in the preparedness of some team members to take risks with disclosure or disagreement. The bulk of team members have either a science/engineering background or an agriculture/ farming background, meaning they have a high focus on practicality and pragmatism.

As detailed in the table above, the team completed the first exercise in roughly the same timeframe as all the other groups (17 seconds) and it was described by the group as easy. The second exercise took slightly longer than other teams (1 minute 58 seconds), the extra time taken up with a review of final placements and relative scaling. This team wanted to make sure they got it right! Exercise 2 was described by the group as being slightly more difficult than the first exercise, and no team members reported experiencing any discomfort. In each of the first two exercises the team moved quickly into line with a minimum of interaction.

In the third activity the team was asked to line up in order of how much the business would miss them should they leave. Interestingly, the first few comments from team members reflected the power dynamic in the room, and crystallised the team's initial conditions (as highlighted two paragraphs above):

Male speaker 6:	I reckon [Head of Sales] is at the front.
Female speaker 1:	Yeah. I think [Head of Sales] should be the first.
Male speaker 4:	Yes – Head of Sales.
Team leader:	Well [Head of Sales] can't sell anything if he doesn't have products and if it doesn't have regulatory…

Immediately you can see some team members playing up to the Head of Sales who is a source of tenure power, referential power and has critical performance credibility in the group. The Head of Sales also entered the exercises from a somewhat sceptical position. In this exchange some team members attempt to push the Head of Sales to the "most important" end of the line, but the team leader steps in to point out that other functions are equally important, and that Sales can't operate without others in the room. The team grabbed this and ran with it:

Male speaker 1:	The question is how much the business would miss us.
Researcher:	Yes. How much would the business miss you?
Male speaker 1:	So the question is very important.
Male speaker 5:	I'd argue one [points to male speaker 3], two [points to female speaker 1], three [points to Head of Sales].
Male speaker 6:	Right – because without the registration we can't sell it, without you [points to female speaker 1] we're stuck.

Notice that male speaker 5 has taken a risk by "demoting" the Head of Sales in a proposed order, which was picked up and agreed to by other team members. From this point on there was no obvious placation of either the Head of Sales or the team leader until the very end.

Instead, the team now began testing alternative criteria against which to evaluate and rank each other:

Male speaker 1: Yeah. I think we need to come up with a common measure of the group. So, yeah, how are we gonna define, um, how the business will miss us. Uh, and then we can kinda rank from there. But if we don’t have that common measure, we can, we can be all through what we can achieve in the task.

Male speaker 6: Wait, hang on. No before sales and supplies, is it, um, are people going to personally miss you in terms of the, the culture. Or is it a functional aspect, and we need to have the business continue?

Here male speaker 1 has focused the group on the core question: how will we evaluate team members? Speaker 6 then posed an intriguing question to the group: are we going to evaluate each other based on our function, or on the more personal measure of how we contribute to the culture? These are two different types of criteria with different consequences for how the group will tackle the task. Imagine a spectrum of criteria running from “personal” (eg how much you are liked as a person) to “impersonal” (eg tenure at the business). The more personal criteria are riskier for the group to embrace, involving personal judgement and its associated social and political risk. On the other hand, impersonal criteria are less risky and so represent an “attractor” for most groups undertaking this task. I return to this topic in more detail in the next section.

So it was with this group. This brief exchange was the last time anything to do with culture would be referenced by the group. Instead, they tested various more impersonal criteria, which have been collated below. Note that the discussion was not as organised as presented below, it bounced all over the place. But topics have been collated for the reader to follow more easily.

- *tenure in the business*:

Male speaker 7:	And I think that, um, like we start at the back, you know, without being disrespectful, the newest people would probably be missed the least.
Male speaker 1:	Huh! Who's that??
Male speaker 7:	So, it's you guys. (pointing) And then maybe you. (laughing)
Multiple voices:	[laughing and crosstalk]
Male speaker 6:	And, uh, and a brand new person like [male speaker 5], well they'd look at the announcement and just move on.
Male speaker 5:	Mm-hmm. (affirmative)

- *relative size of function*:

Male speaker 6:	No. I'd argue you [male speaker 5] should be up with [male speaker 7], because of size.
Male speaker 5:	Nah – it's small…
Male speaker 6:	He [the researcher] didn't say anything about size, representation. So, if you went there—

- *sustainability of function*:

Male speaker 5:	Well my test is: Would [my unit] go on if I was to walk out the door? A bit like [male speaker 7]. [crosstalk]

- *immediacy of impact*:

Male speaker 3:	The business would miss you.
Male speaker 4:	Yeah. From day 1, or day 13?
Male speaker 3:	If you walked out the door now, all of us, who would be missed the most?
Male speaker 5:	I would be last.
Female speaker 2:	No, I will be last.
Male speaker 6:	HR last?

Team leader:	No. I think it's just more about the longer term. So you'd be missed desperately by—
Male speaker 6:	Yeah. But Regulatory you're gonna be up to here in the middle somewhere.
Male speaker 5:	Yeah. And you [male speaker 6] should be up with [Male speaker 7].
Male speaker 2:	So, so, I mean, the, the, there are some tasks that needs to happen today.
Male speaker 7:	Yeah.
Male speaker 2:	Next week and, and the other tasks with more long-term support.

- *relative importance of function*:

Team leader:	It's very complicated. (laughing) Sales and supply has to be the front. [crosstalk] Otherwise, nothing works.
Male speaker 6:	Make it commercial supply and finance.
Female speaker 1:	You don't need finance. Why do you need this? (laughs) Really honestly, you need to prioritise our stakeholders.
Female speaker 2:	What if we separate by functions, you know, commercial, operations, corporate function, yeah.
Male speaker 6:	If we did it by function… and you would put commercial supply products together, …
Male speaker 6:	Mm-hmm. (affirmative)
Female speaker 2:	No. I think it's commercial then, um, the operations side and then the, um, corporate function. Yeah.
Male speaker 7:	But if you wanna talk about [field location], no one will miss me out there. But they might miss [male speaker 4].
Female speaker 1:	Well, but you are the one who is trying to lead them, they will miss you.

Male speaker 7: Yeah. But they—

Male speaker 6: Yeah.

Team leader: Then they will miss you.

Male speaker 6: I agree with [male speaker 2], there are core business functions which have to go on. The support functions – there's gonna be less dependence on the support functions.

Team leader: Yeah.

Male speaker 2: So, [four names] are probably the support functions?

Of the three teams reviewed to this point, this team canvassed and tested the greatest range of potential criteria. Eventually, some team members grew tired of the various attempts, and the group's inability to come to consensus on a decision:

Female speaker 1: How, how much time do we have? Do we have like a week to do this?

Other speakers: [laughing]

Others – notably including the Head of Sales *and* the team leader – began to suggest that the group should all be equal and the "stand in a circle" solution *emerged* into conversation again:

Head of Sales: This is not really, there's not really an order here, it's sort of a circle, you know. I don't think there's any real front and back. I mean, I, I think it's true to say that, um, you know, I've a lot of relationship with customers and, and, uh, and staff and that would be, clearly would be missed, you know, but I can't do it without the rest of you.

Male speaker 6:	But, um, and, and between us, you can't be separate people very much, you know. So I would say you can stand wherever you like.
Team leader:	With [male speaker 7], I think we need each other to, to make things work. We can't have one without the other.
Male speaker 3:	Yeah.
Female speaker 1:	It doesn't, yeah.
Head of Sales:	I still think it's more of a circle than a line.

Note that these suggestions above were scattered throughout the challenge, but not really taken up by the group in a serious way. Instead, they ended standing in a line that approximated the functional importance criteria discussed above, with local customer units at the more important end and support functions at the less important end. At this point I asked the group if they thought they had achieved consensus, which they affirmed. I then asked group members to close their eyes and raise their hands if they thought they agreed with the presented solution. In this more anonymous vote only three of the ten team members raised their hands – there was no real consensus in the answer.

In the debrief the team was asked why they stood in a line with which most did not agree. The following exchange is illuminating:

Team leader:	Uh, for me it's not, uh, you know, I have the belief, like we all, we all need each other.
Researcher:	So why are you lined up like this then?
Female speaker 2:	Yeah!
Female speaker 1:	(laughs)
Team leader:	Well, I think it's a circle.
Male speaker 7:	Doing what we're told. (laughs)

Team leader:	I still think it's… I would, I wasn't in consensus. I still think it's a circle. Yeah.
Researcher:	So you wanted to do "all of us are equal" which is what (Head of Sales) suggested. So you (team leader) wanted that, but were happy to stand here (in a line). You (Head of Sales) suggested it, but happy to stand here (in your place in the line). Other people didn't have their hands up, disagreed with it, but were happy to stand where they are.
Male speaker 5:	Mm-hmm. (affirmative)
Researcher:	What's all that about?
Male speaker 7:	Doing what we're told!
Male speaker 3:	Consensus.
Male speaker 7:	Worried we'd get fired if we break the rules.
Female speaker 2:	Consensus, absolutely. (nods)
Multiple voices:	Consensus, yeah.
Researcher:	Was it consensus, was it?
Female speaker 2:	Following the rules.
Male speaker 3:	Not wanting to rock the boat.
Male speaker 5:	Not according to the show of hands!
Team leader:	It was just good enough.

In this exchange a number of reasons were given along the theme of "trying to fit in with the group", "not rock the boat", conforming to what they thought was a consensus. The result is not unlike that in the management groupthink paradox "the Abilene Paradox" (Harvey, 1974), which I return to in greater detail in the next section. There was one notable exception to the thinking above: male speaker 7 mentioned "doing what we're told" twice and attempting to not get fired once. This is only half spoken in jest – speaker 7 is expressing a small rebellion against the exercise and the leadership of the MD.

Eventually the group agreed that they found the last exercise difficult and uncomfortable to complete. One speaker summed it up thus:

Male speaker 1:	Yeah, and I think, um, you know, the nature of what we were trying to do, it's not precise, like, ranking in birthdays, it… there's, um, a lot of unknowns, and people have got different definitions of what, how to interpret the question. And I think when we've ordered ourselves… I didn't put my hand up, 'cause I, I'm in R&D and I'm a little bit anal, I probably would've changed one or two.

Despite the difficulty and discomfort, the team still prioritised coming up with some sort of solution. When pressed on why they went along with a solution they didn't agree with, they answered:

Male speaker 5:	I think it's the [business name] way: "you need to get it done".
Team leader:	(laughs)
Researcher:	So, coming up with a result is better than…
Male speaker 3:	No result.
Male speaker 5:	No result.
Female speaker 2:	No result.
Team leader:	But it, for me it's, like, do you, do you want to… Where to put the energy, you know. Is it, is this good enough? That, you know, was it worth saying, "Oh, but it really needs to be a circle." For me [I] didn't feel like, like, that needed to happen. This is good enough.

This last comment is instructive. The previous group arrived at a similar point: the difficulty and discomfort involved in pushing the group towards the most ideal solution is not justified by the return in this exercise, so in the end the solution they presented was “good enough”. Again, this is a calculation that happens separately in different team members’ heads, it is not an explicit topic of discussion, and yet it emerges into several heads across different groups and results in sub-optimal solutions. I return to this point in the next section.

5.5 Team 4

The following sections analyse data for Team 4, the content leadership team from a top tier multi billion dollar Telco.

5.5.1 Team 4 – starting conditions

The starting conditions of the team.

Industry	Function	Functional spread	Seniority	Time together	Participant experience	Composition
IT/Telco	Product/ Content	Narrow	3	2 yrs	Mid	1F/10M

Table 5.5.1: Team 4 initial conditions

The fourth team was the digital content/product leadership team from an Australian Telecommunications Company. This company turns over multiple billions of dollars per financial year and employs thousands of people.

This team leads the division that is at the forefront of the wider business' strategy to move into a content delivery space. The team sources content (both canned and live) from around the world, turns it into content products, and then packages and streams it to consumers. The team has eleven members, including the team leader (the Executive Head of Streaming and Content). Ten team members are male (including the team leader) and only one is female; all come from technical backgrounds.

5.5.2 Team 4 – analysis of the team's journey

Once again I begin with a comparison of the three tasks for team 4. The table below compares raw data for how the team tackled each task. The headers are as follows:

- *Time Taken* is the time from the beginning of the exercise (the end of the instructions) to its conclusion (when the team agrees it is done).

- The *Beginning* headers refer to when the team begins to *speak* about the task or *act* on the task (timed from the end of the researcher instructions).
- *Interaction* describes how they physically interact with each other.
- *Discussion Focus* describes what the conversation between team members is about.

Task	Time taken	Speakers #	Avg time	Interaction	Discussion focus
1	0:37	9	~2 s	Some local interaction between members, only when exchanging information. One team member gave global instructions: how the line should be oriented.	Executing task – giving instructions to each other on what to do, checking with each other on what has been done.
2	0:49	11 (all)	2-3 s	As above, slightly more interaction when checking where others were born. Two team members gave global orientation instructions at the start. International and local groups split, then re-formed into line.	As above.
3	6:43	11 (only 6 spoke more than once)	~6 s	Full focus on the discussion. At one point two team members appeared to distance themselves from the discussion.	Significant wide-ranging conversation about the task and how to go about it. Discussed future roles vs current roles, the importance of leaders, and more. Lots of nervous laughter.

Observations	Exercises 1 and 2	Exercise 3
Complete the task	Tasks completed to group's satisfaction.	"We're all equal" solution suggested at 3 minute mark. Eventually the group decided not to complete the exercise.
Physical positioning	All began to move into line. Some local jostling, one person misplaced themself.	The physical positioning in this exercise was incredibly important to the team – it was a topic of discussion. But the team didn't

		change their positioning much at all.
Eye contact	Some local eye contact between members, only when exchanging information. No eye contact with other members not speaking. Significant looking at floor or others' positioning so as to decide where to stand in the line.	Continuous eye contact with other team members. Eye contact both with those speaking (listening) and those not speaking (checking for how others are responding). This team used deliberate broken eye contact as a signal of disagreement.
Debate	Some debate about technical details of task (eg relative distances in exercise 2).	Significant debate about how to tackle the exercise and who should be where. Most people presented arguments as to why they were replaceable. Leader tried to drive the group to a solution and offered solutions which were not acted on. Leader tried to bring others into the conversation.
Debrief Reported		
Difficulty	Little to none	Most people agreed task was harder. One person suggested the hardest part was that there was no obvious return for the risk in the exercise.
Discomfort experienced by team members	None	Nine people agreed they felt some to high discomfort doing the exercise. One person said the risk to relationships in doing the exercise was very high.

Table 5.5.2: Team 4 task data

5.5.3 Team 4 narrative

This team tackled the exercises at the start of a team offsite gathering. This session happened after the initial first wave of Covid-19 lockdowns in Sydney, Australia, and so there were good spirits amongst team members due to having time in a physical location together. There was also some natural scepticism from some team members, given that this is a highly technical team who are generally reluctant to engage in “open group discussions”.

As detailed in the table above, the team completed the first exercise in a longer timeframe than some of the other groups (37 seconds) because the team wanted to check that the order was right. This first exercise was described by the group as easy, and no one reported any discomfort in tackling the task.

The second exercise was completed faster than all other teams (only 49 seconds). The team immediately split into local and overseas-born clusters and then parallel-processed their order. One team member suggested they check the whole order, but this time the group disagreed. Exercise 2 was described by the group as being a bit hard but not much, and again no team members reported experiencing any discomfort.

In the third activity the team was asked to line up in order of how much the business would miss them should they leave. Perhaps primed by the first two exercises, team members almost immediately began moving to what they determined would be the “not missed/not important” end of a line:

> Team leader: Is this end miss you or useless?
>
> Speaker 1: We need to decide that.
>
> *Team members begin heading towards the team leader’s end.*
>
> Speaker 6: What’s with these guys? (points to the movers)
>
> Multiple voices: [laughing]
>
> *Crosstalk, team members shuffle, each trying to move towards “low” end of line. Speakers 1 and 2 stand at other end, watching. Team leader forces way to low end of line.*

This initial movement by team members framed much of the discussion to come. The first significant consequence of the movement was to cement the team leader as being at the bottom end of the line, a place the team leader was happy with:

Team leader forces way to low end of line.

Team leader: (sitting on table at low end of line) Come on guys! I'm looking forward to this, this will be good.

By deliberately placing himself at the bottom of the line, the team leader is trying to role model how he thinks leadership should work. And by sitting on the edge of table, looking at the rest of the team, he is setting himself outside the team for this exercise – perhaps to remove himself from their judgement. However, other members of the team disagreed:

Speakers 7, 8, 9, 10 tell team leader he should be up the other end of the line.

Team leader: I just do the paperwork! I think the person at the top of the tree should be easier to replace.

Speaker 8: I totally disagree.

Team leader: Really??

Speaker 8: Yes.

Speaker 9: [Team leader] will need to be up there sometimes and back here sometimes because "shit we need something", then "leave us alone", then "we need something", then "leave us alone". Everyone's level of importance will change for me. So for me to do this, if I had to sit down and do this, it would be different week to week.

The leader didn't move. Instead, conversation moved to focus on the other end of the line:

Speaker 8:	The funny thing that I noticed is that no one's up that end (high end) of the line, we're shifted this way.
Speaker 1:	Yes! We all moved that way… (points to low end)
Speaker 8:	No one's actually moved straight up the front.
	[brief pause]
Speaker 8:	[Speaker 1], move that way! (laughing and pointing to "high" end of line)
Speaker 1:	I don't want to go up there!
Speaker 3:	Come on, we've got to achieve consensus! (laughing)
Speaker 1:	(moves to top spot in the line) No one else is going to take this spot.
Speaker 8:	[Speaker 1] you can be at the end.
Speaker 1:	But I don't want to be at the end.

Team takes a long pause and looks at each other.

Speaker 1:	(raises hand) [Business name] lived without me for a year. So, I'm just saying.
Speaker 9:	(to speaker 1) Obviously we'd miss you more now though.

Speaker 1's repeated protests about being moved to the top of the line were genuine, and were for the most part ignored. It was only at the end that speaker 9 made an attempt to placate speaker 1. Notice that the objections are not couched as disagreements with the logic of positioning, the criteria chosen, or the application of those criteria – the objections are much more plaintive and subjective: "I don't want to go up there!" This could be because there are in fact no criteria being employed by the group to support any rankings at this stage – the decisions to move yourself and others around are largely personal. The reactions to being moved are clearly personal too.

Speaker 2 is also unhappy with his position at the top of the line, but expresses the dissatisfaction as a more objective disagreement with the ordering in general:

Speaker 2:	(next to speaker 1, near top of the line) It's hard to justify this position.
Researcher:	Is this your answer?
Speaker 1:	I'm not comfortable with this.
Crosstalk, a number of people shake their heads.	
Speaker 2:	I don't think there's any logic here whatsoever.
Multiple voices:	[laughing]
Team leader:	So [speaker 2] how come you're there if you think there's no logic to this?
Speaker 2:	I was the one person who didn't move… a lot. Because I just wanted to see what would happen when everyone moved that way (points to low end).
Speaker 1:	And I didn't get a chance to move down there!

So whilst speaker 1 is unhappy with their positioning in the line, speaker 2 is unhappy with the team's process. But neither makes any effort to change this: speaker 1 remains at the top of the line, and speaker 2 does not engage in any efforts to correct or change the group's process. In fact, speaker 2's response "I just wanted to see what would happen…" has the effect of seating him outside the group and its efforts (placing him in the position of an observer). It might even be that he is mimicking the team leader's behaviour from the start of the exercise. In any case, both speakers 1 and 2 are content to merely complain about the situation rather than engage in improving it.

Soon thereafter the group began exploring ways to go about ranking each other:

Speaker 5:	I reckon it's the way we organised ourselves that's key. The people who keep the business running are up this end (points to high end of line), while all the people who

	are building future capability or future horizons are down there.
Team leader:	On the flipside, though, you might argue that our skill sets (points to low end of the line) are eminently replicable. Whereas the skill sets as you go this way (points to top end) are so situational that to try to replace them the time goes up dramatically.
Speaker 5:	Interesting that [speaker 9] rationalised his position based on tenure of role, so he jumped towards something that was easy, and [speaker 10] just for being a contractor…

This interaction represents an opportunity to generate some interesting and potentially useful discussion amongst group members. Speaker 5 has contributed a useful observation that might point to an implicit criterion operating in the group's ranking. The team leader engages with this suggestion critically and builds on it. Then speaker 5 suggests that perhaps the group took an easy option in ordering in this way. But rather than engage meaningfully with this thrust of argument, the group instead took refuge in making light of the observations made above:

Speaker 9:	I agree! I came here (low end of line) because I'm a programmer and you can pick one up off the street.
Team leader:	Just out on the street? (looks out window)
Speaker 9:	Of course they won't be as good as me! (laughing)
Speaker 1:	That's the next exercise!
Speaker 9:	And [speaker 10] here's a contractor…
Speaker 10:	And I'm a Kiwi!
Multiple voices:	[laughing]
Speaker 9:	But try to suppress that.
Speaker 10:	Like an ugly cousin in the organisation.

The only other effort made by the group to resolve the task was when the team leader offered the “we’re all equal” solution to the group:

Team leader:	So we would all stand in the same vertical line? (makes perpendicular line motion with hand)
Speaker 9:	Yeah, but up there (points to high end)

Despite the apparent agreement, no one in the team moved and the conversation turned away from resolving the exercise. Instead, the group began spontaneously debriefing the task – despite not yet having completed it. The exchange below sums up why the team tackled the task in the way they did, why they were so subjectively concerned, and why in the end they engaged in debriefing the task rather than *doing* it:

Team leader:	(to researcher) Do you want to ask us a question about how uncomfortable this exercise is?
Multiple voices:	[laughing]
Speaker 2:	I don’t think we found it that uncomfortable because I don’t think we really… did it. (laughing)
Speaker 5:	It’s funny, like, because compared to this, right, this is really hard to do, but if you look at the (performance review) system which we have to do every year that’s less hard. I thought compared to that this was real awkward. As a manager you get to kinda rank people for performance and pay…
Speaker 9:	But you’re ranking yourself here so it’s harder.
Speaker 5:	Harder, right. Like [speaker 8] said, it’s more comfortable not to do it.
Researcher:	Are we still doing [the task]? Or is it easier for you… are you debriefing it now?
Speaker 5:	We’re debriefing it.
Researcher:	Right, so we’re done, we’re not going to stand in a line?

Multiple team members shake their heads.

At this point we moved formally into the debrief of the exercise – although arguably that had already begun! When asked, the group agreed that this exercise was much more difficult than the other two. They also unanimously confirmed that the exercise was uncomfortable to complete and began to explore why that might be:

Researcher:	Why? Where does the discomfort come from? Given everything we've talked about so far?
Speaker 8:	Is it because we're ranking ourselves? It would be very easy for someone to stand out the front and say "You're at the front, you're at the back, you go second, you guys swap places, you know…". Whereas we've been asked to do this ourselves.
Researcher:	You're saying it would be easier for someone else [outside the room] to execute this?
Speaker 8:	Mmmm-hmmm. (affirmative)
Researcher:	So if I put one of you behind a one-way mirror, and said "Rank the rest of the team", you could do it?
Speaker 1:	It would be an answer.
Speaker 5:	It would be your perspective.
Multiple voices:	[crosstalk]

Speaker 5 then offered a potential reason why the discomfort they felt resulted in the group not completing the exercise:

Speaker 5:	But the thing I found difficult about that exercise was that I had very little to gain out of that exercise, by standing in the right order. But I potentially would have offended some people who are friends, by belittling what they do or demonstrating my lack of understanding of their value. And therefore I didn't want to take that risk in that exercise because I had nothing to gain by getting us in the right order. I knew that

eventually you were going to give up and then we could go sit back down again!

Multiple voices: [laughing]

Researcher: Comment on that. Comment on what [speaker 5] just said.

Speaker 6: He's talking about value and the different types of value that people might add is… is hard to compare.

Speaker 3: I agree, in a way he's doing a risk analysis.

Researcher: Remember we talked about risk [in social interactions] being social and political? So you say there's risk in doing this exercise. What is there to gain?

Five people shake their heads.

Speaker 6: Not a lot I'd say.

Here is a theme that has emerged in two of the previous groups and emerges again here: the risk analysis of pushing through an uncomfortable discussion for a return that is perceived to be uncertain or low value. In spite of his assertion above, however, speaker 5 did find some value for the group in doing the exercise, making a connection between some of the behaviour exhibited in this exercise and the way the team tackles complex problems at work:

Speaker 5: It's interesting, because one observation I have of our dynamic, of the group, is that there are quite a few complex or hard problems that we do need to solve, but we do have some of those tendencies where we back away from the problem and I think a couple of things have compounded that as a result of the current situation.

A connecting observation like this is useful indeed!

5.6 Team 5

The following sections analyse data for Team 5, the executive leadership team from a travel/software as a service (SAAS) provider.

5.6.1 Team 5 – starting conditions

The starting conditions of the team.

Industry	Function	Functional spread	Seniority	Time together	Participant experience	Composition
Travel SAAS	Executive Team	Broad	1	3 yrs	Mid	2F/5M

Table 5.6.1: Team 5 initial conditions

The fifth team was the executive leadership team from an Australian software as a service (SAAS) startup in the travel industry. The company turns over approximately ten million dollars per financial year and employs about fifty people.

This is the executive team that leads the business. It is composed of the CEO, CFO, and the heads of critical functions (sales, technology, product, people).

5.6.2 Team 5 – analysis of the team's journey

Once again I begin with a comparison of the three tasks for team 5. The table below compares raw data for how the team tackled each task. The headers are as follows:

- *Time Taken* is the time from the beginning of the exercise (the end of the instructions) to its conclusion (when the team agrees it is done).
- The *Beginning* headers refer to when the team begins to *speak* about the task or *act* on the task (timed from the end of the researcher instructions).
- *Interaction* describes how they physically interact with each other.
- *Discussion Focus* describes what the conversation between team members is about.

Task	Time taken	Speakers #	Avg time	Interaction	Discussion focus
1	0:47	7 (all)	~2 s	Some local interaction between members, only when exchanging information.	Executing task – giving instructions to each other on what to do, checking with each other on what has been done.
2	1:19	7 (all)	~2 s	As above, some debate over the order of three team members (all involved).	As above.
3	6:39	7 (all fully contributing)	~2 s	Full focus on the discussion.	Significant wide-ranging conversation about what criteria should be used for judgement, and how to apply those criteria.

Observations	Exercises 1 and 2	Exercise 3
Complete the task	Tasks completed to group's satisfaction.	Eventually reach a solution with consensus.
Physical positioning	Walked into a line. Then re-arranged and spread out to accommodate social distancing.	Stood in a U-shape to maximise eye contact with each other. Shuffled order as they moved into a line and then from time to time as they debated the order.
Eye contact	Some local eye contact between members, only when exchanging information, and then full eye contact when checking the solutions.	Continuous eye contact with other team members. Eye contact both with those speaking (listening) and those not speaking (checking for how others are responding).
Debate	Some debate about how to accommodate social distancing into the lineup, and then about the order of some people. This group checked Google Maps to confirm relative distances in exercise 2.	Significant debate about how to tackle the exercise, including disagreement, debate and influencing each other.

Debrief Reported		
Difficulty	Little to none	All agreed the task was harder than the others.

Discomfort experienced by team members	None	All agreed there was some discomfort. Three people articulated for the group where the discomfort came from. They agreed that in the end there was less discomfort than expected at the start.

Table 5.6.1: Team 5 initial conditions

5.6.3 Team 5 narrative

This team came together specifically to undertake these exercises. They are a tight team who have been together through the growth phase of this business, know each other well, and respect each other's capabilities. At the time this exercise was conducted, the majority of the wider business was working from home due to the Covid-19 outbreak. The exec team was pleased to see each other in person, and planned to share lunch after the morning session. They were in very good spirits.

The team took the longest time to complete the first exercise (49 seconds), largely because there was some initial discussion about how to maintain social distancing whilst completing the exercises. In the end, the first exercise was described by the group as easy, and no one reported any discomfort in tackling the task.

In the second exercise this was the only team to engage in any debate: they briefly debated the order of three team members, and then confirmed the relative distances using Google Maps. Exercise 2 was described by the group as being only a little harder than the first one, and again no team members reported experiencing any discomfort.

Like all other teams, in the third activity the team was asked to line up in order of how much the business would miss them should they leave. Unlike other teams, we will consider this narrative from a reverse perspective, beginning by noting that this was the only team that reached a consensus solution for exercise 3. What did they do that may have helped them achieve this unusual result?

I start by considering the level of discomfort experienced by the team, since this has been a strong theme throughout all the narratives – and a theme I return to in more detail in the next section. It was initially evident that this team anticipated significant discomfort at the prospect of attempting exercise 3:

Researcher:	… you've had enough, you're out of here, right. So imagining that, what I'd like you to do is to line up in order of how much the business would miss you when you're gone.
Male speaker 1:	Uncomfortable now. (laughing)
Male speaker 2:	Uh …
Female speaker 2:	Cor … (laughing).
Researcher:	Now, at one end, "this whole place would fall apart without me". At the other end, "I doubt they'd even notice I was gone". And again, you're responsible for the entire team's lineup, not just where you stand.
Male speaker 2:	Wow.
Researcher:	Good luck, people. Go.
Male speaker 4:	Uh, this is awkward.
Female speaker 2:	It is awkward, isn't it?
Male speaker 4:	Yeah.
Female speaker 2:	How we gonna decide?
Male speaker 1:	Yeah, this is hard because—
Male speaker 3:	Well, what's important to a business, right?

Despite the anticipated discomfort, the team jumped into discussing the task. This would suggest that this is not the first time this team has been faced with uncomfortable conversations, because they didn't let the prospect of discomfort manifest in the avoidance behaviours that emerged in the other teams. Indeed, during the debrief the team reported experiencing less discomfort than anticipated:

Researcher: Okay. Did anybody feel any discomfort at all doing that exercise?

Male speaker 3: Some, sure.

Male speaker 3: Talking about, you know, that a company will have to adapt if people leave… it's the reality situation.

Female speaker 2: I just feel like we've been doing it for two years and so… (laughing)

Female speaker 1: For the first few years in the business they didn't have a me at all. So… (laughs) They can survive without me.

Researcher: Did it feel as comfortable for you at all, male speaker 1?

Male speaker 1: It didn't feel very uncomfortable for me, no.

Researcher: No?

Male speaker 1: I felt like we could talk about it quite openly. Which is good for a management team, that we can do that. You know?

Given that this is a small team that has led a business through its startup phase, perhaps it is not surprising they have had significant experience with uncomfortable conversations. Next, consider the manner of their interactions with each other, as in this example:

Female speaker 1: But, no, no, no—

Male speaker 2: I'm not sure—

Female speaker 1: No we've gotta decide, um—

Male speaker 3: So … it's not—

Female speaker 1: … 'cause there's produ—

Male speaker 3: It's not a function, right?

Female speaker 1: Yeah.

Male speaker 3: It's about the people.

Female speaker 1: It's about the—

Male speaker 3: Is it? Or is it about the function?

Female speaker 1: … person, yeah.

Female speaker 2: Mm.

Female speaker 1: I think it's—

Male speaker 2: I think … the person.

Male speaker 3: So it's about the person. Right? So if you left right now, what happens? Is the business a … how much risk is in—

Female speaker 1: Yeah, 'cause [name] can't close … or he's learning to close deals.

Male speaker 3: Mm.

Female speaker 1: Learning.

Male speaker 1: I think, I think female speaker 2 is pretty important—

Female speaker 2: I'm okay.

Male speaker 1: [laughs]

Female speaker 2: I'm on a wonderful team. (laughing) It's definitely (laughs) …

This is difficult to read and follow! Team members are half completing sentences, completing each other's sentences, engaging in rapid fire building on each other's thoughts, and yet the group sensemaking progresses significantly. You will also notice in the table in section 5.6.2 above that the average talk time for individuals in this exercise was less than 2 seconds! For the other groups, the average talk time was more than triple that as individuals took the time to fully flesh out their own perspective. This rapid fire exchange builds stronger co-dependent links between group members, pushing the group into a more complex state to match the task complexity. I return to this observation in the next section.

A final feature of this group's interaction was that the team leader did not play a strong or separate role, rather just played the same role as other team members. For example:

Female speaker 1: Team leader, you need to be over there!
Male speaker 2: No, I, I, I think—
Female speaker 1: Oh—
Team leader: Well—
Male speaker 2: … I think because we're listed…
Team leader: … people, people put me here, so I just stood here, but I can move…
Male speaker 2: I think because we're listed particularly—
Female speaker 1: Oh, yes.
Male speaker 2: Then that's like a short term—
Female speaker 1: Yes.
Team leader: Yeah, I got key man risk in the relationships with the investors—
Female speaker 1: Yes.
Team leader: Now, if I, if I manage to get out of that, and somebody else was front man, then that would be better. We'd have less succession risk in my position.
Male speaker 3: So we, we've put you there, but do you think you belong there?
Team leader: I, I am here [top of the line]. And I would ideally be there [bottom of the line]. And it's a failure that I'm up here.
Male speaker 3: Okay.
Female speaker 2: Oh, that's fair.

This role was unlike that played by the leaders in the other groups. The leader in the first group tried to not be directive, but found himself in a jester role. Group two's leader was very directive but regretted it later. Group three's leader tried to not be directive but couldn't avoid the power dynamic in the room, while group four's leader deliberately set himself outside the group. This group's leader did not play a directive role, but still made himself available for critical review by other team-mates, which may have had the effect of normalising the "agent values" across the team. I return to what effect the role of the leader might have in the next section.

Put together, these features had two impacts on the team. Firstly, this team canvassed a wide number of potential criteria for ranking each other, including:
Dependable/important

> Male speaker 4: More dependable.
> Team leader: Sorry? This is—
> Male speaker 4: The more dependable here and then—
> Male speaker 2: More dependable here and then—
> Team leader: Dep— dependable? Meaning—
> Male speaker 4: Well, more and less, more or less important.
> Team leader: More important, less important.
> Male speaker 4: Yeah.
> Team leader: Okay. Good.
> Female speaker 2: Let's make the call. We might pause recording for this bit!

Notice in this exchange how they're seeking to understand what the suggested criterion might mean, and making sense of it together. They then went on to canvas:
Keeping the business running

> Male speaker 3: Well, what's important to a business, right?
> Female speaker 1: But, yeah, operations and—
> Male speaker 3: Is it money?
> Female speaker 2: Ooh, ooh.

Male speaker 3:	Is it keeping the thing running?
Female speaker 1:	Yeah. I think we want things running.
Male speaker 2:	How stable's the system?
Male speaker 3:	(laughs) Yeah. I don't know (laughs) —
Female speaker 1:	Yeah, you do need to, you …
Male speaker 3:	You need to maintain, right?
Female speaker 2:	Yeah.
Male speaker 3:	You don't need to build, but you need, like—
Female speaker 2:	Yeah.
Male speaker 3:	… if the systems stop, then that's a problem.
Female speaker 2:	That's right.
Female speaker 1:	Okay.
Male speaker 1:	How do you restart the system?
Female speaker 2:	Pop him [points to male Speaker 3] in. Go.

Revenue

Female speaker 1:	Can [business name] survive with no more revenue?
Male speaker 2:	No offence, but I think—
Female speaker 2:	I mean, we've been doing it for a while now (laughing).

Service delivery

Male speaker 2:	Making sure things travel.
Male speaker 1:	Making sure things travel—
Female speaker 2:	Yeah.
Male speaker 1:	That's pretty important.
Male speaker 2:	That would be, that would be my, my bet.

Bench strength/succession planning

Male speaker 1:	I, I, I have a question. If we are no longer here, are our teams still here, and could they—

Female speaker 1: Yes.

Male speaker 3: … like, so like, [person in my team] could restart the servers, so—

Female speaker 2: Ooh.

Male speaker 3: … and all that kinda jazz.

Male speaker 1: Yeah.

Female speaker 2: Yeah. [person in your team] He could train us.

Female speaker 1: Yeah, train and support.

Female speaker 1: [Another team person] can run transport.

Male speaker 1: Yeah.

Male speaker 3: It's interesting.

Female speaker 1: Yeah.

Male speaker 2: 'Cause there's a replacement thing.

Male speaker 3: Is it about the knowledge gap between you—

Female speaker 1: Yeah.

Male speaker 3: … and your … Is it that? The knowledge gap between you and the people below you? So how much would they need to learn to be able to—

Male speaker 3: … do the role, that type of thing? Is it that?

Female speaker 1: I think, I think that's a really important factor.

Male speaker 1: Yeah, I think that's a factor.

Female speaker 1: The knowledge gap. Um, and how structured your … how your team is structured in the sense of your 2IC, if … are they a real 2IC or … and can do your role? And, and not miss a beat? So—

Female speaker 2: Yeah.

Team leader: There's also business knowledge versus market knowledge, so replaceable or non-replaceable skills.

Notice the team tried a number of different criteria – some of them attracting much more discussion than others – before settling into succession planning or bench strength as the main criterion they would use. Again notice the style of interaction, characterised by short, sharp sentences, often incomplete, lots of questions and affirmations (the word "yeah" or "yes" appears nine times in that short burst of conversation). This team appears able to have sufficient social capital as a group to work "in draft" together.

The second impact on the team's performance in the exercise was the higher level of direct challenge and debate in which the team engaged. For instance:

> Male speaker 2: [Female speaker 2], what's, what's your reason for being over there?
> Female speaker 2: [explains her rationale]
> Male speaker 3: That's the, that's how a business works.
> Male speaker 1: But that means you're probably over here. Nothing personal.
> Female speaker 2: Yeah, no, you've got a valid point. Got a valid point. I agree.

And…

> Team leader: … little triggers that you got to think about when you're thinking about succession. I didn't know this was going to be a succession task, it's just a—
> Female speaker 2: Well, we made it one.
> Female speaker 1: We made it one. You know, but then, then for, for what you just raised then, you're not immediately replaceable. But we're all replaceable over time but do we consider the immediate like—
> Male speaker 2: That's the point—
> Female speaker 1: … if I left today—

Male speaker 2:	That's the point.
Female speaker 1:	Oh, okay.
Team leader:	Yeah, so if I left today, that would—
Female speaker 1:	Yeah.
Team leader:	… then the company wouldn't be able to meet its compliance obligations next week.

Notice in this exchange that the group is able to recognise decisions they've made together: "We've made it [a succession task]", and then apply them in the debate with each other. Other groups could not reach any consensus on how they would do the ranking. This ability to take risks in challenging each other is another indicator of social capital or trust in the group – along with the risks of working in draft form together mentioned above. I discuss social capital in more detail in the next section.

5.7 Cross-group analysis

In this section I compare the groups with one another, as outlined in section 5.1.3 above. I begin by looking at the initial conditions of the various groups, then compare codes and memos across the groups, and then finally compare them visually on phase diagrams.

5.7.1 Table of initial conditions

The following table compares the initial states of each group prior to beginning the first exercise. The purpose of the table is to assist in understanding which (if any) of these factors influenced the group's final outcome.

Team	Industry	Size: Turnover	Size: Employees	Parent?
1	IT/Telco	> $5 billion	> 5000	Offshore owner
2	Construction	$1 billion	~ 1500	Locally owned
3	Agriculture	> $5 billion	> 5000	Global parent
4	IT/Telco	> $5 billion	> 5000	Offshore owner
5	Travel/SAAS	~ $10 million	~ 50	Locally owned

Table 5.7.1: About the businesses

Two of the five teams (teams 1 and 4) were from the same industry, although they differ in a number of respects. The teams span four different industries and are completely dissimilar in their internal cultures and brands. Three of the businesses are very large, one is small, and the other in the middle. This is a reasonably broad mix of organisations.

Team	Function	Functional spread	Seniority*	Team size	Time together
1	Marketing	Mid	2	13 people	2 years
2	Finance	Disparate	2	11 people	<1 year**

3	Executive team	Broad	1	10 people	5+ years***
4	Product/Content	Narrow	3	11 people	2 years
5	Executive team	Broad	1	7 people	3 years

Table 5.7.2: About the teams

* ***Seniority** is measured in "steps" between this team and the Chief Executive Officer. For instance "1" signifies the CEO's executive team, "2" indicates the leader of this team reports to the CEO, etc.*
*** This team has been restructured in the last year.*
**** This team has been together a long time, but has a new MD (only two years in team).*

Two of the five teams (teams 3 and 5) were Executive teams, meaning they have a seniority rating of 1 and a broad functional spread: they span the business. The Finance leadership team (team 2, reporting to the CFO) was the most disparate group, including functional heads of all the non-client facing functional groups. On the other hand, team 4 was the most narrowly focused team, as you would expect since it is three levels away from the CEO. There is a broad spread of experience together across the teams, from less than 1 year together to more than 5 years together. This is – again – a dissimilar set of teams.

Team	Gender split	Participant experience	Show up?
1	5F/8M	Mid	Engaged, attentive for the day ahead. Had just done a sharing exercise.
2	6F/5M	Mid/Long	Mixed frame of mind leading into these exercises – nervous and awkward at the unusual nature of the meeting, yet buoyant about the following Christmas lunch together.
3	3F/7M	Very Long	Good spirits at being offsite together, some scepticism and power dynamics at play reduced social capital.
4	1F/10M	Mid	Good spirits at being offsite together, some natural scepticism at doing "team things".

5	2F/5M	Mid	In good spirits at prospect of spending time together.

Table 5.7.3: About the team members

Teams 1 and 2 had a good gender balance, teams 3 and 5 were less good, and team 4 was overwhelming male. All participants in every group had middle to long experience in their roles at leadership levels. Finally, the groups arrived in the room for these exercises in different frames of mind.

As discussed previously, it is a characteristic of complex systems that their evolution over time is sensitive to their initial conditions, due largely to the magnifying effect of non-linear relations. On the other hand, for group-level behaviour to be truly "emergent" it should derive from the interactions between the team members ("agents") rather than by a predictable function of some initial settings. The various cases in this study have a broad range of initial conditions – there are no obvious patterns in them, and yet we have seen (and will see below) a number of behaviours repeated across the groups. This suggests that we are dealing with truly "emergent" behaviours.

5.8 Coding the data

The Code Map in Figure 5.2 below shows the codes applied to the various exercise transcripts. Coding was undertaken in NVivo. In reading the Code Map, it is useful to understand how the codes have been organised**:**

1. There are five top-level parent codes, represented in black on the map, and lined up down the middle of the map. These parent codes include:
    a. **Act** – codes associated with actions taken by people in the various groups whilst attempting to complete the exercises;
    b. **Leader** – actions taken by the team leader in each group;

   c. **Discomfort & Difficulty** – the reported level of discomfort felt by various team members whilst undertaking the exercises, and the difficulty ascribed to each task by participants;
   d. **Solution** – the solution reached (or not reached!) by each group to each exercise; and
   e. **Sensemaking** – how the group made sense of the exercises in their debriefs.
2. The coding is divided into those associated with the first and second exercises (right-hand side of the page) and those associated with the third exercise (left-hand side).
3. The codes are colour coded. There is a key to the colour coding in the bottom right corner of the map. The colours represent the number of teams represented by this code. In this way, a blue-coloured code only applied to one team whereas a red-coloured code applies to all five teams. The colour coding helps us see how common the behaviour is across the teams.
4. Each code features a number representing its **frequency** – the number of times the code appears across all five teams' transcripts. The number helps us see how often the behaviour appears across various teams.
5. Grey connector arrows perform one of two functions:
   a. Arrows from top-level parent codes connect children to parents.
   b. Arrows connecting various child codes to each other link those codes. The linkages either appear explicitly in the transcripts, or have been made in the various narratives or sensemaking. The direction of the arrow implies a causal relationship where that makes sense.

Further meaning was then extracted from the Code Map by comparing it to the table of Memos that was assembled during the exercises and the compiling of the narrative analysis section above.

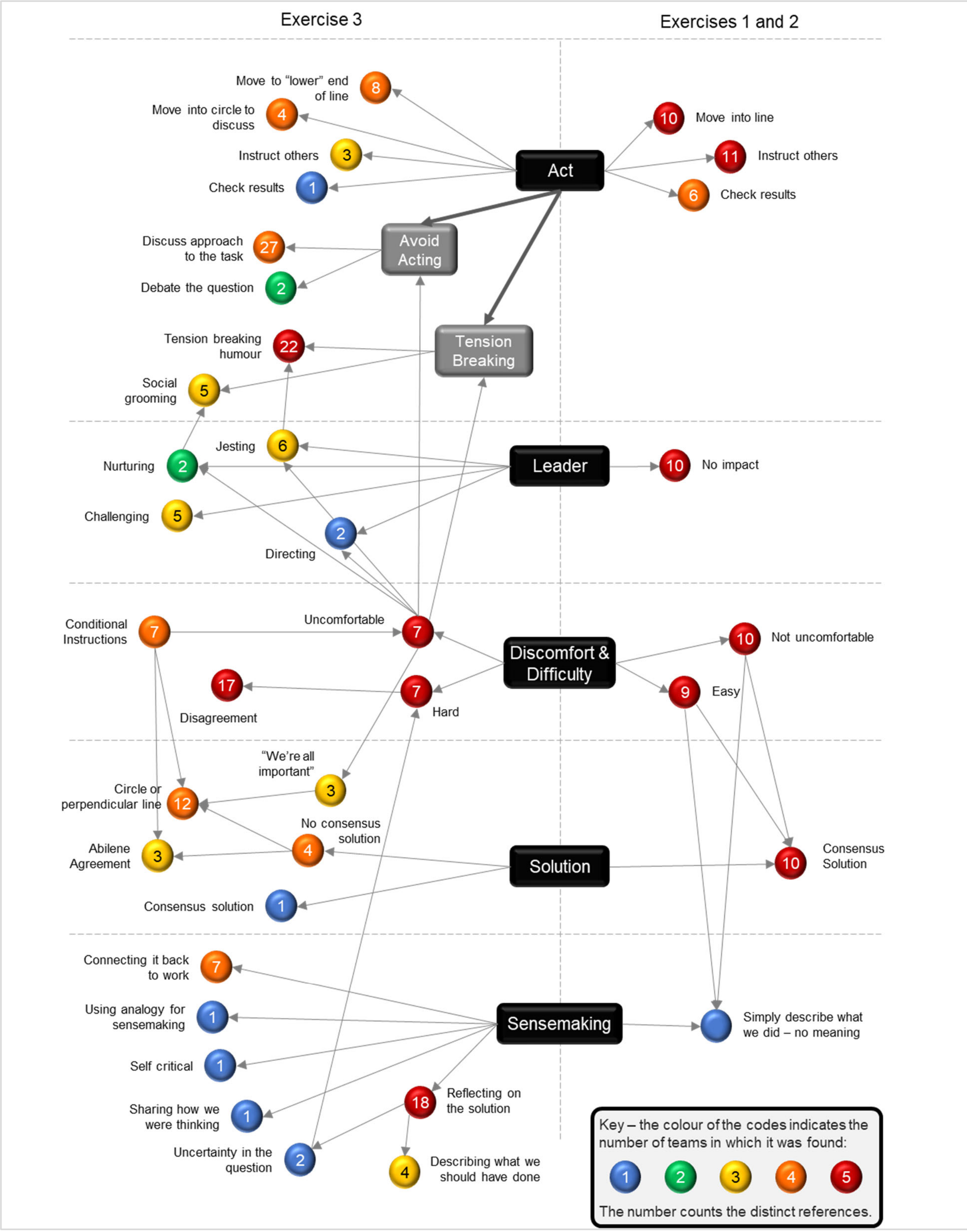

Figure 5.2: Code Map

5.9 Table of Memos

The Memos are laid out in the table below. Each Memo has a numerical label that connects it to a deeper description below the table. The table shows the **commonality** of the Memo (which teams it applies to), which correlates with the appropriate code colour in the Code Map if there is a code connection. The table also shows the **frequency** of each Memo (how many times it is referenced or appears in transcripts), which correlates with the frequency number in the Code Map.

Label	Memo	Commonality	Freq
1	At the outset of exercise 3, team members loudly walked to the "low importance" end of a supposed line	1, 2, 3, 4	8
2	A circle structure emerged at the beginning of exercise 3, but not exercises 1 and 2	1, 2, 3, 5	4
3a	Exercises 1 and 2 were easy and not uncomfortable	1, 2, 3, 4, 5	19
3b	Exercise 3 was difficult and uncomfortable	1, 2, 3, 4, 5	27
4	Acknowledged taking others' feelings into account in deciding what to say or how to act (conditional instructions)	1, 3, 4, 5	6
5a	Using humour to reduce tension in exercise 3	1, 2, 3, 4, 5	22
5b	Using social grooming to reduce tension in exercise 3	1, 3, 5	5
6	The discomfort in exercise 3 affected the team's progress towards a solution	1, 2, 3, 4	4
7a	Emergence of a solution that avoids judgement: circle or perpendicular line	1, 2, 3, 4	12
7b	Explicitly saying "We're all equally important"	1, 2, 3	3
8	The "Abilene solution" – the group says it has achieved consensus, but then it is discovered some people chose not to voice their disagreement	Team 2: 7 up, 2 down, 2 halfway Team 3: 3 up, 7 down Team 4: 3 up 8 down Team 5: 6 up, 0 down	
9	Insufficient ROI to take the risks and work through the discomfort	2, 3, 4	3
10	Leader Behaviour: nurture/bolster	1, 3	2
	Leader Behaviour: jesting	1, 4, 5	6
	Leader Behaviour: challenge	3, 4, 5	5
	Leader Behaviour: directing	2	3

11a	Sensemaking: connecting it back to work	2, 3, 4, 5	7
11b	Sensemaking: reflecting on the solution	1, 2, 3, 4, 5	18
11c	Sensemaking: everything else	1	1
12	Pace of interaction – see table in memo 12	See table in Memo 12	

Table 5.9.1: Table of Memos

The notes for the Memos are below:

1. An unexpected behaviour that emerged in exercise 3 for four of the five teams was that the earliest movement in the group was one or more people moving to the "I would not be missed" self-deprecating end of the line. The behaviour was always announced to the team – it was not surreptitious. Members of team 3 first deferred to Head of Sales, suggesting he move to the "important" end of the line, then moved to the bottom end themselves. Interestingly, nobody did the reverse behaviour of moving to the "I am important" end of the line. In fact, in team 4 one participant twice told the team that they did not want to be at the important end of the line (where they had been placed). Only in team 5 did this behaviour not emerge at the start of the exercise.

2. The teams finished exercise 2 in an ordered line. After the initial movements described in Memo 1 above, four of the five teams coalesced into a circle structure for their discussions. Only team 4 stayed in a semblance of a line to do the discussion for exercise 3. Standing in a circle is the simplest formation for a discussion in which team members can maximise their eye contact and see each other's non-verbal cues. This type of structure then maximises the conditional behaviour in the group dynamic (see Memo 4 below).

3. a) All five teams labelled exercises 1 and 2 as comfortable and easy. There was some suggestion that exercise 2 was slightly harder than exercise 1.
   b) All five teams labelled exercise 3 as uncomfortable and difficult. Members

of team 5 discussed the discomfort in exercise 3 while they were attempting the exercise. This discomfort is a key factor in driving the different behaviours between exercises 1 and 2 versus exercise 3.

4. Recall that in the literature review we found that a key feature of complex systems is that agent behaviour is *conditional*; that is, the behavioural instruction set in agent A includes behaviours which are conditional on inputs from other connected agents. It is this conditional behaviour that can create the feedback loops that drive the group behaviour into non-linear unpredictability.
   In four of the five groups (all but team 2), team members specifically acknowledged taking others' feelings into account in deciding what they would say or how they would act. In particular, they were conscious they did not want to upset others and wanted to avoid discomfort for themselves and others. Even in team 2 – which you will recall was dominated by the intervention of the team leader – the leader said in the debrief that in his choices of behaviour he was driven by a desire to protect the group from discomfort and potential conflict. This is the "conditional behaviour" that drove some of the group behaviours seen in Memos 5 to 9 below.

5. In Memo 5 we see two common behaviours that appeared in all five teams to reduce the group discomfort that built up from time to time during the discussions. You can see this behaviour reducing the group tension visually in the phase diagrams in section 5.10 below. The two behaviours are:
   a) Using humour to reduce tension in exercise 3. In their investigation of humour in group psychotherapy sessions, Bloch et al. (1983) found that humour played a key role in tension reduction, or as a release of tension in groups.
   b) Using social grooming (complimenting or attending to other people in the group) to reduce tension in exercise 3.

6. The discomfort in exercise 3 affected the team's progress towards a solution. Of the five teams, four teams consistently applied tactics from Memo 5 above to reduce the team tension or discomfort, breaking the team flow. They treated the discomfort as something to retreat from or avoid. By contrast, team 5 also described exercise 3 as uncomfortable but stayed in that discomfort to push through to a solution. In the end, they were the only team to reach a consensus solution. It is possible they might have developed an increased ability to tolerate discomfort as a group, as suggested by Stephanie Burns (2010), staying in a different state to the other teams, which enabled them to reach a consensus solution (see Memo 12 below).

7. A peculiar resolution to exercise 3 emerged in four of the five groups. Teams 1 to 4 came up with variations of a solution to exercise 3 in which they avoided judging each other. Members of teams 1 and 3 specifically suggested to each other that they stand in a circle whereby they would all be equal. Team 2 stood in a line perpendicular to the judgement direction that indicated they all occupied an equal "importance". Team 4 suggested and agreed to stand in a perpendicular line but then didn't act on it. It was only team 5 that didn't even suggest an "all equal" resolution. This lines up with Memo 6 above in that teams 1 to 4 suggested and acted on a solution which avoided judgement and so reduced the team discomfort, whereas team 5 stayed in the higher discomfort state and were able to reach a consensus solution.

8. Four teams attempted some sort of solution to exercise 3. In each case, the researcher tested the consensus in the solution by asking the team to:
   - check out the solution they arrived at,
   - close their eyes, then
   - whilst keeping their eyes closed, raise their hand if they agreed with the

solution as presented.

The Memo in the table summarises the response to that question for each team. For team 2, 64% of the team agreed with the solution (if you recall, this was the perpendicular line or “we’re all equal” solution!). Teams 3 and 4 each had 30% or less agreement. In team 4 there was explicit discussion in the group about why team members had not voiced disagreement in the exercise debate. I have coined the term “Abilene solution” after the famous Abilene Paradox (Harvey, 1974) to describe this behaviour. In the “Abilene solution” the team achieves a false consensus (Ross & Anderson, 1982), reporting a consensus, but then it is discovered some people (or in two cases most people) chose not to voice their disagreement. Instead, they chose to conform to what they thought was a consensus but wasn’t, again to reduce the discomfort and debate in the group, and to draw the exercise to a close. Team 5 was again the outlier, with all team members confirming their agreement with *everyone’s position in the final lineup*.

9. An interesting piece of sensemaking emerged in three of the five debriefs on the exercises. In each of teams 2, 3 and 4, one person acknowledged there was discomfort in the group, and that there might be some social risk in pushing the group through to a solution. They explained that they thought there was insufficient apparent return on investment to take the risks with sitting in the discomfort and working through to a solution. One speaker from team 2 phrased it this way:

   > I think what’s interesting for me is we have a complex question, but the stakes of not solving it or the motivation to solve it is not significant enough to go through the pain as a group of solving it.

10. Memo 10 is about the role taken by the team leader in each team’s responses to the exercises. I begin by drawing your attention to the Code

Map above. Notice that no leader played any role of any significance in exercises 1 or 2. These exercises were accomplished quickly, and the leader's role was indistinguishable from other team members. In exercise 3, four different types of behaviour occurred across the leaders. In the Memo table above, the following terms are used:
- Nurture/bolster means the leader deliberately tried to support or positively reinforce team members they perceived to be in discomfort. Leaders in teams 1 and 3 tried to do this.
- Jesting means the leader employed humour specifically to reduce the group tension. Leaders in teams 1, 4 and 5 tried this.
- Challenging is the opposite of nurturing or jesting. Where nurturing and jesting moves aim to reduce the discomfort in the team, challenging is an agitating move to add to the team tension. Leaders of teams 3, 4 and 5 tried this, whilst the leaders of teams 1 and 2 clearly thought their team did not need any increase in tension.
- Directing. Only the leader of team 2 engaged in directing or instructing the team on what to do. During the debrief this leader admitted regretting his directive focus, explaining that it was driven by his concern for the team's discomfort – he directed the team towards a "we're all equal" solution.

Team 5's leader role was unlike that played by the leaders in the other groups. This group's leader did not play a directive role, but still made himself available for critical review by other teammates, which may have had the effect of normalising the "agent values" across the team.

11. Memo 11 concerns the sensemaking the teams engaged in during the debrief discussions. Once again I direct you back to the Code Map in the previous section. Notice the child codes hanging off the sensemaking parent at the bottom of the map. Two codes are strongly represented across the teams, whilst the others are not.

11 a) All teams connected their behaviour in the exercise back to the way they typically behave in their real work context, except team 1 who held the exercise at arm's length, exploring it by analogy instead.

11 b) All five teams focused on talking about the solution they achieved, might have achieved, or what solutions were possible.

11 c) The rest of the sensemaking was sporadic and idiosyncratic – each group tried different ways to make sense of how they had behaved in exercise 3.

12. Memo 12 describes an interesting piece of data across the teams. The table below compares the speaking rate of the various teams during exercise 3:

Team	Exercise time	Total contributions	Contributions/min	Avg speak time
1	7:00	48	6.9	8.8 s
2	3:03	20	6.6	9.2 s
3	6:43	86	12.8	4.7 s
4	6:43	62	9.2	6.5 s
5	6:39	231	34.7	1.7 s

Table 5.9.2: Memo 12 – conversation rate

The table shows how many people spoke during the time taken to complete the exercise. We can then work out the average contributions per minute and average speak time per participant, presuming that a negligible amount of time was spent where no one was speaking. We can now compare these statistics across the groups, and discover that there is a remarkable difference between team 5 and the other teams. Team 5 spent an amount of time on exercise 3 that is roughly equivalent to that spent by teams 1, 3 and 4, and yet crammed a staggering 231 contributions into that time – nearly three times as many as their closest rival. This translates into an average speak time per contribution of less than 2 seconds – a remarkable rate of interchange. When you go back to the narratives you can see what is happening in some of the team 5 interactions. In section 5.6.3 above I noted, while discussing team 5, that:

> For the other groups, the average talk time was more than triple that [of team 5] as individuals took the time to fully flesh out their own perspective. This rapid fire exchange [in team 5] builds stronger co-dependent links between group members, pushing the group into a more complex state to match the task complexity.

Faster interaction between team members means the communication is more highly conditional – members' contributions build on colleagues' contributions and team members must keep up with the conversation pace rather than have time to reflect while a colleague engages in a longer contribution. More conditional communication indicates a complex state, and in this memo we can see a correlation between this conditional fast-paced communication and the speed with which the group was able to explore ways of resolving the problem and arrive at a solution. Further, it is possible the group achieved a stronger consensus because all team members had a chance to contribute to the conversation many times.

5.10 Dynamic phase diagrams

In the final section I bring together a lot of what we've learned in the previous sections and display it visually on a series of micro-scale "phase diagrams".

The first landscape below is empty, serving to orient us to what we will see in subsequent landscapes.

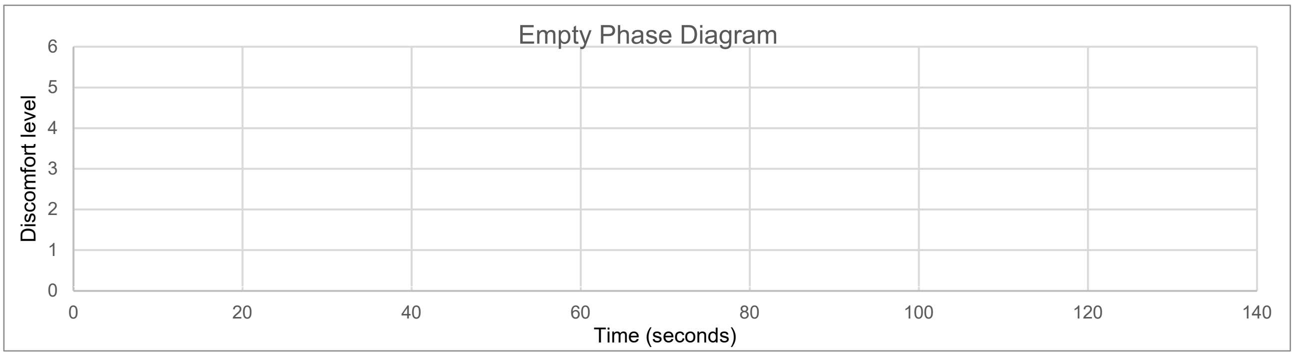

Figure 5.3: Empty phase diagram

The vertical axis provides the environmental "pressure" that tests the team's fitness. In this case, I use the apparent discomfort in the team as the pressure. I plot the team's discomfort over time (the horizontal axis, measured in seconds).

Now let's populate the landscape. This next landscape features the reported and apparent discomfort levels for the teams over the first two exercises:

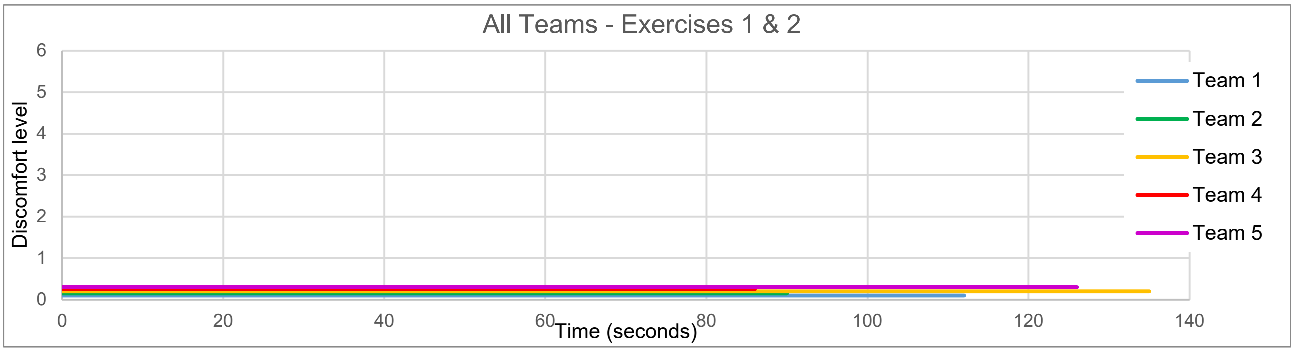

Figure 5.4: Phase diagram for exercises 1 and 2 – all teams

Note that in this landscape I have stylised the lines so they can each be seen, but they are all effectively zero. No teams reported or showed any sign of any discomfort in completing the first or second exercise.

Let's compare this landscape with the composite landscape showing how all teams responded to exercise 3:

Figure 5.5: Phase diagram for exercise 3 – all teams

Two things are readily apparent:

1. this graph is very different to the previous one showing the landscape for exercises 1 and 2; and
2. this graph is difficult to make sense of – it appears to be all over the place!

The first point above is a demonstration of what we expected to see – a clear difference of group state between exercise 3 and the other exercises. To address the second point – and help us better understand what we're looking at in the landscape for exercise 3 – let us remove all the teams from the landscape except for team 1:

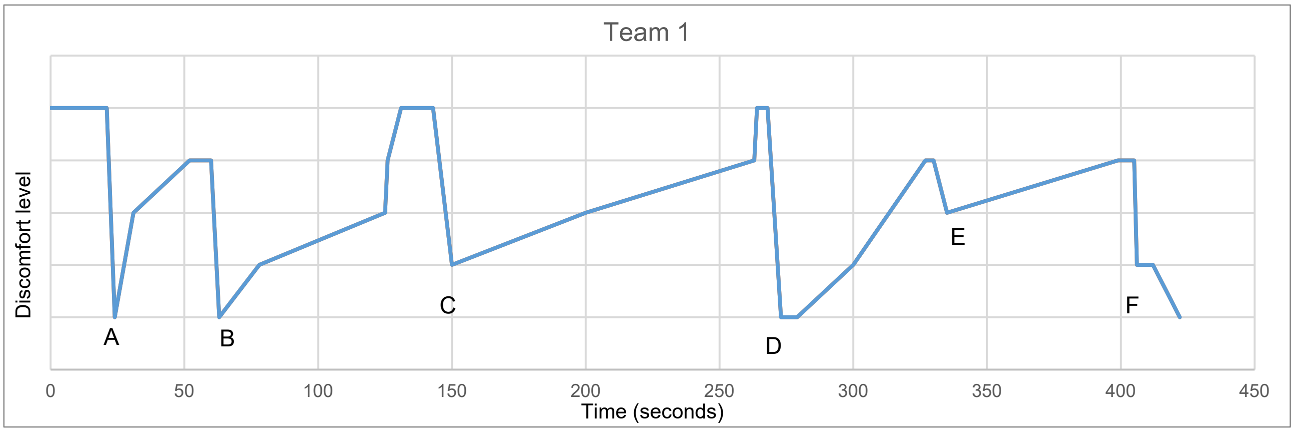

Figure 5.6: Phase diagram for exercise 3 – team 1

There is a pattern here. Each time the group builds some discomfort in the discussion, someone in the group acts to reduce that discomfort. These reduction points are marked on the landscape: A, B, D mark tension-releasing jokes made by the team's leader. F is a joke made by another team member, in fact the same person who had pushed the group to the previous uncomfortable peak then turned around and let the tension out with a self-deprecating joke. C was someone reinforcing to the group how important each member was, and at E a team member pointed out the value of standing in a circle, affirming how together they were. The landscapes for teams 2, 3 and 4 show a similar pattern:

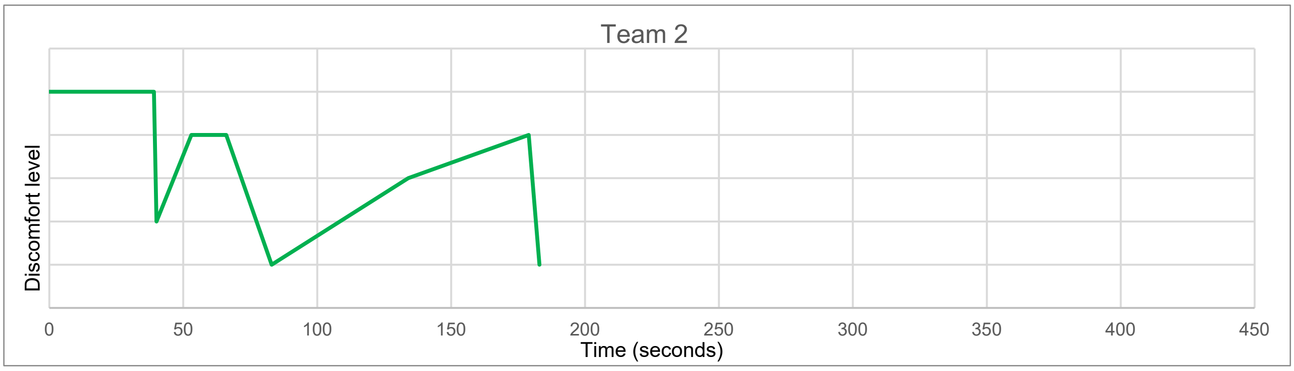

Figure 5.7: Phase diagram for exercise 3 – team 2

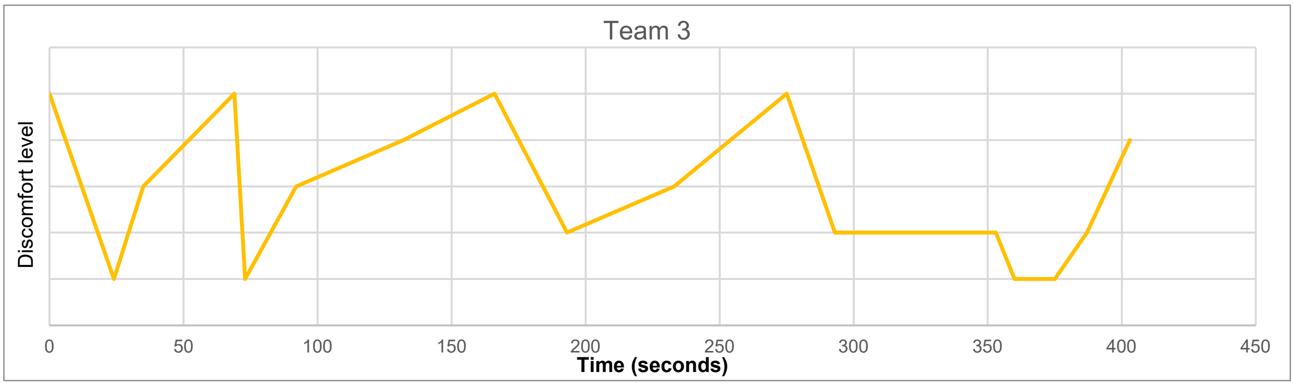

Figure 5.8: Phase diagram for exercise 3 – team 3

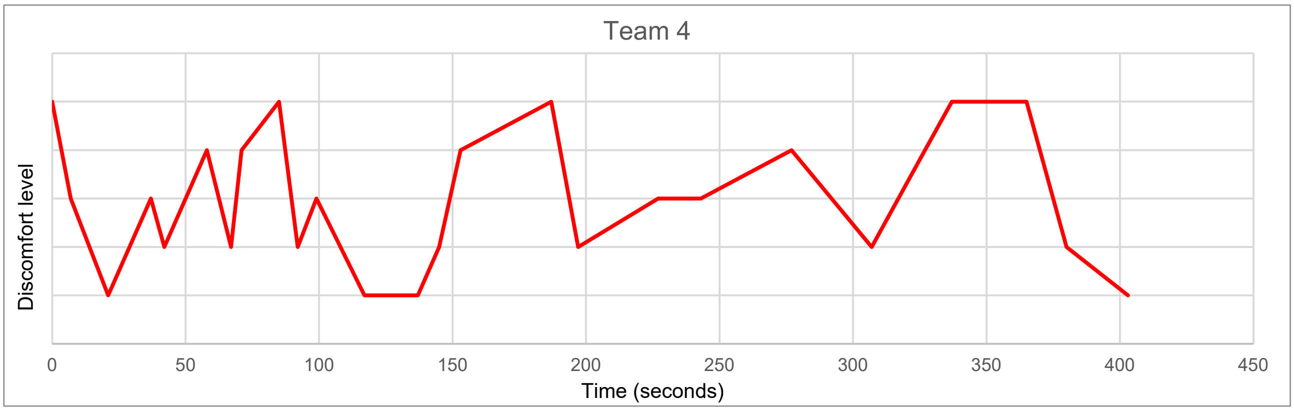

Figure 5.9: Phase diagram for exercise 3 – team 4

In each case, we see peaks of discomfort followed by sharp releases of tension as the group drops back to a baseline state.

Now let us compare these landscapes with that of team 5:

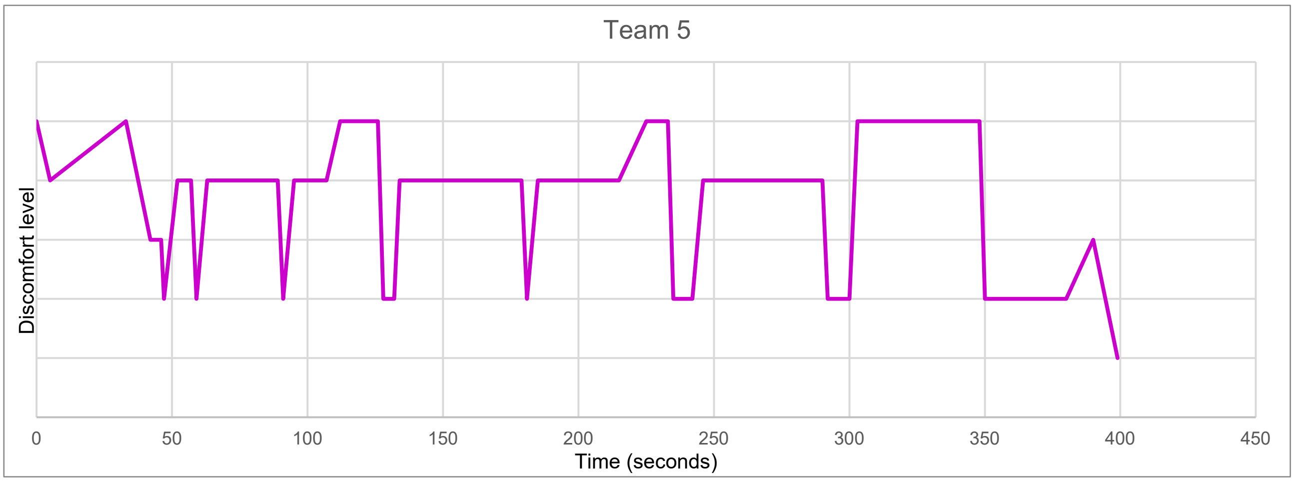

Figure 5.10: Phase diagram for exercise 3 – team 5

In this case, there are still the drops or releases of tension, but they're different. For a start, there are more tension-breaking moments than in the other teams. This is most probably a function of the significantly faster rate of interchange of communication in this group. But more noticeable is the different shape of this group's landscape. This time there is a relatively stable plateau of working in uncomfortable conversations, sitting regularly just inside their capacity (which I've rated as a 4). There are a few bursts of full discomfort (rated 5) where someone has (for example) challenged the team leader or another team member directly. And there are regular short, sharp drops of tension, almost all of them being humour related. Where the other groups use tension-breaking behaviours to reduce the discomfort in the group, team 5 uses it to take a short break or a "quick breather" from the discomfort, occasionally check in on a team-mate or two, and then get right back into the uncomfortable discussions. The end result for team 5 is that they were able to debate more options more effectively to find a solution that was ideal for them, and there was an environment in which everyone could air their thoughts and have them challenged appropriately. This led them to a more stable consensus – they had searched widely for a solution and there were no unaired opinions or undebated points by the time the group checked for consensus.

5.11 Brief recap of key findings

The study surfaced both some expected and unexpected findings.

The expected

The five teams chosen were very different. All five were organisational leadership teams; however, four different industries were represented, five different functions, and three different levels of seniority within their organisational hierarchies. Within each team there was a wide variety of individuals with different tenure and experience, and the teams themselves had been together different lengths of time with different experience bases. These differences surfaced in different conversations and behaviours within each team’s narrative, and in different leader behaviours and approaches. And yet despite all these differences, some remarkably similar behaviours *emerged* in the quasi-experiments.

Each team’s dynamic shifted noticeably between exercise 2 and exercise 3 of the quasi-experiments. Key changes included the physical layout of the group, increased eye contact, increased discussion, increased reflection in real time during exercise 3. The dynamic shift was clearly correlated with the different challenges: challenges of the types in exercise 3 prompted a shift to a team dynamic that was different from the dynamic observed in exercises 1 and 2. It seems there is indeed some link between the type of challenge a team faces and the dynamic it adopts in response.

Discomfort turned out to be a significant driving factor in those dynamic state shifts, with all teams reporting a significant difference in experienced discomfort between exercise 3 and exercises 1 and 2. This discomfort triggered consistent avoidance type behaviours across four of the five teams, despite their differences in initial state. In the next chapter, I consider the dynamic shift between exercise 2 and exercise 3 in detail and see whether it is indeed the physical manifestation of the complicated to complex shift theorised about in chapter 2 above.

The unexpected

My early theorising about complex team dynamics connected challenge types with team states: different types of challenges were supposed to trigger different team states. What I hadn't expected to see so clearly was the extent of dynamic state shifting *within* exercise 3. All five teams changed their dynamic within the attempt at exercise 3, four in a consistent way and the fifth team in an unexpected way. Furthermore, the pace of interaction differential reported in Memo 12 was both unexpected and exciting.

These unexpected findings prompted further theorisation in the next chapter, adding elements of theory from far from equilibrium complex systems to help create a richer picture of how and why complex team dynamics change.

6. Discussion

Sensemaking and theorising

In section 4.1 of the Methodology chapter above, I outlined the research questions this study proposed to address. You might recall that the questions were split into two levels of focus: the first being on the content of the study and the second on the study's approach. The questions at the content level were:

a) What phase shifts do leadership teams undergo as they face different types of challenges? How and why do they undergo them?
b) And how do the lenses of complexity science and the Uncertainty Landscape synthesised above help us understand and make sense of those shifts?

The question at the level of the approach to this study was:

c) What middle ground is there between complex systems modelling and analogy, and how might we investigate it?

This chapter attempts to make sense of the results obtained in the study by connecting and integrating them into an explanatory narrative. Like all good stories, my narrative has three "acts", which line up with the three contributions to the field this study aims to make:

- *Act 1*, in which I begin by drawing together what I have learned about state changes into an augmented Uncertainty Landscape.
- *Act 2*, in which I then apply some concepts from thermodynamics to further enrich our understanding of the observed team dynamics.
- An *Interval*, in which I pause to consider the implications of the first two acts for the practice of working in leadership teams.

- A *Final Act*, in which I consider what might be learned from the methodology constructed for this study.

6.1 The Uncertainty Landscape

What phase shifts did the leadership teams in our study undergo as they tackled the three exercises in our study, and to what extent do the lenses of complexity science and the Uncertainty Landscape synthesised in the Literature Review chapter help us understand and make sense of those shifts?

6.1.1 Group histories and the Markov property

Before delving into a discussion on what was observed in the exercises, it is worthwhile to begin with a review of group histories and their impact on this chapter. In the literature review above it was noted that complex groups (and human groups) do not have the Markov property (Helbing, 2010); they are not merely stochastic. A Markov process is a memoryless process (Grosskinsky, 2013), and so groups and individuals within groups have memory, have histories, and those histories matter (Arrow et al., 2000; Mowles, 2022; and others). Many complexity authors agree that "histories matter", the question is "how much?"

Another feature of complex systems discussed in detail in the literature review above is that system behaviour is non-linear, that it is extremely sensitive to initial conditions – see for example Goldstein (1995), Anderson (1999), Uhl-Bien et al. (2007), Hazy et al. (2007), Miller & Page (2007), Stacey (2011) and Byrne & Callaghan (2013). One can see how the combination of these two features (histories matter and sensitivity to initial conditions) might leave the theorist or researcher in an endlessly regressive loop, searching for every possible historical feature to account for in the behaviour witnessed today.

But we don't need to deliberately account for each such historical event in our model construction – the simulation does that for us. Each group enters the simulation exercises carrying all of their prior histories in their “backpacks”. The question is how might we account for such factors in the analysis and discussion?

First, let’s be clear on which histories matter. In complexity theory, contexts matter. Mowles (2022) extends this dictum into how we construct our understanding of our personal identity and group identity when a member of a complex group. He uses the terms “social self” or “socially constructed identity” to describe the process of conceiving who we are *contextually*; that is, a function of the social context in which we find ourselves. Mowles is an admirer of Norbert Elias, who writes:

> Plans and actions, emotional and rational impulses of individual people, constantly interweave in a friendly or hostile way. This basic tissue resulting from many single plans and actions of people can give rise to changes and patterns that no individual person has planned or created. From this interdependence of people arises an order *sui generis*, an order more compelling and stronger than the will of the people composing it. (Elias, 2000, p. 543)

In this, Elias – despite not being a complexity scholar himself – is describing the complex phenomenon of *emergence*, a group-level behaviour not ascribable to an individual within the group, but applying it to how the group works. Mowles (2022) describes this as the group creating a form of *habitus,* habituated ways of working that are generated interdependently with the group. But Hodgson (2011) goes a step further, arguing that these “habits” of working together are contextually nuanced, that they might be co-created in the group in response to situations as they arise. In these exercises, each group was faced with a novel situation (they had not experienced this exercise before), and then went about constructing some habits to deal with it, or falling back potentially on other habits from different situations (which may or may not have been useful).

What does this mean for how we account for histories in this discussion?

Firstly, if we take the view of Mowles (2022), Hodgson (2011) and Elias (2000) above, it is the history of the group that matters much more than the histories of individuals outside the group context. It is possible that certain events in an individual's history might be "triggered" by the exercises, and we should watch out for that, but by and large we're concerned with the group's co-constructed *habitus* as a reflection of its history.

Secondly, it is not the objective, nor within the scope of this thesis, to attempt to justify the observed behaviour of each team as a function of its history. In fact, we will use the initial data on each team for a comparative purpose: to show how different the teams are at the start. This means that any similar behaviours found to be repeated across multiple teams are less likely to be a function of their initial states and past histories, and more likely to be truly emergent.

Finally, should there emerge some significant differences across some or all of the teams, we can then return to that group's initial conditions and history to search for possible explanations.

6.1.2 Different states

In the analysis of the results obtained in the various exercises we saw above that there were a number of clear differences in the way teams tackled exercises 1 and 2 compared to exercise 3. The Code Map in the Results and Analysis chapter above shows this visually – it is easy to separate behaviour and comments coded in exercises 1 and 2 from the codes in exercise 3. The codes on either side of the map are very different, and there are significantly more codes on the left (exercise 3) than on the right (exercises 1 and 2). Some of the differences are worth noting in more detail.

Firstly, there were physical differences:

- physical configuration differences: teams stood in a circle to discuss exercise 3, but moved straight into lines for the other exercises; and
- interrelational differences: there was significantly increased eye contact between team members in exercise 3 compared with exercises 1 and 2.

Secondly, there were conversational differences:

- sensemaking differences: there was significant discussion and debate in exercise 3 as teams tried to make sense of how to approach the exercise, whereas sensemaking was absent from exercises 1 and 2;
- team members reported that in exercise 3 they modified what they said and did out of concern for how other team members might feel, which didn't happen in exercises 1 or 2;
- team members reported that they felt uncomfortable doing exercise 3 and that there was risk involved in attempting exercise 3, but no discomfort was reported in exercises 1 or 2; and
- in exercise 3, team members engaged in what I described as "Abilene solutions", choosing to go along with the group instead of making their real opinions known, whereas no such behaviour emerged in exercises 1 or 2.

These differences noted above were consistently observed across all five teams. They noticeably distinguish team states in responding to exercise 3 from team states responding to exercises 1 and 2.

In the literature on group dynamics a number of authors have built models that distinguish different types of team states or phases. Some of the more well-known models include Tuckman's (1965) group evolution model (*forming, storming, norming and performing*), Fisher's (1970) decision emergence model (*orientation, conflict, emergence and reinforcement*), Gersick's (1988) punctuated equilibrium model (*phase 1, transition point, phase 2*), Wheelan's (1990) integrated model of group development (*dependency and inclusion, counterdependency and conflict,* *trust and structure, productivity*), McGrath's (1991) T.I.P. model (*inception, technical problem solving, conflict resolution, execution*) and Tubbs' (1995) system model (*orientation, conflict, consensus and closure*). One can see that describing group or team states is not a new idea; however, the majority of these models of team dynamics are developmental in their orientation – they describe a series of states or phases a team passes through on a longer journey, where each state is thought to contribute in some way to the team's development. By contrast, in this thesis I am not concerned with team state or phase changes as steps on a developmental journey, rather as responses to triggers in a single conversation. As a result, the time scale under investigation in this piece of research is also considerably shorter than the more traditional studies outlined above.

At this scale of a single conversation, we can study the conversation at different levels. In his 2003 paper, Hackman introduces three levels of analysis for group dynamics:

- a micro level, focused on characteristics of individual group members,
- a meso level, focused on the characteristics of the group as a whole, and
- a macro level, focused on the group and its embedding context (for example the wider organisation within which it is located).

Hackman (2003, p. 905) further writes:

> I suggest that robust understanding of social and organizational dynamics requires attention to higher as well as lower levels of analysis.

In explaining why this multi-level analysis is necessary, Hackman (2003, p. 906) argues that too many scholars in the group dynamics field engage in a type of linear "explanatory reductionism", attempting to explain group behaviour at a single level, often based on linear causal mechanisms from the level below:

> Explanatory reductionism… holds that things operate as they do entirely because of the properties of their constituent parts, and that the operation of

> even highly complex systems could, in principle, be explained if one had enough knowledge of their components.

One of the benefits of the complexity perspective on theorising about group dynamics adopted in this thesis is that it naturally avoids "explanatory reductionism" and meets Hackman's multi-level dictum. Rather than searching for causal explanations for team-level behaviour in the proclivities, traits and capabilities of the individual team members, complexity theory addresses linkages between micro, meso and macro levels of team dynamics that resist explanatory reductionism through the concept of emergence (see for example Anderson, 1999; Bar-Yam, 2004; Fernández et al., 2014; Goldstein, 2007). In complexity theory, "emergent" behaviour is behaviour seen at one level that is not represented in lower constituent levels.

In the physical and conversational characteristics of exercise 3 (that were absent in exercises 1 and 2), we can see further signatures of complex systems, including the physical structural attractors described by Hazy (2019) (see section 6.1.5 below for a deeper discussion). In chapter 2 above, I theorised that when a system shifts into a complex state:

> The interdependence of the agents in the system increases as the focus on agent interactions increases (Hazy et al., 2007; Marion, 2008) – in a human team, team members should increasingly focus on each other's reactions.

It is this "interdependence", what I have called "conditional behaviour" in this thesis, that is the key signature of a system in a complex state. Cabrera and Cabrera (2019, pp. 5–6) explain how this type of signature behaviour was first described in herding, flocking or schooling animals, but has since been readily recognised in human behaviour as well:

> It is not difficult to find human examples of this phenomenon either – think of spontaneous human waves at sporting events. The agents (fans) follow one

> simple rule: do what the person to your left does. When they stand up, you stand up and when they sit down, you sit down. The key step with respect to these simple rules is to only focus on what's happening around you. When individual agents focus their efforts locally, we can see amazing macro-level results.

Cabrera et al. (2015) presented their "DSRP" framework in an attempt to present a unifying theory of systems thinking as applied to human systems. The DSRP is an acronym, standing for *distinctions, systems, relationships* and *perspectives.* The last two elements – *relationships* amongst agents and their action/reaction responses, and the incorporation of others' *perspectives* or points of view into thinking – describe the mechanics of conditional behaviour. The *system* element then describes how these parts interact to produce the complex whole:

> What emerges from the use of DSRP is an adaptive, evolving mindset – something that closely resembles complex and adaptive systems thinking. (Cabrera et al., 2015, p. 538)

This is precisely what we saw in this study. The physical configuration of the people in the room during the discussions (but not including the reported solutions of some groups) allowed for increasingly local interactions between "agents". A circular layout affording continuous eye contact provides for these *local* interactions, which then increases the likelihood of the behavioural feedback loops that drive non-linear behaviour. Furthermore, participants in four of the groups specifically mentioned making perspective shifts, as described by Cabrera et al. (2015), during their debriefs:

Team 1 debrief:

Female speaker:	I was trying to go there and almost depersonalise it and just make it function.
Researcher:	Why were you trying to depersonalise it?

Female speaker: To not hurt someone.

Team 3 debrief:

Researcher: Um, I want to explore, (male speaker 1) at one point said let's make a distinction here, are we judging the people in the room or are we judging the roles? How did you answer that?

Multiple voices: Role.

Researcher: Roles. Why did we pick that one?

Team Leader: Easier.

Male speaker 7: It's easier, absolutely.

Male speaker 3: People are more emotive, we don't want to provoke that.

Team 4 debrief:

Speaker 5: But I potentially would have offended some people who are friends, by belittling what they do or demonstrating my lack of understanding of their value. And therefore I didn't want to take that risk in that exercise.

In the increased concern for others' emotional states we can see the increased "social sensitivity" of Mahmoodi et al (2018), first introduced in section 4.3.1 above. Recall that social sensitivity means that individuals are increasingly paying attention to and empathising with the emotional states of their local team-mates. The social sensitivity leads to "rapid, localized feedback about the emotional states of others" (Hazy and Boyatzis, 2015: p806), resulting in emotional contagion.

These non-linear behaviours that emerged only in exercise 3 are examples of *conditional behaviour*, which is a critical feature of a complex system: in short, the behaviour of agents is conditional on the behaviour of other agents, not independent of them.

This seems a surprisingly simple insight: in order for a team to be in a complex state, *team members must actually be paying attention to each other*. By extension, a team in which members are not currently paying attention to each other cannot be in a complex state. This shows qualified agreement with Hackman's finding that group dynamics are "messy" and "complex" (2003, p. 919). Instead, we find that group dynamics are *sometimes* messy and complex. This finding also adds nuance to the thinking of the Complex Responsive Processes school (Mowles, 2015; Stacey, 2003; Stacey & Griffin, 2006) where human dynamics are thought to be *always* complex. In this study, I discovered that leadership teams are not locked into a single state or phase, they undergo state changes.

This is significant in an organisational context, since "not paying any attention to each other" may be considered a common feature of a considerable proportion of meetings attended in a typical organisation! In our simulations all teams accomplished exercises 1 and 2 whilst paying only the minimum of attention to each other, and hence did not display any characteristics of complex systems.

I can now separate exercises 1 and 2 from exercise 3 as triggering different team states, and apply a series of state names for them from the field of complexity. The locality of interaction and conditional behaviour of the agents marks the team task state in exercise 3 as *complex*. If I return now to the *Uncertainty Landscape* constructed in the Literature Review above, I can place the states on the Landscape below (Figure 6.1):

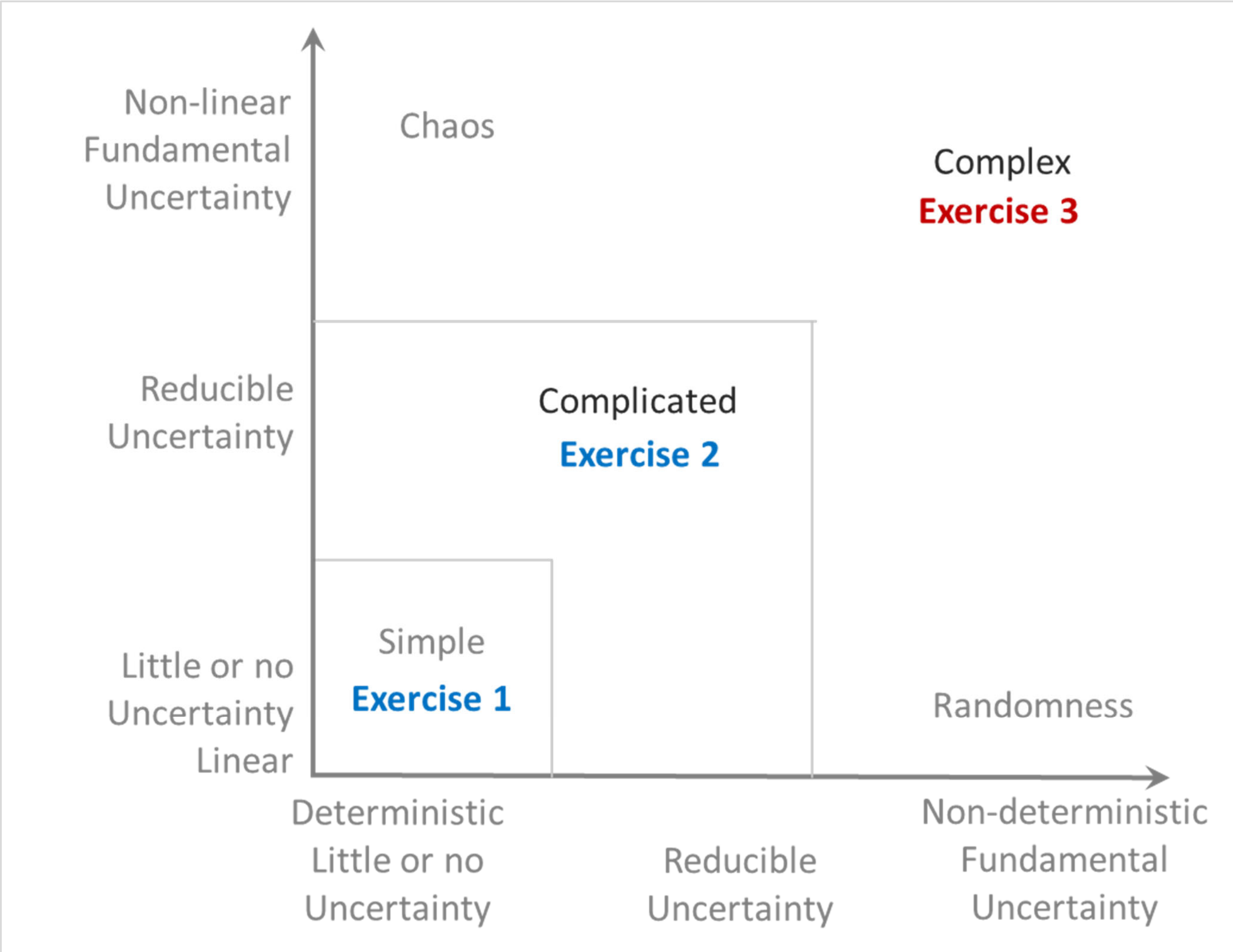

Figure 6.1: Exercises on the Uncertainty Landscape

1. The team state triggered by exercise 1 is Simple: all the data required to complete the exercise is immediately available to the team, no debate was required to complete the exercise, and the exercise was completed with no conditional behaviour.
2. The team state triggered by exercise 2 is Complicated: not all the data was necessarily available immediately to the group, some groups used a smartphone to compare relative distances. Some discussion was required, for example to decide whether the relative distance should be travel hops or

“as the crow flies”. However, there was no conditional behaviour and no discomfort.

3. The team state triggered by exercise 3 is Complex due to the local interaction, conditional behaviour and uncertainty described extensively above.

In practice, although exercises 1 and 2 were designed to represent simple and complicated challenges (respectively), there turned out to be little difference in the way the teams attacked the challenges, the time it took to reach a solution, or the difficulty and discomfort reported. I return to this discovery in section 6.4.3 below in reviewing the simulation. Suffice for now to say that the major distinction between the team states triggered by exercises 1 and 2 and the team state triggered by exercise 3 was significant.

6.1.3 Different problems trigger shifting to different states

To this point, I have talked about the states of the teams as they addressed the various challenges. This is because the evidence and data I collected was of what the team members said and did – that is, descriptive of the state the team was in. However, a number of authors in the complexity field use the terms *complicated* and *complex* to categorise types of organisational problems one might meet rather than team states.

Recall that Cynthia Kurtz and Dave Snowden’s Cynefin framework (Kurtz & Snowden, 2003) does this – it is a cataloguing system for problem types. Once a problem has been categorised, Kurtz and Snowden then prescribe different processes or approaches to be taken for each type. Ronald Heifetz and Marty Linsky use the labels “technical problems” and “adaptive problems” for *complicated* problems and *complex* problems respectively (Heifetz & Linsky, 2002a), and then (like Kurtz and Snowden) prescribe different approaches to be taken to different problem types. Mary Uhl-Bien, Russ Marion and Bill McKelvey (2007) go one extra step, suggesting that a different type of leader is required for the two different problem categories, what they call an "administrative leader" for *complicated* problems and an "adaptive leader" for *complex* problems. Figure 6.2 illustrates these different approaches.

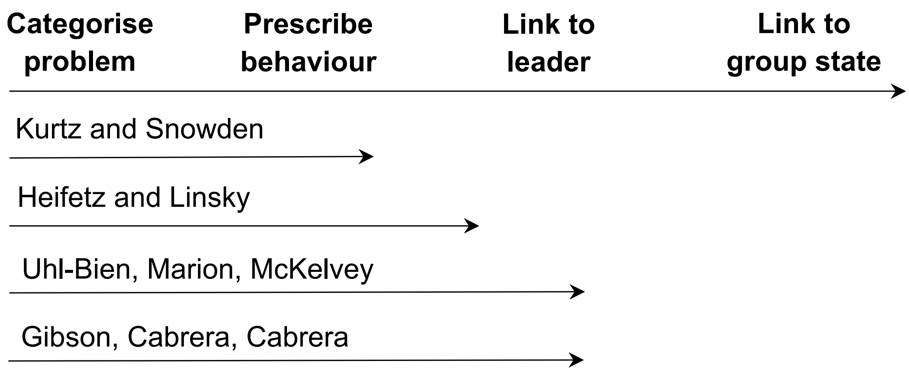

Figure 6.2: Problem categorisation

In each case above, the assumption is that we begin by identifying and categorising the problem, and then extend from there into the type of either process or leader that is required to deal with that problem type.

The approach to this study is different. I set out to understand to what extent the categorisation of the problem (as simple, complicated, complex) affects team dynamics, to investigate the links between different types of problems and the group states they might trigger. My thesis is that certain problem types provoke certain team states, which was what was found in the data. Figure 6.3 below illustrates this linkage between types of problem and group or team state.

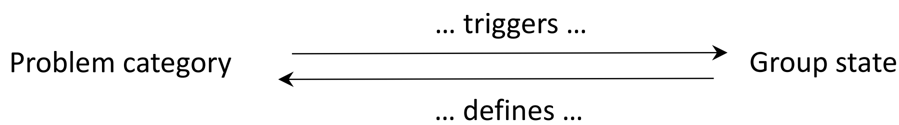

Figure 6.3: Problem linked to group state

As a result, we get an interplay between the team state and the problem type, and can define *complex problems as those that trigger phase changes into a complex state*.

One might at this point ask: “Isn’t it possible to define some problems as always complex for everyone? What about, for example, so-called *wicked problems*?” Wicked problems “are ill-defined, ambiguous and associated with strong moral, political and professional issues” (Ritchey, 2013, p. 2). The term was first coined by Rittel and Webber (1973) in relation to planning and policy, but has since been extensively used much more generally in organisational discourse (Crowley & Head, 2017; Skaburskis, 2008). Rittel and Webber (pp. 161–166) defined their wicked problems as having ten characteristics:

1. There is no definite formulation of a wicked problem.
2. Wicked problems have no stopping rules.
3. Solutions to wicked problems are not true-or-false, but better or worse.
4. There is no immediate and no ultimate test of a solution to a wicked problem.
5. Every solution to a wicked problem is a “one-shot operation”; because there is no opportunity to learn by trial-and-error, every attempt counts significantly.
6. Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan.
7. Every wicked problem is essentially unique.
8. Every wicked problem can be considered to be a symptom of another [wicked] problem.
9. The causes of a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem’s resolution.
10. [With wicked problems,] the planner has no right to be wrong.

In this study, exercise 3 fails characteristics 1, 2, 4 and 6 of Rittel and Webber's list: there was a single simple formulation of the problem, there was a stopping rule ("line up" and you're done), solutions were tested in the rooms with participants, and there is a simple mathematical description of the possible solution space (there are *n!* ['n' factorial] possible solutions where n is the number of people in the team). Clearly, exercise 3 was not a wicked problem, yet it triggered *all* tested teams to go into a complex state. It follows that "wicked problem" is neither a necessary nor sufficient criterion to put teams into a complex state. In fact, what triggered the teams to go into a complex state for exercise 3 was the risk involved in solving the problem: participants were required to judge each other in front of each other, which presented a risk to damaging relationships in the group. In section 6.2 below I explore in greater detail what it is about the problem statement in exercise 3 that triggered the state change for the teams. For the moment, it is noted that it is *not* one of the characteristics of Rittel and Webber's wicked problems as outlined above. It is my thesis that this is because Rittel and Webber's list attempts to categorise problems independent of the group tackling the problem, much in the same way as Kurtz and Snowden (2003), Heifetz and Linsky (2002a) and Uhl-Bien et al. (2007) above.

Defining a problem as complex only by the state it triggers has a benefit over the traditional problem categorisation method in that it allows context into the definition of problems: *not all teams will regard a given problem as complex*. By including the team triggered state as part of the problem definition, we can now cater for problems that one team might regard as complex but another regards as merely simple or complicated.

6.1.4 State or phase changes

The picture painted of different team states connected to problems doesn't yet match what we saw in the exercises in the empirical section of the study. The

Landscape in Figure 6.1 above seems static, yet what we saw was dynamic movement between different states – even *during* exercise 3.

Once again, the group dynamics literature is a useful starting position because it doesn't generally treat states as fixed, but rather refers to changes in group state or phase. In his meta-analysis of group development models, Smith (2001) categorises models into one of three types:

- linearly progressive models;
- cyclical and pendular models; or
- non-phasic or hybrid models.

Smith explains that the "linear-progressive models are perhaps the best known and most widely cited type of developmental model. These models assume that groups develop in a definite linear fashion and that there is a 'definite order of progression' from one phase or stage to another." (2001, p. 17). Tuckman's (1965) *forming, storming, norming and performing* model is possibly the most well-known example. Consider two of the phase diagrams from chapter 4 of this thesis (Figures 6.4 and 6.5 below):

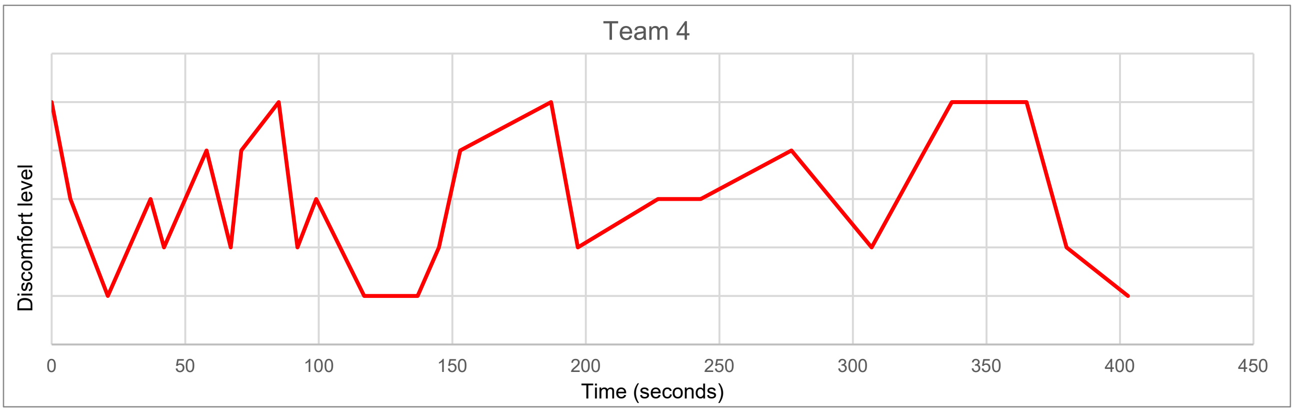

Figure 6.4: Phase diagram for exercise 3 – team 4

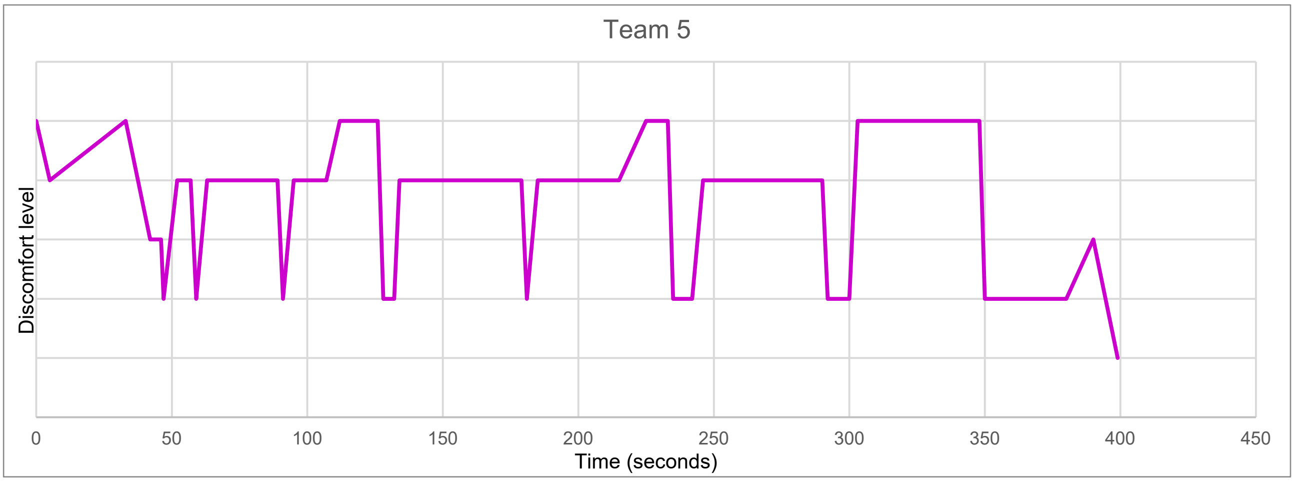

Figure 6.5: Phase diagram for exercise 3 – team 5

We can immediately see that there is no "definite order of progression" in either team. The teams in this study did not linearly progress.

Smith's second category is cyclical and pendular models. These models "have much in common with the linear progressive models with respect to the terminology used to describe group development" (Smith, 2001, p. 27); however, unlike the linear models, these models suggest groups "revisit stages and phases over and over or swing between issues again and again during the developmental process" (Smith, 2001, p. 25). We can see the teams in this study appearing to "swing" between two phases or states in the phase diagrams in Figures 6.4 and 6.5 above, but our groups do *not* fit a cyclical or pendular model. Smith uses the words "stages" and "development" deliberately in the quotes above. He elaborates: "Each cycle or swing serves to strengthen the group's understanding of its present situation and its assigned task and to modify the group's approach to dealing with those issues." (Smith, 2001, p. 25). The swinging in these models is developmental, it serves to progress the group in some way. By contrast, what we saw was groups swinging to the ground or equilibrium state to *avoid* dealing with the problem rather than to progress it – especially in teams 1 to 4. A cyclical or pendular model will not serve our needs here.

Smith’s final category is non-phasic or hybrid models. He describes these models as “‘contingency models’ of group development in that the observed patterns of development are largely the result of environmental factors, such as time, that affect the development process” (Smith, 2001, p. 32). He places Gedrsick’s (1988) punctuated equilibrium model as the most well-known model in this group. In Gersick’s study she found that teams experienced a transition in their work state or stage at about the midpoint of a project or task. We can immediately see that there is a problem with our study fitting into this category too: the state changes in our teams were not prompted by external or environmental factors, certainly not a repeatable function of time. Instead, the triggers for the various state changes happened entirely as a result of behaviours inside the group.

Given that the team behaviours in this study can’t neatly fit into Smith’s team development model categorisation scheme, I return instead to my Uncertainty Landscape.

In Figure 6.6 below, I have removed exercises 1 and 2 to focus solely on exercise 3. The complicated area of the Landscape is now identified with the lower discomfort levels of Figures 6.4 and 6.5 above, and has been labelled “attractor state 1”. The complex area of the Landscape is now identified with the higher discomfort levels of Figures 6.4 and 6.5 and has been labelled “attractor state 2”. The arrows in the Landscape now show the teams bouncing from one state to another, as depicted in Figures 6.4 and 6.5. I will return to attractors and attractor states in a moment, but first, what is driving the phase transitions for these teams?

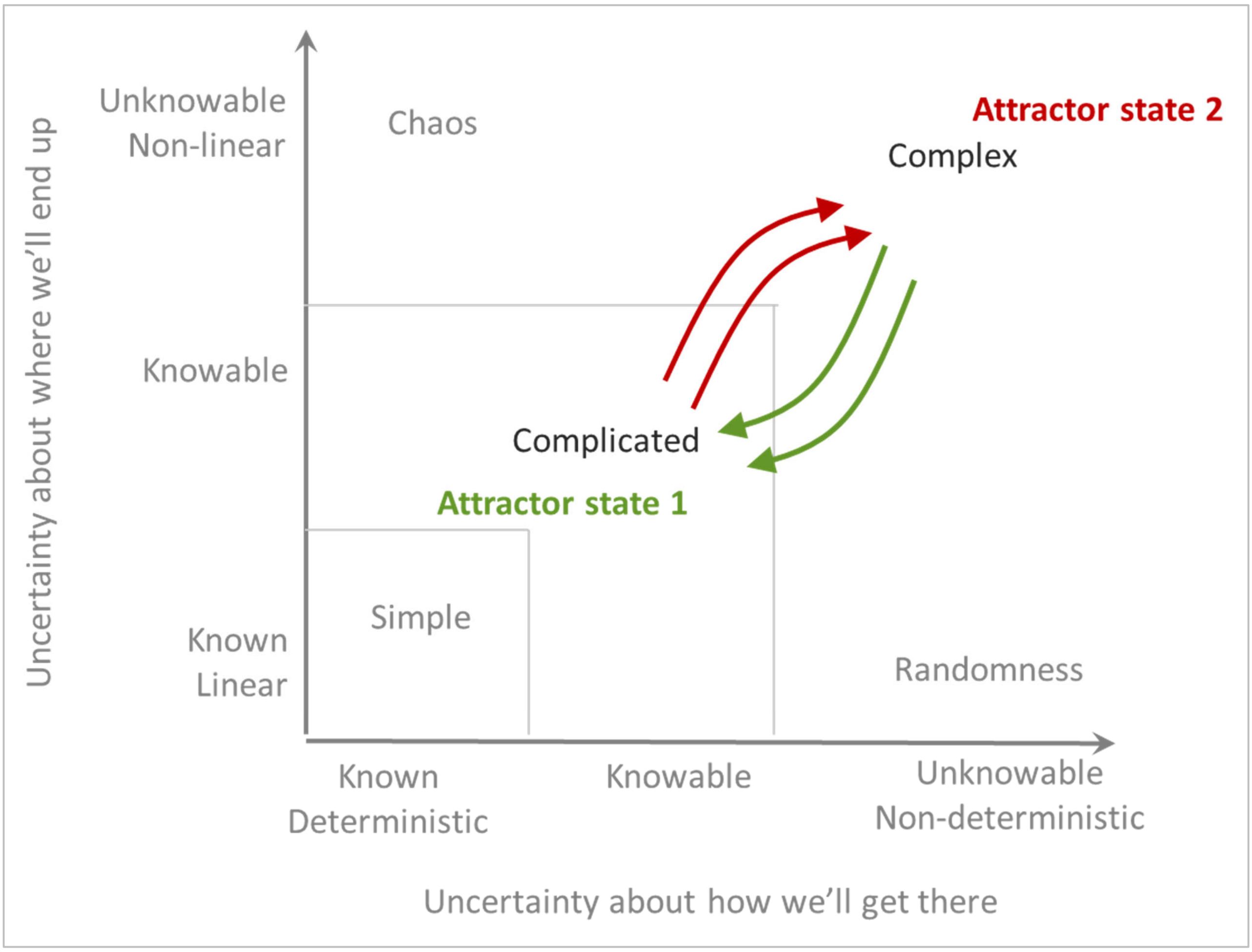

Figure 6.6: Triggered state changes for exercise 3

6.1.5 Self Organised Criticality

Bak, Tang and Wiesenfeld (1989) first coined the term *self-organised criticality* in their study of sandpile avalanches in the late 1980s. Miller and Page (2007) explain the term in this way:

> "The key driving point behind self-organised criticality is that microlevel agent behaviour tends to cause the system to self-organise and converge to critical points at which small events can have big global impacts." (p167)

In explaining how this works, they describe how in Bak et al's original sandpile model the system slowly evolves towards a critical state attractor at which point increasingly large avalanches become increasingly possible, until eventually one such avalanche triggered by one sand grain drops the system into a less critical state. They found that such behaviour is not just the province of inanimate sandpiles or forest fires, it can also be modelled with more purposeful, thoughtful or directed agents.

Mahmoodi, West and Grigolini (2018) developed a model of *self organized temporal criticality* (SOTC) based on their modelling of rational/emotional agents in systems. In their models agents made rational and emotional decisions on imperfect assessments of some of their neighbours. They found that such networks did indeed evolve toward critical states in which the decisions of single agents could have an increasingly large impact at a global level. Importantly they found that in social systems critical events could have divergent results:

> "It is remarkable that according to SOTC the crucial events may be harmful as well as beneficial." (p7)

In the team behaviour in this study you could see the build-and-release of tension in the way all teams oscillated between low and high discomfort levels in the dynamic phase diagrams of section 5.10 above. In the next section I will associate these high and low discomfort levels with the concept of attractors.

6.1.6 Attractors and attractor states

The term "attractor" I have introduced into the discussion is one that find its roots in mathematical descriptions of complex or chaotic dynamical systems. Eric Weisstein at Wolfram Mathworld defines an attractor as "a set of states (points in the phase space), invariant under the dynamics, towards which neighbouring states in a given basin of attraction asymptotically approach in the course of dynamic evolution".[7] Thietart and Forgues (1995) note that attractors are functions of non-linear dynamics, and Panzar et al. (2007, p. 134) identify four types of attractors in such systems:

1. Point attractor: the system tends to settle into a stable equilibrium.
2. Oscillating attractor: a system periodically oscillates between an attractor point and its previous state.
3. Quasi-periodic attractor: oscillates between multiple states or attractors but not simply periodically.
4. Strange attractor: the system moves in a chaotic cycle.

The attractor concept has found its way from the mathematical formalism of analytical or computational complexity into the narrative approach to complexity as well, appearing in works by Byrne and Callaghan (2013), Vallacher and Nowak (2008), Arrow et al. (2000), as well as multiple times in Hazy et al.'s (2007) textbook on complex systems and leadership.

Allen and Strathern (2003) define a *structural attractor* as "the emergence of a set of interacting factors that have mutually supportive, complementary attributes" (p29). These mutually supportive attributes tend to have an amplifying effect, driving the system towards the structural attractor. Hence we might suggest that *a structural attractor is a state toward which a system tends to evolve, despite its initial conditions*. Hazy (2019) added significant detail to the concept of a structural attractor, finding they appear in three types:

i) "Physical structural attractors (PSA) simplify spatial complexity" (p6)
ii) "Dynamic structural attractors (DSAs) simplify temporal complexity." (p8)
iii) "Social structural attractors (SSAs) simplify social interaction complexity." (p11)

[7] Weisstein, Eric W. "Attractor." From MathWorld—A Wolfram Web Resource. Retrieved November 7, 2021, from https://mathworld.wolfram.com/Attractor.html.

Behaviours that were consistent with physical structural attractors were observed in all teams tackling exercise 3. This includes those documented in the Memos in section 5.9 of the Results chapter above: the tendency to walk to the “low” end of the room at the start of the exercise (Memo 1), the circle structure the groups adopted for discussion (Memo 2), and the “stand in a circle” teams adopted to avoid the discomfort of completing the task (Memo 7). This third behaviour is also linked to a strong social structural attractor, and it is these social structural attractors that are of most interest in this study.

In the observations of teams tackling exercise 3 there was an immediate shift for each team into the complex state, which has been labelled “attractor state 2” in Figure 6.6 above. Attractor state 2 is a type of social structural attractor, driven by the “social sensitivity” of Cipresso et al (2017) and Mahmoodi et al (2018), and the “emotional contagion” of Hazy and Boyatzis (2015) introduced in section 4.3.1 above. At the beginning of exercise 3 every team showed a marked increased focus on each other’s comments, body language and interactions: local conditional behaviour. Then, despite the various initial conditions of the teams, some patterns emerged in exercise 3 at the system (team) level that were relatively consistent across the teams. These patterns included the physical structural attractors described immediately above, utilising humour and social grooming to reduce tension, suggesting and/or employing the “we’re all equal” avoidance solution to exercise 3, and settling for what I described as the “Abilene solution”. The fact that these similar group behaviours were observed across the different teams would suggest that they are emergent solutions that are not a function of the groups’ initial conditions.

Now that the groups were “complex”, theory suggests that the dynamics of the system would become non-linear, extremely sensitive to initial conditions and small changes, and complex patterns begin to emerge at the system level (Anderson, 1999; Ball, 2005; Helbing, 2010; Marion, 2008; and others). It is here that we see a bifurcation on behaviour states begin to occur, as in Figure 6.7 below.

Figure 6.7: Phase diagram for exercise 3, team 5, showing attractor states

This graph is looking like Panzar et al.'s (2007) "quasi-periodic attractor", oscillating between two structural attractor states. Vallacher and Nowak (2008) explain that systems may have multiple attractors, and Arrow et al. (2000) explicitly describe two attractor systems in human dynamics. One such system, which is of particular interest to us here, is their "consensus/conflict two point attractor system" (Arrow et al., 2000, p. 184).

Arrow et al. (2000) explain that some teams work towards a single attractor state of consensus, whilst others develop patterns of oscillating between conflict and consensus. Sometimes this is a generative pattern that either progresses the group's learning or progresses towards solutions (Kaufman et al., 2019; Vallacher et al., 2011), and sometimes it is not generative, rather just a developed pattern.

Byrne and Callaghan (2013) note that drivers towards attractors can include patterns, "regularities, successful outcomes, capabilities, knowledge forces, and power" (p. 29). But attractors can also be "negatively defined by no-go areas, obstacles, … ignorance, powerlessness, lack of freedom or opportunity" (Byrne & Callaghan, 2013, p. 30). Hazy and Boyatzis (2015) considered emotional interactions in an agent based simulations, and also posited bifurcated emotional attractors: Positive Emotional Attractors (PEAs) and Negative Emotional Attractors (NEAs). They found that individual agents could find themselves in emotional basins corresponding to either PEA or NEA states, and that further these states would be *contagious*, they would spread through local interactions in the network and hence become self reinforcing. This reinforces Mahmoodi, West and Grigolini's (2018) finding above that critical events in self organized temporal critical states can be either harmful or beneficial.

It is now possible to suggest that in each team's behaviour in tackling exercise 3 we saw two attractor states, just as proposed by Byrne and Callaghan (2013) and Hazy and Boyatzis (2015). One attractor state was at the uncomfortable level that was for some negatively defined (*teams wanted to avoid it* but returned to it) and might be a "conflict state" and the other attractor state was at the more comfortable level that was positively defined (*teams ran towards it*), as shown above in Figure 6.7. We saw that each group was indeed sensitive to small changes: the shifts from attractor 2 in the uncomfortable state back to attractor 1 in the more comfortable state were often precipitous, as were some of the triggers that threw the group into more discomfort. The team dynamics were sensitive to any contributions, from the humour or social grooming triggers used to drop the team back into a more comfortable state through to the challenging or disagreeing comments that increased discomfort.

Our explanatory narrative to this point, however, is still incomplete. The two attractor states – attractor state 2 at higher discomfort and attractor state 1 at lower discomfort levels – are not the same. The dynamics of each team were not reversible as they traversed from one state to the other and back again. It seemed as though attractor state 2 was perched on top of a hill, it was metastable, easily disturbed, and it took teams effort and energy to reach it and maintain it. By contrast, attractor state 1 seemed in a valley, and teams readily “rolled downhill” to reach it. These two states are not symmetric, and so we need to add an extra layer to the understanding provided by the Uncertainty Landscape if we are to fully capture what was observed in the teams’ dynamics.

6.2 Complex dissipative teams

In chapter 2 above, I articulated four indicators we might expect to see as a system evolved from a complicated to complex state. One of those indicators was:

> *The system evolves towards a new order (this new order is called an “attractor”), far from equilibrium, and with characteristics of a dissipative structure (Anderson, 1999; Marion 2008; Prigogine & Lefever, 1973). In this context, “dissipative” refers to the system using (and hence requiring) energy to be sustained.* (section 2.4.4 of this thesis).

As the teams tackled exercise 3 we actually saw them evolving forwards and backwards between two attractor states as described in the previous section. The first attractor state was the more comfortable or equilibrium state corresponding to a discomfort level of 1–2 on the phase diagrams. For teams 1, 2, 3 and 4, this second state proved the stronger attractor – they consistently pushed the team state back to equilibrium. Attractor state 2 was the uncomfortable, far from equilibrium state characterised by discomfort level 4–5 on the phase diagrams. For team 5, this far from equilibrium state was a stronger attractor and so the team spent more time there.

I wasn’t expecting to see two diametrically opposed strong attractor states in the study, with different groups attracted to both states with different coupling strengths. To understand what is going on here, I propose employing the language from Ilya Prigogine’s work on complex states as dissipative structures (Prigogine, 1997; Prigogine & Lefever, 1973). This is not the first time such language has been employed; in fact, in his commentary on Kilburg and Donohue (2014), Jim Hazy (2014, p. 300) notes:

> many serious authors have attempted to bring rigorous mathematical formulations, born in the natural sciences and including the laws of thermodynamics, into the social sciences.

Hazy uses his review to initiate a broader discussion on the relative merits of importing classical scientific concepts into organisational discourse. Hazy notes that in general he “applaud[s] efforts to bridge the divide between the natural sciences and the social sciences” (2014, p. 301). However, he cautions against the loose application of theoretical concepts from the natural sciences in the form of metaphor. Consequently, I am careful to note that the theorising in this section is based on real empirical results, and that the theorising builds on the work done by previous authors in the field.

This section begins by discussing the observed drivers for behaviour change. The discussion happens at two dynamical scales:

i) at the micro level (Hackman, 2003), what Vallacher and Nowak label intrinsic interpersonal dynamics (2008, p. 51); and
ii) at the meso level (Hackman, 2003), the emerging team dynamical properties.

6.2.1 Micro-scale or individual properties: uncertainty and discomfort

Our formulation of the Uncertainty Landscape to this point is of a two-dimensional map with attractor states labelled as in Figure 6.8 below. To further distinguish the two attractor states, let us consider the vertical axis from the phase diagram graphs, see Figure 6.9 below. The vertical axis is labelled “discomfort level”, a dimension that measures group tension or discomfort in the discussions. There is some precedent in the literature for associating a “discomfort” scale with increasing complexity: the vertical axis in the Stacey Matrix (Stacey, 1996) is a “disagreement” scale; and Vallacher and Nowak (2008) and Arrow et al. (2000) reference “conflict” as a driver of the bifurcation of group dynamical trajectories. The link between the uncertainty in complex dynamics and its experience as anxiety was also established in the literature review above (see Buhr & Dugas, 2002; Carleton et al., 2012; Chen et al., 2018; Freeston et al., 1994; Hirsh et al., 2012). What has been discovered in this study is that conflict or disagreement are not necessary or sufficient drivers for state change. Instead, it is the reported human response to conflict – anxiety or discomfort – that seems to drive the state movement.

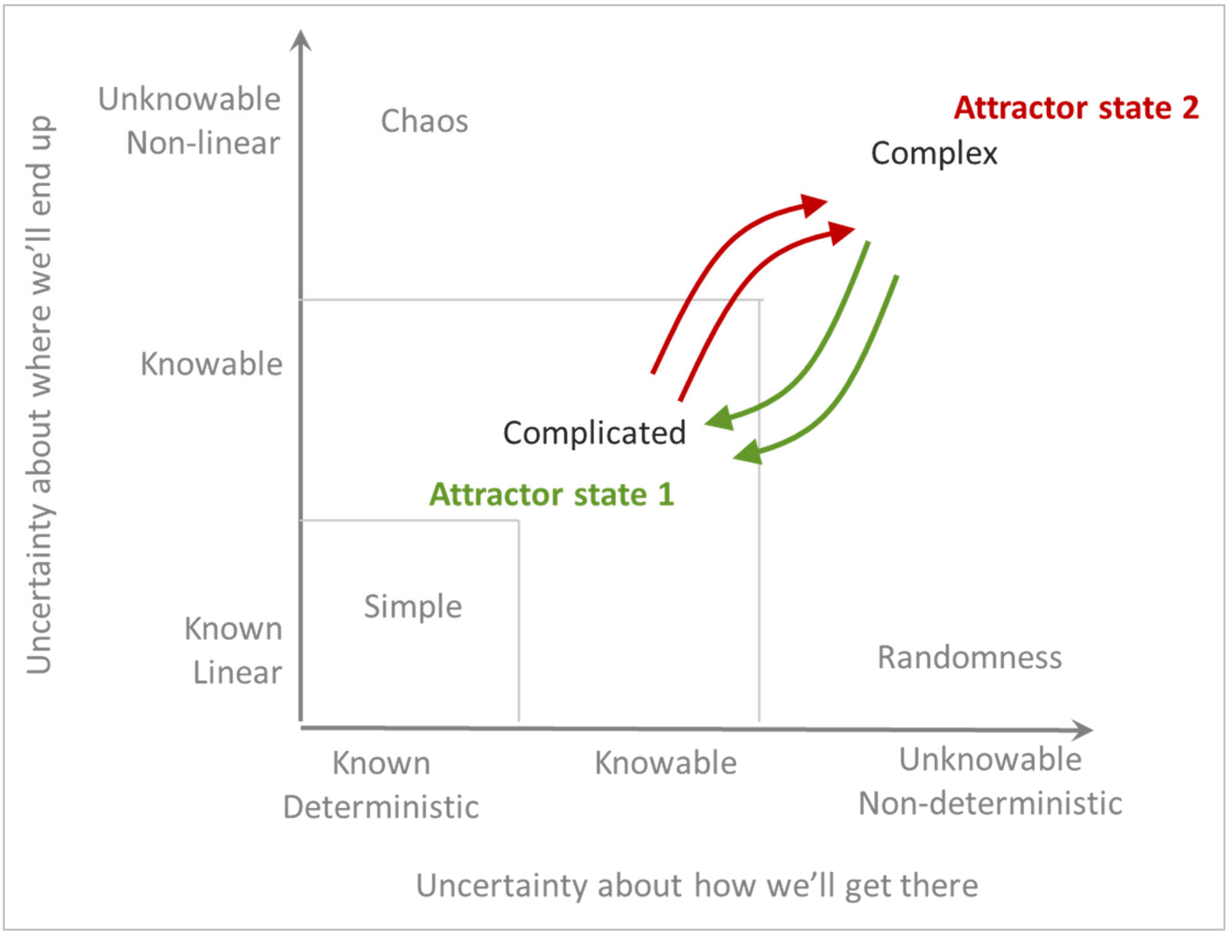

Figure 6.8: 2D Uncertainty Landscape with attractor states

Figure 6.9: Phase diagram for exercise 3, team 5, showing attractor states

I can treat this extra dimension of information by adding an extra physical dimension to the Uncertainty Landscape – a "z axis" we might imagine projects out of the page. The z axis looks like Figure 6.10 below. In Figure 6.10, I have labelled this z axis "discomfort" to connect it to the phase diagrams from the Results and Analysis chapter, but what is it actually measuring? Where does this discomfort come from?

Recall that all groups rated exercise 3 as uncomfortable, whilst no groups reported any discomfort in completing exercises 1 or 2. In the 2D Uncertainty Landscape, I primarily distinguish complicated states and challenges from complex ones by uncertainty: uncertainty arising through non-linear dynamics or non-determinism. I found that in complex states some of that uncertainty is fundamental or irreducible. The uncertainty in the third exercise in our study occurs at two levels:

i) There is uncertainty in the content of the challenge: what does success look like? what criteria should we use to rank ourselves, and how should we apply those criteria if we have imperfect information on each other?
ii) There is uncertainty in the team dynamic in actioning the task: how will some or all people in the room respond if I make suggestions or judgement

calls? What are consequences of any social or political risk I might take, and what consequences might there be if I choose not to take any risks?

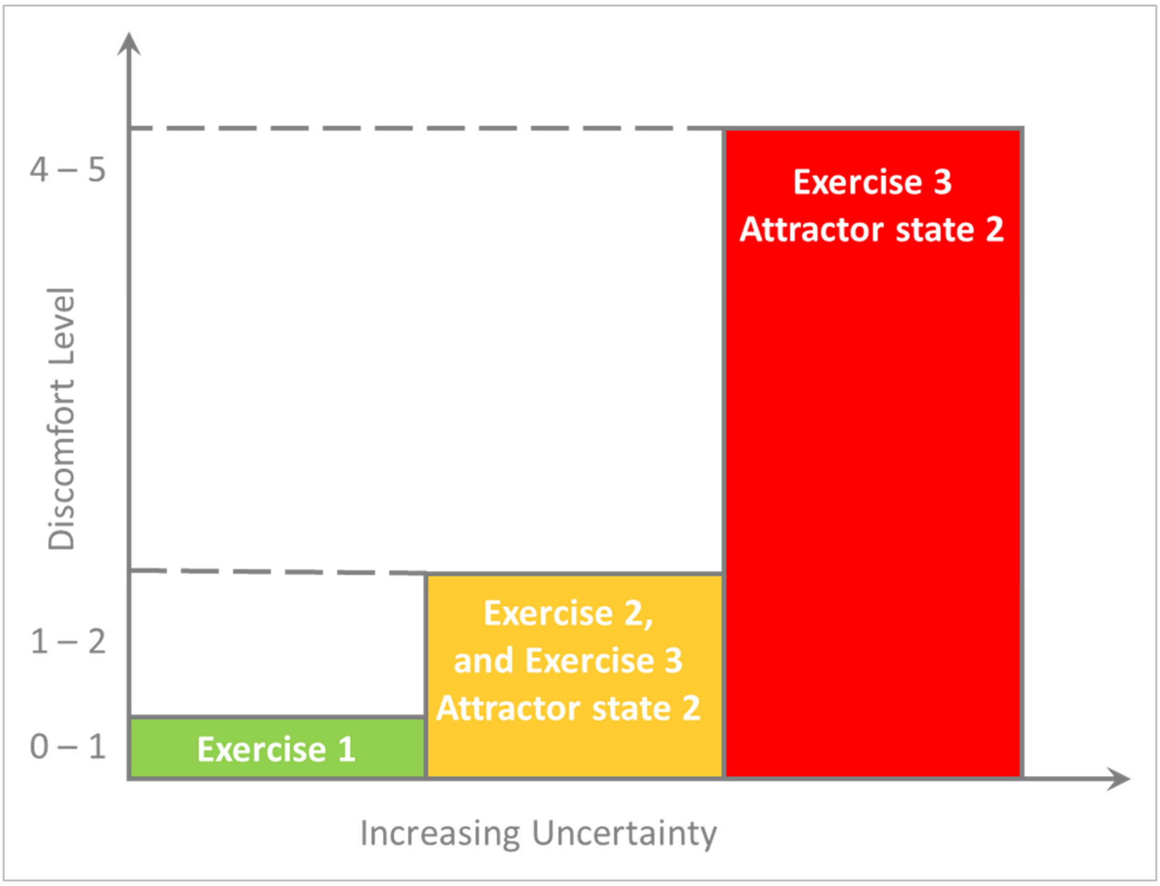

Figure 6.10: Uncertainty Landscape 3rd dimension

Both types of uncertainty were referenced in the various group debriefs of exercise 3 in connection with either the difficulty or discomfort associated with completing that exercise.

It might be tempting to suggest at first that the source of the discomfort is this uncertainty. As McDaniel and Driebe argue, “surprise in organisational life is predominantly viewed from a negative perspective” (2005, p. 8). Arrow et al. (2000) explicitly connect uncertainty with stress – people find uncertainty uncomfortable or anxiety-inducing. However, this is not always true. McDaniel and Driebe (2005) suggest that some surprise and uncertainty could be viewed positively. In fact, there are particular types of uncertainty that many people enjoy: for example not knowing the result of a sporting feature, not knowing the ending of a novel or movie, not knowing what you may receive as a gift for your birthday or other festival. These "enjoyable" uncertainties tend to have two common features:

i) they are "bounded" in space and time (they occur at or within certain locations you can leave, and they all have a finite finish time); and
ii) they have relatively low downside risk associated with them.

This second feature is particularly illuminating. For example, the more I am invested in the characters in the book I am reading, the more I might feel uncomfortable or anxious about the uncertainty in their fate. Similarly, if I have placed a wager on the outcome of a sporting event then my anxiety increases at the uncertainty in outcome. It may be individuals' apprehension of risk that is driving the discomfort experienced in the sessions.

6.2.2 Responding to micro-scale properties: risk and power

What is at "risk" in these exercises? Because the exercises were explicitly constructed as simulation "sandbox challenges" there is no risk at the task level – there is no consequence connected to a team's ability to complete the tasks (or not). The risk in this case is entirely at the level of Bion's (1961) "basic assumption group", the relationships that comprise the team dynamics. Despite the sandbox nature of the specific challenge, each team arrived in the room with pre-existing relationships, and those relationships would persist after the exercises. It is possible then that in this exercise there was a very real risk that by an action or utterance, a team member might do damage to either:

i) their relationships with other team members (a "social" risk); or
ii) their membership of the group or their standing within any formal or informal group hierarchy (a "political" risk).

It would not be appropriate to discuss the apprehension of risk within a team setting without considering how it may be influenced by power. In section 2.4.5 above, I theorised about how power might influence complex team dynamics, and, in particular, discussed formal versus informal sources of power in teams. Now it is possible to consider how each type of power manifested in the exercises.

Formal power

Formal power is situated in formal structural positions (Bolman & Deal, 2017). Each of the teams in this study had a positional team “leader”, with authoritative power. In the exercises, three of the team leaders used their formal positional power to influence the team discussions in exercise 3.

In team 1, the team leader played a “jester” type role, trying to keep the conversation light and the team away from too much tension. Initially, the group paid a lot of attention to the leader’s jokes, with the result that the tension dropped out of the conversation (see markers A, B and D in the team 1 phase diagram, Figure 5.6 in section 5.10 above). Over the duration of the conversation, the team paid less and less attention to the leader as they associated his interjections with play or distraction. In team 2, the team leader played a “director” type role, instructing the team to resolution to prematurely finish the discussion and reduce the tension. This resulted in the team adopting the “Abilene solution”, being divided over the “resolution” achieved but going along with it because it was the team leader’s suggestion. During the debrief the team leader regretted taking this role. In team 4, the leader played a “challenger” role, trying to drive *more* tension into the discussion. As a result, his team physically moved away from him, and his contributions were sometimes met with silence.

Mahmoodi, West and Grigolini (2018) compared the evolution of so-called “top down” and “bottom up” social system models in self organized criticality. They found that:

> “When the spontaneous bottom-up emergence of altruism is replaced by a top-down process, mimicking the leadership of an elite, the crucial events favoring the system’s resilience are turned into collapses.” (p1)

This is an interesting finding in that it runs counter to the conventional views of leader-led action in organisational discourse, as covered in section 2.3 above. In teams 1, 2, and 4 top down leader activity triggered some of the slides away from attractor state 2. By contrast in team 5 the absence of top-down instruction meant attractor state 2 was more resilient, as suggested by Mahmoodi, West and Grigolini (2018):

> “An attractive interpretation of the resilient nature of the bottom-up SOTC model is that the ideal condition of full democracy is the most robust form of social organization.” (p8)

The common element in each case is that the deliberate exercise of power by an authority figure in complex dynamics leads to increasingly uncertain and unpredictable outcomes. It would seem that the non-linear nature of complex systems means that small perturbations (such as the utterance of an individual, even with positional power) have unpredictable outcomes.

Informal power and risk

According to Fleming and Spicer (2014) and Mowles (2022), power in complex organisations is usually exercised informally. It may be that the main influence of power in the observed team dynamics was on the risk apprehended by team participants. As a team member, my understanding that someone else in the group might deliberately (or unconsciously) exercise some informal power to damage my standing in the group, my relationships within the group, or even my formal or informal membership of the group, might exacerbate my sense of the risk present. Some of these power sources might directly threaten my group relationships or membership, such as alliance or network power (sometimes called relationship power) and charismatic power. On the other hand, some forms of power could be exerted to control the conversation in ways that might reflect poorly on me, for example referent or expertise power, control of agendas, or framing (control of meaning or symbols) (Bolman & Deal, 2017, pp. 192–193).

In either case, it seems the apprehension of these risks, exacerbated by participants' perception of the informal power currents in the team, is what drove the discomfort reported by the majority of individuals across all groups. What was the impact of this individual discomfort at the meso or team level?

6.2.3 Meso-scale or emergent properties

I claimed above that "there is uncertainty in the team dynamic in actioning the task", the uncertainty in how others might respond to my utterances or actions in the exercise. At risk are my relationships with others in the room (social risk) and my own standing within the group formal or informal power structures (political risk). We can see then that the uncertainty is actually about whether my relationships in the room (social risk) or my standing (political risk) will survive whatever action I take in the group.

This uncertainty is not novel, and its attendant discomfort is felt individually and asymmetrically across the group. What is interesting in this study is that this asymmetric individual discomfort aggregates into a systemic emergent factor in the group. In statistical thermodynamics there is an analogous effect: the individual kinetic energies of various particles in a gas aggregate into an emergent macroscopic property called "heat". There is no sense in which "heat" or "temperature" can be applied to any of those individual particles, it is only a systemic property. In a similar manner, we find here that the individual discomforts and anxieties felt by team members in exercise 3 aggregate into a systemic property.

It is tempting to call this emergent group property “heat”. After all, the idea of some sort of property of a team discussion called “heat” has been used before, for example by Jane Fried (2016, Appendix A – Working in Groups and Facilitating Discussions):

> Watching group dynamics is like watching a pot of soup heat up. As the soup gets hotter you can see currents and bubbles in the pot. These currents affect the various ingredients in the soup differently.

However, the term “heat” is not rigorously defined for use in this way. Instead, scholars tend to focus on “conflict” or “disagreement” as a driver of what we might call “heat” in discussions. Franz (2012) devotes a whole chapter of his book *Group Dynamics and Team Interventions* to conflict and its impact on teams, Aula and Siira (2007) apply complexity thinking to conflict in groups, and the original version of the Stacey Matrix (1996) plotted “disagreement” on its vertical axis as a driver of team state change. Guastello (2011) takes a non-linear systems dynamics approach to understanding conflict and its consequences.

This study proposes that defining group tension in terms of conflict is too limiting. In the team exercises we saw evidence of high tension in the team dynamics at various points that were not associated with conflict. In fact, often the tension arose from individuals’ expectations that contributions might possibly lead to conflict and their consequential effort to avoid that possible conflict. In fact the anticipation of future conflict or disagreement can be as impactful in the group as its actual manifestation.

This emergent, meso-scale group property acts like a type of social emotional contagion. Schoenewolf (1990) calls emotional contagion a process of “induction” in which one group member’s emotional state influences others in the group. Hatfield, Cacioppo and Rapson (1993) explain that an emotional convergence results from a “tendency to automatically mimic and synchronize expressions, vocalizations, postures, and movements" (p96). We saw above in sections 4.3 and 6.1 that Hazy and Boyatzis (2015) have already shown how emotional contagion can spread through simulated agent populations in complex networks.

My interest in this study is in the meso-scale aggregate of this "discomfort contagion" in the group. As discussed in the preceding section on micro-scale individual properties, it is discomfort associated with risks. This discomfort is then rapidly socialized through the group via emotional contagion, until it becomes an emergent group level property. Thus I will call the property Emergent Social Discomfort (ESD).

Now let us consider how groups work with ESD. The sections below establish the two attractor states and the implications for each on our understanding of team ESD.

6.2.4 Equilibrium and far from equilibrium states

In sections 2.4.1 to 2.4.4 of the Literature Review chapter, I discussed Ilya Prigogine's work in applying equilibrium-based thermodynamics to complex systems (Prigogine, 1997; Prigogine & Lefever, 1973). I summarised my discoveries in those sections in this way:

1. Complex team states are relatively low entropy states.
2. Complex team states operate out of – and potentially far from – equilibrium.
3. Such team states are dissipative structures (Prigogine, 1978), meaning they require energy and resources to be sustained.
4. Left unsustained, they decay to equilibrium states, like an unkempt garden.

I might now apply the understanding gleaned in those sections to our discussion here. I begin with points 2 and 3 above. We've found that teams were triggered into a phase change into a complex state at the beginning of exercise 3, and so we can now equate *beginning of exercise 3* with *complex state,* with *far from equilibrium* *state,* and *dissipative structure*. I can add this extra information to the 3rd dimension of the Uncertainty Landscape from Figure 6.10 above to obtain an updated Figure 6.11 below:

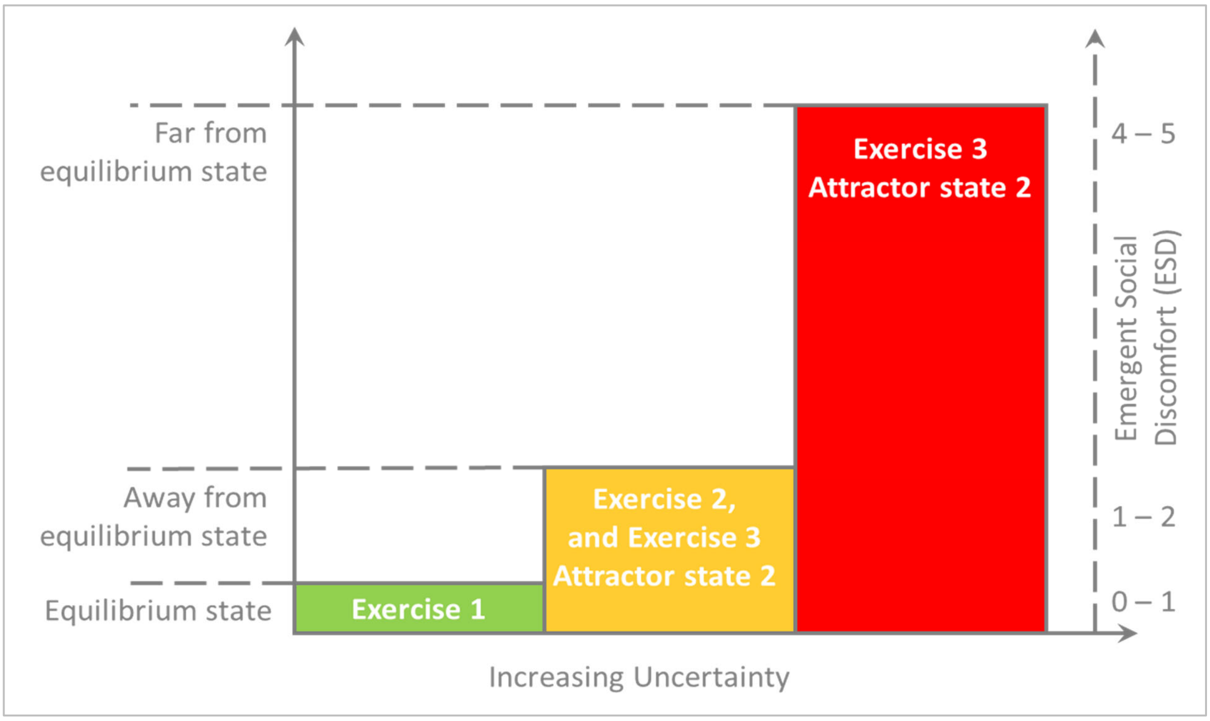

Figure 6.11: Uncertainty Landscape 3rd Dimension (updated)

We saw in the teams experiments that the complex state triggered by the start of exercise 3 is truly metastable in the manner described by Bak et al. (1989), Ball (2005) and Solé (2011). For teams 1 to 4, the complex state was easily disturbed by a range of tactics such as humour, social grooming or finding non-judgement solutions, each of which had the impact of reassuring group members of (or privileging) the relationships in the room, which reduced the feeling of risk and discomfort, and dropped the group back closer to an equilibrium state. Hence the complex state is metastable (easily disturbed).

There is something of an “attractor” in this complex state in that the triggering was consistent across all five teams. This attractor persisted for team 5, which returned to this state time and again, and in fact spent most of their time in exercise 3 in this state. But remember that this metastable complex state is dissipative (Prigogine, 1978), meaning it requires constant energy or work to be maintained. For team 5, this work was evident in the rapid pace of discussion and constant building on each other’s contributions. It is clear this type of work takes a toll on the participants over time, because team 5 also utilised a number of short dips down into states characterised by lower ESD to rest, to check in on each other, before resuming the far from equilibrium, higher ESD state.

In summary, team states can be distinguished by a group-level property ESD. This group level discomfort appears to be generated when teams engage in tackling a complex challenge (such as that in exercise 3). Team ESD, then, may be considered a complex aggregate of individuals’ apprehensions of social and political risk in tackling the challenge, and the discomfort and anxiety they consequently feel. When teams shift into complex states, they have higher ESD than when they are in complicated or simple states. In fact, teams in simple states characterised by little or no attention-driven conditional behaviour operate as baseline states or equilibrium states. By contrast, complex team states operate far from equilibrium and are dissipative – they require work or energy to be sustained.

6.2.5 Entropy and decay

The Second Law of classical thermodynamics introduces the concept of entropy, a measure of the unavailability of a system’s thermal energy for conversion into useful mechanical work. We met this concept in the Literature Review chapter above, where I used its more common definition as a measure of disorder in a system. The Second Law states that entropy never decreases in any closed system; in order to produce a decrease in entropy (and hence a local increase in order) in a system, you must add energy to it. To illustrate the Second Law in action: tidy gardens naturally evolve into unkempt gardens (increase in entropy or disorder), but it requires work and energy for an unkempt garden to evolve into a tidy one (decrease in entropy or disorder). In the absence of a source of energy or work, all systems will tend to decay into their highest entropy state, which happens to be when the system is in equilibrium with its external environment.

We live, however, in a universe of order, of pockets of low entropy. In complexity sciences the emergence of self-organisation in complex systems is an example. The energy cost associated with local reductions in entropy is a common theme in discussions of self-organisation, from the Narrative perspective (see for example Merali and Allen, 2011) to the hard computational Modeller's perspective (for example Dirk Helbing's *Social Self-Organization*, 2012). Maturana and Varela's (1980) cellular autopoiesis is also a type of (biological) local self-organisation and reproduction that represents a localised reduction in entropy for an energy cost.

Goldstein (2007) argues that complex self-organisation is not "order for free" (p. 66), it requires work. Andriani and McKelvey (2011) go a step further, contending that the supply of energy required to maintain a far from equilibrium state is itself an entropy production "factory", hence requiring *more* energy just to keep it stable: in other words, "running to stand still".

What does entropy mean for teams?

In the literature review above, I built on Claude Shannon's (1948) information-entropy formulation, Wissner-Gross and Freer's (2013) work on causal entropy and William Lawless' (2017) work on "the physics of teams" to establish what entropy might mean for teams.

The teams in this study have been shown to exhibit characteristics of complex systems when tackling the complex problem in exercise 3 – the problem triggered the initial state change. As a direct consequence of the above, we can say that when a team is in a complex state:

1. It is operating away from equilibrium.
2. It is dissipative.
3. It has lower entropy than when in complicated or equilibrium states.

This gave us a workable useful definition of entropy in a team context: a team's entropy level measures the availability of energy for it to use to do productive work. A low entropy state correlates with high energy consumption (highly dissipative) and hence high entropy production. Furthermore, that energy consumption and entropy production might be split into different tasks and activities, and some of these might be in tension.

The main value of the concept of entropy in this study is that it provides a directional asymmetry between the complex state and the complicated state. In this study, I found a second "basin" attractor state on our landscapes: the yellow complicated state. This attractor strongly pulled teams 1 to 4 consistently back down to a state marked by lower ESD and higher entropy, and influenced the solutions at which they ultimately arrived. Arrow et al. (2000) discuss dual attractor states in the context of tension and conflict in small groups. They make the point that basins in phase diagrams are generally stronger attractors than fitness peaks. This is for two reasons:

i) because basins are locally stable (movement out of the basin is resisted locally by restoring forces) whereas peaks are metastable (movement away from a peak tends to be reinforced locally); and
ii) because (in this case) the yellow basin state is higher entropy than the red complex state, and the second law of thermodynamics points in the direction of increasing entropy. Hence there is an energy cost associated with going in the other direction.

Now it is clear why the yellow state is such a strong attractor for the teams in this study – it is closer to an equilibrium state, and of lower team ESD but higher entropy than the complex state. In the absence of concerted work, teams will inevitably naturally find themselves regressing to this state. In the exercises in this study, however, I found that the human experience of discomfort associated with the social and political risks in exercise 3 added an extra impetus to drive the teams to a more relaxed closer to equilibrium state. The aggregated ESD plays the role of local forces on the phase diagrams, reinforcing movement away from peaks of complexity and lower entropy and towards basins closer to equilibrium.

Further, Lawless' (2017) treatment of entropy in teams gives us some insight into what happened differently with team 5, and perhaps why it did. We saw above that one of the consequences of the complexity of the challenge in exercise 3 was that team members spent time and effort concerned about how what they say or do might damage team relationships or result in social or political consequences. This type of thinking falls under Bion's (1961) basic assumption group, and Lawless' (2017) "work on itself". Teams that spend less energy on this type of work have more energy available to spend on resolving problems. In this study, team 5 oscillated between the two attractor states, but spent less time in the complicated, higher entropy attractor state and more time in the complex, lower entropy state. They also processed considerably more information than the other teams (Memo 12 shows they had four times the contributions of other teams) and were the only team to reach a consensus solution. It may be that teams are more practised at this type of challenge and so have more confidence in their team structure, allowing them to minimise the production of entropy on their assumptive group, freeing up more capacity to consume energy on their problem at hand.

Bringing it all together

I can now add all we've learned in this section to the Uncertainty Landscape and expand it into a third dimension, showing the increase in team ESD towards the metastable complex state, and the increase in entropy driving back towards the equilibrium state:

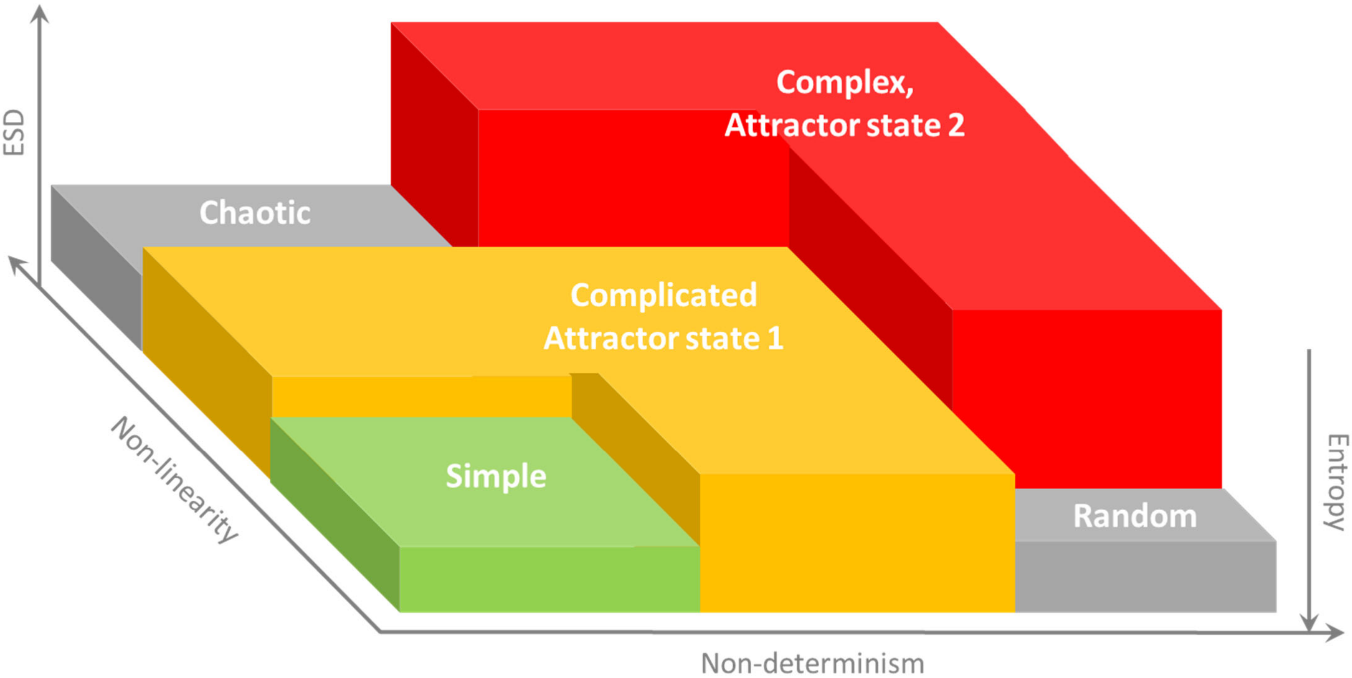

Figure 6.12: 3D Uncertainty Landscape

The green section of the Landscape is an equilibrium state with maximal entropy and minimal ESD. The red section of the Landscape is one attractor state: a dissipative, relatively low entropy, complex state far from equilibrium that is metastable and requires work or energy to be sustained. And the yellow state is the basin attractor state: with lower ESD and higher entropy than the complex state, and little or no complex conditional behaviour. We now have the beginnings of understanding of the operation of entropy on team states. Complex states are states of local organisation and lower entropy. In the absence of work or energy, they will naturally decay into simple or equilibrium states, which are characterised by little or no complex structure or organisation and higher entropy.

6.3 Contribution to practice of leading teams

What do the Uncertainty Landscape and the theory of Complex Dissipative Teams synthesised above mean for members of leadership teams in organisations?

6.3.1 Complex states are uncomfortable for team members

Let us begin with a summary of what we have learned about the behaviour of teams. Firstly, teams will experience state changes when dealing with different types of challenges. The different challenge types may be located on the Uncertainty Landscape (see Figure 6.13 below).

The challenge types are actually defined by the state response provoked in teams tackling them. Teams tackling complicated challenges need not work in highly interdependent complex states. Tackling a complex challenge or issue triggers a state change into a complex state.

When a team enters into a complex state, interactions between people in that team will have increased uncertainty in them. This uncertainty is at the content level (what we're talking about) and at the dynamic level (how others will respond to what I say). Dynamic-level uncertainty requires people to take risks with each other – both social and political – which is felt by individual team members as discomfort. At a group level, this discomfort aggregates to team emergent social discomfort (ESD).

Note that discomfort is not necessarily a bad thing. Elliot and Devine (1994) found in their study that some psychological discomfort is attendant on any cognitive dissonance, which Bareil et al. (2007) found to apply in organisational change,

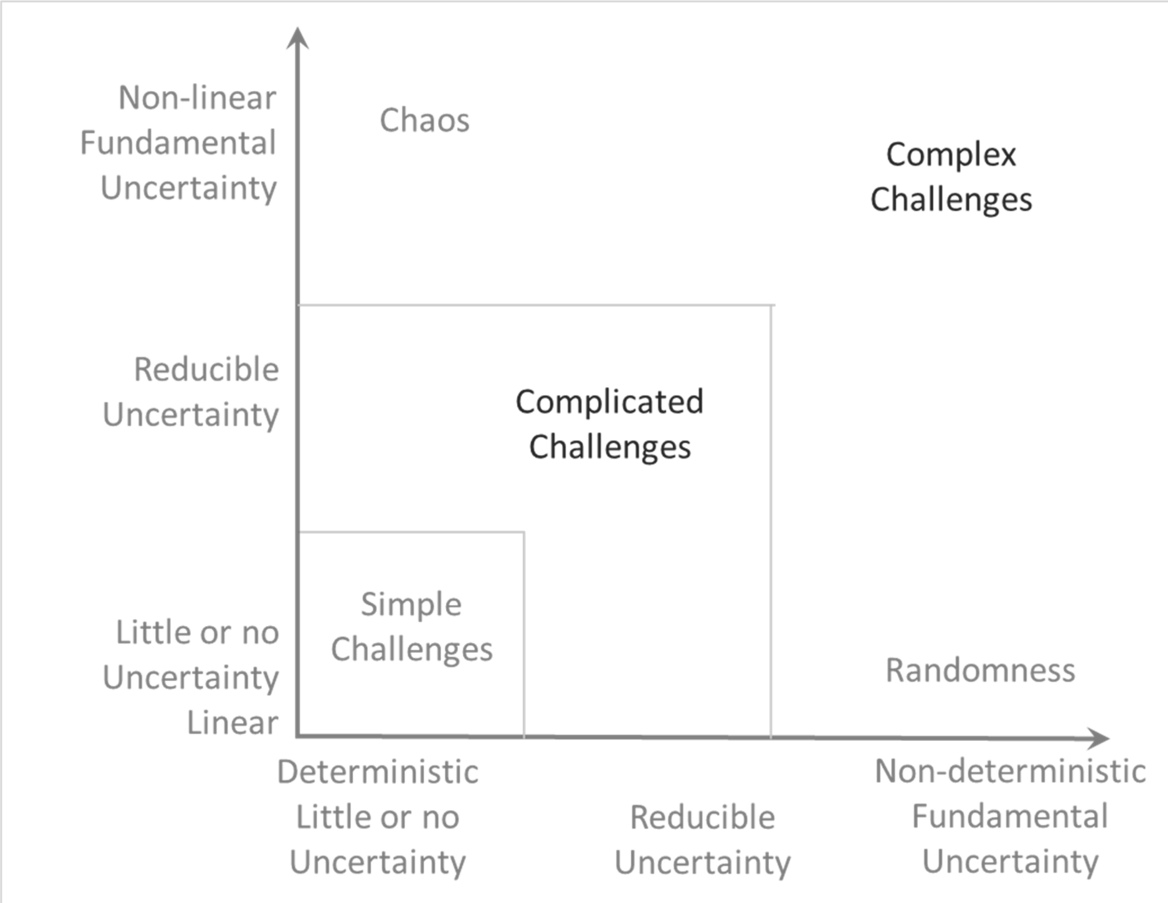

Figure 6.13: Uncertainty Landscape

and Taylor and Baker (2019) amongst many others applied to learning. Regardless, most people do not enjoy the experience of discomfort or anxiety, and so teams don't like to stay in complex states, since these states usually involve discomfort. Team members and teams in general may try to dissipate or relieve the discomfort in various ways:

Using humour to relieve tension

Team members (including team leaders) may engage in humour specifically for the purpose of dissipating tension or redirecting the group to a less complex, uncertain or challenging topic. This is a well-documented strategy in groups. Noël Carroll, in his "very short introduction to humour", wrote "[Humour] can be used to relieve stress, … to dissipate tension within a fractious group" (2014, p. 76). Similarly, Coetzee and Cilliers, in their work on diversity, found: "It could be argued that this [humour] is not progress, but a (unconscious) defence against the anxiety provoking work" (2012, p. 22). In this study, four of the five teams used humour specifically to dissipate tension in the group discussion. Sometimes the humour is unhelpful for the group, for example the team leader in team 1 used humour to distract the group or move them away from potentially difficult topics. Some groups use humour to cope with tension, but not dissipate it (Bouwmeester, 2013; Grugulis, 2002). This can be helpful for the group, for example team 5 used short jokes to provide temporary relief or a break from the topic before jumping straight back into it.

Using "social grooming" to relieve tension

Kate Fehlhaber (2013, p. 1) provides a good working definition of social grooming and its function in groups:

> Humans are particularly unique in that social grooming can take on a completely non-physical form due to our extensive spoken and written language and is probably the dominant form of social grooming. A few kind words are often all the "grooming" it takes to strengthen social relationships with others.

Every team studied in this piece of research engaged in some form of generalised social grooming whilst tackling exercise 3. This is interesting because social grooming in humans is specifically undertaken to reinforce relationships (Takano, 2018), which suggests that participants felt relationships needed reinforcing *during the exercise*, which in turn might suggest those participants felt those relationships were at risk. As in the use of humour above, social grooming was used in two different ways: in a positive sense to reinforce specific relationships in the group, and in a less constructive way to distract the group from being critically reflective (for example "but we know we're a great team of people").

Devising solutions geared to relieving group discomfort rather than addressing the actual challenge

Four of the five teams studied engineered sub-optimal solutions to exercise 3 that were in service of curtailing the discussion or mollifying the group (for example "we're all equal" circles or perpendicular lines), rather than sitting in the discomfort long enough to arrive at an optimal solution. These engineered solutions were remarkably "emergent", appearing multiple times across the groups. Furthermore, in some teams members decided to refuse to voice contrary opinions or disagreements and instead go along with group solutions they actually disagreed with (so-called Abilene solutions). Jerry Harvey, who originally concocted the Abilene Paradox, uses the phrase "action-anxiety" (Harvey, 1974) to describe the driver for voicing agreement in a group setting to something you actually disagree with. This type of emergent group behaviour is problematic, in particular, if leadership teams engaging with the most challenging, complex problems come up with solutions that are more in service of relieving their immediate discomfort than in actually addressing and resolving the challenge.

It is important to remember that even teams that performed well in the exercises in this study still reported significant discomfort. The task of the leader of a team then is *not* to try to find ways to relieve their team's ESD, rather to build their capacity or fitness for their team to sit in the discomfort and still find ways to be productive.

Given what we have learned about complex team states – their maintenance costs, the social and political risk, the discomfort – how should leaders regard such states in their teams? Are complex states to be sought out or engineered? Or are they to be avoided at all costs?

6.3.2 Why work away from equilibrium?

In the literature review chapter we found some support for the notion that complex team states might be regarded as higher performance team states. For example

Gully et al. (2002) found that “team member interdependence” was one factor that significantly affected team efficacy and performance. Team member interdependence requires team member conditional behaviour – a signature of complex team states. Nowak and Highfield (2011) through their work in population ecology and Axelrod (1997) through his prisoner’s dilemma tournaments also found that cooperative states are more productive, but that they are *not* equilibrium states. Hazy et al. (2007) and Marion (2008) describe how as a system transitions to a complex state it begins to adapt, learn and self-organise. Adaptability and learning are generally recognised as productive competencies for teams.

In this study, four teams spent various amounts of time in a complex state attempting to deal with the complex challenge that was exercise 3. However, the lower discomfort states proved to be too strong an attractor for these teams. This implies that there is a cost associated with staying in a complex state – or a benefit associated with dropping out of that state – which I have described theoretically in the complex dissipative teams section above. By contrast, team 5 spent most of their time in the complex state, only dipping briefly into lower discomfort states. This suggests there is also some benefit to staying in the complex state. The interplay between the different states is illustrated in the 3D Uncertainty Landscape (see Figure 6.12 above).

In this diagram one can immediately see that work must be done to raise a team to a higher complex state, and that it may be easy to drop back down to a complicated or simple state. Let us articulate what some of these benefits and drawbacks of being in a complex state might be.

Benefits of being in a complex state

To extract the benefits, consider that team 5 achieved a consensus solution to the challenge presented by exercise 3, as well as how that solution was achieved:

- The faster pace of conversation privileges group sensemaking conducted out loud over individual sensemaking conducted inside individuals' heads. This results in co-constructed sensemaking, making that sensemaking richer.
- Co-constructed sensemaking is the work that drives the self-organising of consensus in whatever solution is achieved, since group members have contributed to and participated in the construction of the solution, rather than being influenced to adopt someone else's solution that has no input of theirs. Teams 1, 2, 3 and 4 self-organised in some respects, especially into the "we're all equal" solution and "Abilene solution" of Memos 7 and 8 (respectively). However, it was team 5 that really displayed rapid self-organisation and learning: they developed a consensus solution to a novel problem.
- The increased interdependence in the conversation (team members building on each other's contributions) takes better advantage of diversities in the group membership, since more opinions and inputs are canvassed and individuals are encouraged to build on each others' contributions.
- The faster pace of conversation can lead to faster progress towards solutions.
- The sharing and building on ideas canvasses a more broad range of inputs, meaning the group can consider a greater variety of possible ideas. This is important when dealing with situations involving novelty (issues the group has not met before) or uncertainty (issues with unknowns, or unfamiliarities), where a greater assortment of inputs is required.
- As a foundational feature of complex systems, the increased interdependence in the conversation can lead to more emergent and novel solutions that don't sit in any one individual's head. This is much in the same way that the complex "design" for a termite mound emerges from the interdependent interaction of the termites – it doesn't exist as a whole plan in any one termite's head.

Drawbacks of being in a complex state

In order to discern the drawbacks, consider how and why teams 1 to 4 did not achieve consensus solutions, and instead kept dropping back to lower ESD states:

- In maintaining rapid interdependent conversation, there is very little time to pause and reflect on what one is about to say or do before contributing, and hence less opportunity to be careful about contributions. As Ralph Stacey said in his final Complexity and Management Conference address, “You are often not in control of the outcome of what you contribute, but you are nevertheless responsible for it.”[8] This “unfiltered” contribution can hence lead to social and political risk in the conversation, which will be felt by the group as discomfort.
- The increased social risk in the group is real – damage may be done to group relationships if there isn’t enough social capital or trust in the group to insure against the risk.
- Groups with less practice at being uncomfortable together will have a lesser tolerance for it. This can manifest in the group deciding on non-optimal solutions merely to escape the discomfort.
- Honest disclosure in these settings can add extra risk to the conversation; individuals may choose to not share what they’re thinking, which can lead to groupthink, and “Abilene solutions” like those observed in our study.
- Working away from equilibrium requires more work, and more focused attention to a broader range of group members. This will be felt by group members as being more tiring – working in complex states makes you tired!
- Working in complex states is not always enjoyable. Even team 5 mentioned that the experience was uncomfortable.

[8] Ralph Stacey on complex responsive processes of relating at the Complexity and Management Conference. Retrieved September 30, 2021, from https://www.youtube.com/watch?v=wCevq8o-AE4

- The broader canvassing and lack of imposed structure in the discussion can make the conversation inefficient, especially if there is not great need for novelty or not much uncertainty. This reinforces that it would not always be useful to drive a team into a complex state to deal with a merely complicated problem.

Importantly, the analysis above shows that it can't be said that being in a complex state is a universal and unalloyed good. In fact, in section 6.1.3 of this chapter I suggested that a team is triggered into a phase change to a state that matches the uncertainty of the challenge, task or opportunity with which they are currently dealing. This could mean that the ideal team state is one that matches the complexity of the task at hand: there is no point pushing your team into a complex state – with all its attendant risks and costs – if such a state is not required. On the other hand, leadership teams will certainly be presented with complex, uncertain or novel situations that require complex team states to best deal with them.

6.3.3 Being productive in complex states

There is little doubt that part of being a leadership team is regularly having to deal with complex decision making and complex challenges (Anderson, 1999; Hazy et al., 2007; Uhl-Bien et al., 2007; Stacey, 2010, 2011). If such challenges are going to trigger teams to shift into complex states, and if teams are going to wish to avoid such complex states, then how might we ensure that the complex states are sustainable and productive? I propose to address this question in three ways.

1. Building fitness for complexity

Karakul and Qudrat-Ullah (2008) as well as Spector (2008) suggest that a certain type of specialist expertise is required to tackle complex and dynamic decision making. Each of them references work by Ericsson (2006), who describes the attainment of expertise through experience as *deliberate practice*, the development of tacit knowledge, practical intelligence and behavioural resilience through experience (Cianciolo et al., 2006). Deliberate practice is a learning methodology that is more akin to working on your fitness in a gymnasium than traditional classroom based learning: it is essentially practical and builds fitness for task (Ericsson, 2006).

It would appear that two types of "fitness" are required for working in a complex state. The first is a practical capacity to sit in discomfort longer and be productive. Stephanie Burns (2010) notes that this is a capacity that can be grown through repetitive practice, each time pushing further into discomfort and staying there longer.

The second fitness is at the group level. In her work on developing leadership in complexity, Ellen Van Velsor (2008, p. 333) notes that "developing leadership capacity might include enhancing interactive dynamics"; that is, focusing on building the capacity of the team rather than using the more traditional approach of focusing on building individuals as leaders. In this case, the team needs to build a type of social capital to insure against the risks team members will be asked to take.

Portes (1998) notes that "social capital" has become a common term with a wide variety of attributable meanings. In this context, I specifically use the term in the sense of Putnam (2001), who defines it as the connections between individuals as well as the norms and trust that flow from those connections. Coleman (1988) also includes trust in his definition of social capital.

In exploring the concept of trust in small military teams, Adams and Webb (2002, p. 1) suggest "the need to trust other people arises from the need to be able to predict and understand others". Franz (2012) and Mayer et al. (1995) also link trust in teams to an ability to predict responses in others. This "predictability" provides the connection back to my own hypothesis that social and political risks drive the discomfort in the teams that aggregates into the team ESD experienced in complex states. Social capital, or team trust, in the team could help team members feel increased confidence that the relationships in the group will survive whatever risky contributions they are about to make.

2. Working differently when in complexity

We saw in section 6.3.1 above that humour and social grooming could each be used to help teams maintain their complex state, or to dissipate tension so as to drop the team out of complexity. The most productive pattern we saw in the teams who tackled exercise 3 was team 5's pattern of sustaining the uncomfortable discussion by taking numerous short breaks. These breaks took two forms:

a) short humorous interjections to briefly break tension, without an effort to change or redirect the topic, followed by jumping straight back into conversation *where it was left*; and
b) very specific social grooming and care. Rather than the generalised "we're all great" team mollifying, these were specifically directed at a single individual: "are you ok?" or "are you still with us?" The result is that the grooming has the effect of re-engaging specific individuals with the team state rather than dropping that team state for everyone.

Using social grooming and humour in the ways described above helps the team stay in a complex state, rather than using an "escape hatch" to drop back to an equilibrium state.

3. Having a different understanding of what you're experiencing in complexity

It is generally suggested that some understanding of complexity might assist members of leadership teams better understand and then optimise their team dynamics. I hope that the Uncertainty Landscape might help ground understanding of the various team states in which team members may find themselves; and that complex dissipative teams might augment that understanding with drivers for how and why teams came to be in that state, and what it means to be there.

6.4 Positioning this study in the field

> If we are to have an effective complexity science applied to firms, we should first see a systematic agenda linking theory development with mathematical or computational model development. (McKelvey, 1999, p. 24)

In immersing myself in the literature prior to commencing this study, I was struck by the polarised approaches to understanding complexity: the Narrative approach and the computational Modelling approach, labelled the “Metaphorical School” and the “Neo Reductionist School” respectively by Richardson (2011, pp. 372–373). You might recall that the central debate is over whether the agent in a human system can be over-simplified in order to make a human system modellable. This debate is variously called “dynamic minimalism” (Vallacher & Nowak, 2008), “explanatory reductionism” (Hackman, 2003), or another face of the ongoing “science wars” of social science (Flyvbjerg, 2002). The neo reductionist approach is exemplified by papers such as Hazy et al. (2007), Helbing (2010), Hollingshad et al. (2013), Miller and Page (2007) and Bill McKelvey (1997). The Narrative approach is more typified by the work of Stacey (2011), Anderson (1999), Cilliers et al. (2002) and Tsekeris (2015).

In an earlier version of my literature review, I suggested that scholars from these different approaches to the field of complexity don’t exhibit the level of rancour or hostility characteristic of the broader “science wars” of the social sciences. Reviewing this early draft, Chris Mowles (Professor of Complexity and Management at the University of Hertfordshire and a colleague of Ralph Stacey) disagreed: “Oh, yes they do, mate!” More recently, some authors such as James Hazy and Bill McKelvey have attempted to straddle both sides of the debate, but even Hazy has adopted a cautionary tone in his positioning of metaphor in complexity (Hazy, 2014).

6.4.1 Scale

The first way in which this study was deliberately positioned between two traditions of scholarship applying complexity thinking in organisational contexts was in terms of scale, as shown in Figure 6.14 below:

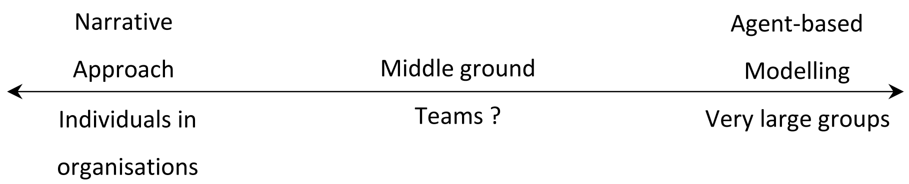

Figure 6.14: The space for a middle ground

The thrust of the Narrative approach to complexity is to privilege the actions and interactions of each individual as being too complex in themselves to be represented by simplified “agents” in a mathematical model. This approach works best in situations where the actions of an individual can have a dominant impact on the system’s trajectory. Meanwhile the Modelling approach reduces the degree of freedom of each individual to a simplified agent so that mathematical or computer-generated models can be utilised to investigate group behaviour. This approach works best in groups of a size and scale where the actions of specific individuals can be safely ignored.

The first step in bridging these two approaches is to find a scale at which they might be feasibly present. This scale is Hackman’s (2003) meso-scale: the scale of group behaviour, noting, however, Hackman’s caution to investigate multiple levels together. At the scale of small teams we can note the interplay between individual behaviour and emergent group behaviour, small enough for individual behaviour to defy the simplification of agent-based modelling, yet sufficiently constraining in individual behaviour for consistent themes to emerge at team level and across teams. This is what was found in this study – the meso-scale of teams was modellable after a fashion (see the “simulation exercises” in section 6.4.3 below), and meso-level group behaviour was extracted from each team. As we shall see in detail below, the study worked well at the team scale.

It is most likely, however, that this type of study is scale specific, it doesn't scale up or down. Dooley and Lichtenstein (2008) argue that the best method for studying complex leadership dynamics is with real-time observation. However, they caution that the biggest problem with observing such dynamics in real time is the sheer volume of data generated – it is a methodology that is difficult to scale. This warning is borne out in this study: even in very short observations of five teams, an extraordinary amount of audiovisual and reflective data was captured for analysis. This reinforces the suggestion above that this type of "bridging" study is not scalable – it works best at the level of teams.

There will remain large group populations such as those in the work of Miller and Page (2007), Galam's (2012) sociophysics and Helbing's (2010) quantitative sociodynamics where individuals can be safely reduced to model agents, and will benefit from the predictive capability and generalisability of models. There will also be individual scales where the metaphor-based work typified by Marion (2008), Uhl-Bien et al. (2007) and Stacey (2011) works best, and there is no use for computational models or simulations, or there are insufficient constraints on behaviour to make simulation possible.

6.4.2 The "agents" in the quasi-experiments

In the literature review above it was found that one of the key points of dispute between the narrative and modelling approaches to complexity was the "dynamic minimalism" (Vallacher & Nowak, 2008) of the agents. In particular, three agent features were identified as crucial questions to answer:

1. How *sophisticated* do the agents need to be? (Miller & Page, 2007; Boisot & McKelvey, 2011)
2. How *heterogenous* do the agents need to be? (Miller & Page, 2007)

3. To what extent does the context of leadership teams *constrain* agent behaviour or reduce degrees of freedom of behaviour? (Mowles, 2022; Stacey, 2003)

Constrained behaviour

It was observed in the various team simulations that team members' potential range of behaviours was constrained by the group context. Examples include:

- Memo 4, in which team members variously reflected that they considered how they thought others in the group might respond before speaking or acting;
- Memos 5a and 5b, in which team members used humour or social grooming to deliberately reduce experienced team tension;
- Memos 7a, and 7b, in which various quasi-solutions emerged in the group to avoid discomfort or disagreement; and
- Memo 8, in which team members signalled agreement to a group solution that they later admitted they did not, in fact, agree with.

The constraints come from the combination of the group and its norms, and the context of the exercise it is confronting with its attendant potential for uncertainty, risk and anxiety. These constraints had the effect of reducing the range of possible behaviours for group members, and hence it is perhaps no surprise that these constrained behaviours were precisely the ones repeated across multiple groups in this study.

Agent sophistication and heterogeneity

In addressing these questions, the study chose to encode the highest possible levels of sophistication and heterogeneity in the agents by having each person in each team simulate themselves in their team context. In the study, it can be seen that agent heterogeneity is critically important to make a theoretical case for emergent behaviour – the richness of the differences between individuals and teams makes the behaviours that were consistently seen across the teams more striking.

On the other hand, agent sophistication is harder to assess. There is no doubt that each agent in this simulation was “over-engineered”; that is, overly sophisticated for the task at hand – operating in a leadership team is only one very small part of each person’s experience and capability. Each person embodied a wider range of potential cognition and behaviour than was required to respond to the task at hand. However, to Miller and Page’s (2007) point about scaling down agents, it is difficult to pinpoint precisely how much each agent could have been “dumbed down” and still contribute appropriately to an accurate representation of their team. However, it is likely a moot point: the main reasons for dumbing down agent sophistication in modelling are to (a) reduce the difficulty and time in designing the agent behavioural rules, and (b) to reduce the processing power required to have all the agents interact, and neither of these reasons are problematic in a self-simulation. The agents come “pre-designed”, and the simulation has precisely as much processing power as required to render itself.

In summary, the simulation met the three agent features to produce a good model: agents that were sufficiently heterogenous, almost certainly over-sophisticated, and we saw evidence of constrained behaviour in the groups.

6.4.3 The simulation exercises

Inspired by Ashby’s (1956) law of requisite variety, Max Boisot and Bill McKelvey created an analogous “law of requisite complexity” (Boisot & McKelvey, 2011). Cilliers’ (1998, p. 58) framing is instructive: “Models of complex systems will have to be as complex as the systems themselves.” Building on this law of requisite complexity, I decided the best way to model a team was with a simulation of the team itself. A case-in-point simulation works particularly well in small groups in which we can readily observe, track and ultimately engage with various individual and group behaviours. This type of immersive activity allows the researcher to observe participants directly, albeit in an artificial environment, rather than at the reflective distance of a qualitative interview or quantitative survey. In this way, the exercises in this study, framed as a simulation, were a model of the team.

I would like to highlight what I believe are two factors that turned out to be key to the simulation's success:

1. The contrasting of complicated/technical challenges with complex/adaptive challenges (Stacey, 1996; Heifetz & Linsky, 2002a; Kurtz & Snowden, 2003; Uhl-Bien, et al., 2007); and
2. the structure of exercise 3 with its conditional behaviour.

The structure of the three exercises was originally designed to mimic the three states on the diagonal axis of the Uncertainty Landscape: simple, complicated and complex. In practice, the teams reported little difference between exercises 1 and 2, and showed little difference in performance. However, it turns out that the first two exercises provided framing (Mowles, 2022) for the third one – the act of lining up for exercise 1 and exercise 2 gave participants a direct and proximate experience of what "success" looks like in exercise 3: standing in a ranked line. In exercise 3 this contributed to the anxiety and discomfort of participants, and they did not want to stand in a line:

Team 2

Team leader:	Yeah, I don't… if we do that, if we line up and do that we, we, we don't believe we are a team. So I don't wanna do it.
Female speaker:	You generally don't rank the people while they're in the room with you! [general laughter]
Male speaker:	That makes it harder doesn't it?

And <u>Team 4</u>

Team leader:	(to researcher) Do you want to ask us a question about how uncomfortable this exercise is?
Multiple voices:	[laughing]
Speaker 2:	I don’t think we found it that uncomfortable because I don’t think we really… did it. (laughing)
Researcher:	Right, so we’re done, we’re not going to stand in a line?

Multiple team members shake their heads.

The other benefit of exercises 1 and 2 was to provide a benchmark for comparison for participants in the reflective debrief section. Participants readily compared and contrasted their experience of difficulty and discomfort between the exercises. It is much easier to do so in relative terms than in abstract absolutes.
Exercise 3 further confirmed the link between uncertainty and anxiety established in the methodology chapter above (Buhr & Dugas, 2002; Carleton et al., 2012; Chen et al., 2018; Freeston et al., 1994; Hirsh et al., 2012). The simple framing of having participants judge each other in front of each other without an objective schema for doing so produced uncertainty at the content level of the discussion (how do we proceed? what criteria do we use for assessment?) and also at the dynamic level (social and political risk), and this uncertainty produced individual anxiety that aggregated into the group ESD defined in the previous section.

The presence of the social and political risks and their attendant emotional responses ensured that groups stayed experiencing the task rather than attempting to intellectualise it and resolve it in the abstract. Such intellectualisation can be considered a defence mechanism where reasoning is employed to avoid emotional stress (Gabbard, 2017; Vaillant, 1992). We saw some people in the various exercises use this tactic of trying to use thinking to avoid feeling. One recurrent example through the quasi-experiments was when participants referred to themselves in the second or third person instead of first person – the effect is to move the discussion into an abstract discussion of how “people” behave, and away from discussion of themselves and their behaviour in the specific. However, the phase diagrams suggest that the pressure of the task and the present political and social risk in the exercises kept dragging participants away from the relative safety of abstraction and into the discomfort of the experiential present.

6.4.4 The application of narrative insight

Narrative was used in two ways in this study: as an explicit tool in analysing each team’s performance in the quasi-experiments, and also in the way insights were extracted from the study.

In the Methodology chapter I noted that complexity authors such as Byrne and Callaghan (2013), Stacey and Griffin (2005), Stacey (2010), Cilliers (1998), Arrow et al. (2000) and Mowles (2016, 2017) include the concept of *reflexive narrative* as a central feature in their narrative approach to working with complexity. *Reflexive* sensemaking is the real-time sensemaking made by the group talking about what it is doing while engaged in that doing. Reflective sensemaking happened after each exercise (researcher and group in the immediate group debriefs, and then researcher alone later) and helped extract the meaning from both. The co-constructed sensemaking in the debrief and by the researcher post session draws heavily from the narrative approach. This approach produced particularly rich data for the cross-team analysis, allowing me to interweave Hackman’s (2003) micro- and meso-level analysis.

A narrative approach is also evident in the structure of this discussion chapter. Rather than using the simulation models to provide systemic descriptions or plug-and-play predictive capacity, insights have been extracted from a comparison of the simulations and then theorised about in a narrative style, as described in the literature review above by Helbing (2012) and Mowles (2022).

6.4.5 Mixed methods

In this study, the "middle ground" positioning described above was originally indexed to scale. However, as the study progressed and a methodological approach was constructed, it became apparent that perhaps the best way to approach this middle ground was with a mix of approaches from either end of the complexity field. What, then, is the best way to investigate this middle ground of teams? In constructing this piece of research, I chose to use a mix of methods and analytical techniques to conduct the study and scrutinise the results obtained. In particular, in investigating this middle ground, my methodology employed elements of both the modelling and narrative approaches to complexity.

Bringing them together: *complementary methodologies*

Dooley and Lichtenstein (2008, p. 277) suggest that the best analysis for this meso-level data is a mixture of "metric and perceptual data". To this end, it was useful to merge two different approaches to data analysis: the reflective perceptual data within each team's narrative and the more metric driven cross-team analyses. Table 6.4.1 below lays out a schema for "middle ground" work with teams. The simulation is a type of model that meets Boisot and McKelvey's (2011) and Cilliers' (1998) demands of requisite complexity. The participatory narratives bring in the individual sensemaking described by Shaw (2003) and by Stacey and Griffin (2006) as crucial to researching complex organisations.

Approach	**Metaphorical approach**	Middle ground	**Modelling approach**
Empirical component	Debrief discussions, researcher reflection		Team self-simulation
Data	Exercise transcripts, researcher reflections		Team and exercise hard data
Analysis	Reflective narrative sensemaking	Code Map, Memos, Phase diagrams	Comparative data tables

Table 6.4.1: Mixed methods from either end of the spectrum

Narrative authors start with case studies or real-time observations (Dooley & Lichtenstein, 2008) and then apply a complexity lens to make sense of them. Modellers use a variety of computational tools and techniques to make analytical or predictive simulations of reality. In this study I combined elements of both – a simulation combined with reflexive and then reflective sensemaking – and found that they were complementary. This is consistent with Arrow et al.'s suggestion that researchers working with complex groups "need to make use of multiple methods, at both strategic and tactical levels" (2000, p. 265). The result is a methodology that may be described as a genuine interweaving of simulation modelling and narrative sensemaking in which each complements the other. There are units of analysis (in this case teams) that are placed in a consistent set of simulated challenges. The analysis contains some hard data extracted objectively from each group and its performance, but the majority of the data were extracted from the reflexive (in real time) and reflective (later) sensemaking of the group and researcher. For these reasons, it is my suggestion that a methodology composed of only simulated exercises or simply observation and narrative sensemaking (but not both) might not be as effective as interweaving both.

Bringing them together: complementary data analysis

In a similar vein, the data in this study were analysed both within and between groups. I started with within-group narratives, and then used the sensemaking constructed therefrom to begin the between-groups analysis. The cross comparative analysis built on both initial approaches, such that the Code Map, Memos and the Phase diagrams of the results and analysis chapter of this thesis contained data elements from both approaches together.

Arrow et al. point out that "between-group designs are more frequently used than within-group designs in experimental social psychology and small group research generally" (2000, p. 252). They suggest that it is generally thought that between-group studies are easier to control for conditions and variables. However, they then argue that this approach may be insufficient for complex groups, which matches what I found. Our richest insights in this analysis did indeed come from the between-group comparisons – particularly the comparisons of team 5 to the other groups. But these between-group analyses were built on strong within-group narrative sensemaking. In positioning this study in “the middle ground” to take both individual nuance and emergent group behaviour into account, I should make sure I take both into account. Again, this may be useful for future researchers deciding on how many groups to work with when constructing their research program.

It may be that merging the simulation with reflexive and reflective co-constructed narrative sensemaking could bridge the gap between scholars with a preference for Narrative or Modelling approaches. The merged approach may find some affinity with the mathematical modellers in that it is ultimately a model: it is a “sandbox” exercise outside of normal work and it has some predictive utility. It might also satisfy those narrative scholars’ concerns in that the agents are actually the very same people who compose the team – with all their attendant individual complexity.

How effective was this approach?

This thesis found this middle ground, explored it, and found it to be rich. In their study on small groups, Arrow et al. (2000, p.4) defined their unit of analysis as “a loosely coupled system of mutually interacting, interdependent members, projects and technology with a shared collective identity”. My unit of analysis was more tightly defined as leadership teams, small groups with a specific identity and associated expectations to provide solutions and direction to a wider organisation. In narrowly defining the groups, I avoided the data scaling traps outlined by Dooley and Lichtenstein (2008), keeping data to a manageable level.

Arrow et al. (2000) and Dooley and Lichtenstein (2008) both point out the challenges with reliability in real-time observation of complex groups. The problem is that groups do not have the *Markov property*; that is, their histories and trajectories matter. Thus you can't "rewind the clock" and revisit observations of a complex team because it changes with time. This means it would be difficult to apply the same simulation in this study to the same team more than once – they will have learned from the first experience. Having said that, there is a benefit to running a tightly defined simulation with different teams – the exercise itself is readily replicable and may be run with a number of different teams. There is an opportunity to test this with more such exercises to further assess the reliability of this study.

On the downside, there is a potential flaw in observing teams in sandbox simulations compared to the traditional real-time observations of teams such as Gersick's (1988), McGrath's (1991) or Wheelan et al.'s (2003) work. It was noted in Memo 9 in the Results and Analysis chapter of this thesis that team members in three of the teams specifically noted that there seemed to be insufficient apparent return for engaging in the social risks associated with pushing through to a solution to exercise 3. This points to a potential gap in the simulation structure; the lack of consequence for engagement would have had an impact on whether some teams chose to stay in a higher discomfort, complex state, or drop to the lower discomfort state. This is a design feature that is in the very nature of a sandbox simulation: that it allows teams to practise working at a challenge without the real consequences of the workplace.

It should be noted here that by contrast one team – team 5 – *did* report seeing benefit in taking the risks in doing the exercise, despite its sandbox nature. Team 5 noted that they saw the exercise as an opportunity to practise working together, and saw that they would benefit from that practice. I hypothesised earlier that one of the reasons for team 5's ability to sit in the discomfort of complexity for longer is that they had attained a level of specialist expertise in complex decision making (see Karakul & Qudrat-Ullah, 2008 as well as Spector, 2008) through more deliberate practice (Ericsson, 2006). It follows that this deliberate practice may have pre-conditioned the team to recognise the value in working in complexity for its own sake, a conditioning possibly lacking in the other teams. In this study, any such pre-conditioning was not assessed prior to the exercises, so it remains another opportunity for future research.

The main benefit of the narrative approach was realised in the group narrative section of the results. If the simulations had been conducted “at arm’s length” – that is, by the researcher as distant and objective observer – then I would have been left with sanitised versions of sections 5.2.3, 5.3.3, 5.4.3, 5.5.3 and 5.6.3 of the Results chapter above. The reflexive (in real time) and reflective (afterwards) sensemaking added richness to the Code mapping and the Phase diagrams, and was responsible for the bulk of the Memos in the results chapter. This extra richness of data brought the individuality of participants within the teams back into the data analysis, recognising the complexity of the individuals within the various teams and the parts they played. As a result, it may be surmised that without the sensemaking debriefs it is likely the simulations would have been much less representative of the groups. There is an opportunity here for further research into the validity of self-simulations for teams, particularly in investigating complex team dynamics.

6.4.6 An epistemological pluralism

I am conscious that a study such as this that attempts to draw from two rather different disciplines within a field may end up disappointing and displeasing both, and end up “neither here nor there”. The two ends of the complexity “spectrum” are epistemologically distinct, embodying as they do two very different ways of knowing about complexity. Further, Richardson (2011) would suggest “membership” of either epistemological approach seems to include as a condition a measure of disdain for the other discipline. Thus the scientific discipline could well suggest that my approach was not scientific enough, my use of theory was too metaphorical, my models were not real models. The metaphorical discipline might argue that my approach was too quantitative, and did not fully account for or embrace individual complexity, history and meaning within my simulations.

What I think I have discovered in this study is a way to soften the edges of those two disciplines by drawing from either end of the complexity epistemological spectrum. Within team-sized groups there is some common ground, and it might be summed up in two insights:

- *for the modellers*: human behaviour at the level of teams is more complex than we might think, or than might be capturable in an autonomous agent; and
- *for the story-tellers*: human behaviour at the level of teams is more constrained and less free than we might think, or allow.

As a result, complex human group behaviour is modellable at the level of teams, but at this stage is best modelled according to Boisot and McKelvey's (2011) Law of Requisite Complexity: by the team itself. Analysis at this level requires inputs, tools and theorising from both disciplines to work. As David Byrne and Gill Callaghan (2013) noted in their book on complexity theory and research in social sciences, "Quality and Quantity – we need both" (p. 194). Perhaps a common shared playground might lead to more collaboration, to more "both"?

6.4.7 Positioning the researcher in investigating live complex dynamics

The final contribution to research practice was the positioning of the researcher relative to the study. I found that positioning the researcher within the study, acknowledging them as an active participant, and including researcher sensemaking as part of the analysis stayed true to complexity thinking in that the researcher becomes part of the "system" being studied. The practical consequence of this positioning was the extra richness in the narrative analysis of each group. It also provided for an interesting and engaging (if somewhat uncomfortable!)

experience for the researcher – authors such as Stern and Porr (2017) and Frost and Stablein (1992) have suggested that a researcher should enjoy what they do!

In constructing this piece of research I deliberately chose a more involved, subjective perspective in working with the groups I was studying. Specifically, I chose to adopt the persona of the experimenter in conducting the group exercises, but then during debrief discussions I chose to play a co-creative role in the group sensemaking. This approach is positioned less like the Leicester Approach / Tavistock tradition of Wilfred Bion and more like that of the Institute of Group Analysis and the Seigmund Foulkes tradition (see for example Dalal, 1998; Mowles, 2017). The effect is that rather than sit outside the group discussion to study it, I engaged in the group in cooperative sensemaking. As Teresa von Sommaruga Howard (2012, p. 239) put it:

> As the conductor I am in the group and part of the group. I feel it, and into it, using my "self" to intuitively tune into what is happening… to help us all make sense together. It is a joint enterprise.

I found this perspective initially uncomfortable. Stacey and Griffin (2006, p. 3) write that despite qualitative and interpretive research being "no longer contested in the literature on organisations… these approaches largely preserve something of the stance of the objective observer… [with] the notion that the researcher should not affect what is being researched." However, I also found that supplying the groups with sensemaking frameworks, helping paraphrase various ideas, asking questions in an unstructured way, and even contributing my perspectives (when asked) during the group debriefs helped the groups engage in a more flowing, meaningful discussion. As a result, I was able to construct the rich narratives in the Results and Analysis chapter, including my perspectives and sensemaking, because they had been co-created with the group (rather than imposed from the outside). This is certainly in line with the perspectives of Stacey and Griffin (2006), as well as Shaw

(2003), Mowles (2017) and others from the complex responsive processes tradition.

I am conscious that this is not a new technique, that it has been used since Foulkes' work in post World War II Britain. However, I hope that my own experience with it adds a small extra data point in a future researcher's decision making on the methodological approach.

7. Conclusion

Whence thus far…

…and whither hence?

7.1 The story before this thesis

In order to bring new understanding and insight to the behaviour of leadership teams, I have located this piece of research in the field of complex adaptive systems as applied to social systems and leadership. Complexity in management and organisation studies is a relatively new field (Brown, 2011; Byrne & Callaghan, 2013). Whilst complexity has been known in the physical sciences since the dawn of systems thinking, it has only been applied to social systems since the 1990s (Goldstein, 1995; McKelvey, 1997), to organisations at the turn of the century (Anderson, 1999), and was first applied to leadership thinking by Russ Marion and Mary Uhl-Bien at the start of this century (Marion & Uhl-Bien, 2001).

At present the field is split by scale. At one end, computational modelling is applied at population scale to understand and predict how large groups behave, exemplified by papers and books such as Hazy et al. (2007), McKelvey (1997), Hollingshad et al. (2013), Miller and Page's (2007) complex adaptive systems, West and Grigolini's (2010) complex webs, Galam's (2012) sociophysics and Helbing's (2010) quantitative sociodynamics. At the other end, complexity concepts are woven into allegorical narratives and frameworks to help leaders understand and respond to how individuals engage with complexity. This metaphorical approach is more typified by the complex responsive processes of Stacey and Griffin (2006), Shaw (2003) and Mowles (2017), the complexity leadership theory of Uhl-Bien et al. (2007), Cilliers' (1998) postmodern approach to complexity, and the emergence and leadership of Goldstein (2007) and Lichtenstein and McKelvey

(2011). Richardson (2011) suggests that the gulf between these two approaches is wide, although the keen reader will have noticed that some author names appear in both camps above.

If population scale (the domain of the modellers) might be regarded as the macro-scale of Hackman (2003) and Dooley and Lichtenstein (2008), and individual scale (the domain of metaphorical narrative) the micro-scale, then what is missing is complexity applied at the level of small groups: the scale at which organisational teams – and in particular leadership teams – most commonly work. This is the scale targeted by this study, and it was positioned as a bridge of sorts between the two different approaches to complexity, investigating a middle ground between populations and individuals: small teams.

7.2. My contribution to the story

This thesis adds to the complexity story in a number of ways.

1. The Uncertainty Landscape

This thesis presents a framework for understanding how teams shift into different states in response to different types of challenges: the Uncertainty Landscape. This new model is not a team development model in the manner of Tuckman (1965), Gersick (1988), Wheelan (1990), McGrath (1991) or Tubbs (1995); rather, it deals with short scale phase shifts or changes that are not necessarily developmental. The model uses terms familiar to the field of complexity through the Stacey (1996) Matrix and Kurtz and Snowden’s (2003) Cynefin framework (such as “simple”, “complicated” and complex”), but expands significantly on these previous pieces. The Uncertainty Landscape locates team states based on the uncertainty in their dynamics, positioning a definition of complexity to include both linearity and determinism as two different flavours of uncertainty.

Building on the work of Kurtz and Snowden's (2003) Cynefin framework (helps leaders identify and respond to different problem types) and the Stacey (1996) Matrix (locates different types of teams), I found that the two are fundamentally interconnected. Different types of challenges will prompt teams to enter a complex state, and it is only the triggering of a team to enter a complex state that defines a problem as "complex". One can't define a problem as "complex" in the abstract or devoid of the team attempting to wrestle with it. This stands separate to the work of Kurtz and Snowden (2003), Heifetz and Linsky's (2002a) and Uhl-Bien et al. (2007) in which they provide various schema for categorising problems as complicated or complex in the absence of the context in which the problem is being tackled. Linking the definitions of complicated versus complex challenges and complicated versus complex team states and making them interdependent allows for localised contextual nuance in application: what is complex for one team may not be complex for another.

2. Complex dissipative teams

The empirical simulations contained a surprise: teams didn't just shift states in response to the challenges with which they were presented, they also shifted states – sometimes rapidly and continuously – while tackling complex challenges. In attempting to understand the various drivers for why this might be so, I found the static two-dimensional Uncertainty Landscape developed to this point to be insufficient. For further illumination I reached for the language of Ilya Prigogine's (1978, 1997) work on thermodynamics in complex systems to explain some of the group behaviour the teams exhibited in the complex state.

In doing so, it was discovered that the complex team states operate away from equilibrium, are metastable and dissipative (require work to maintain them), precisely as described in Prigogine's work. I found that when tackling a complex challenge, two attractor states evolve: a metastable dissipative attractor state in the complex region of the Uncertainty Landscape, and a more stable basin of attraction in the equilibrium or complicated area of the landscape. For the majority of teams investigated, this second equilibrium attractor proved a far stronger attractor, leading to an understanding that the complex states are lower entropy states, again as in keeping with our understanding of thermodynamics.

I found that at the level of individuals, the perception of social or political risk inherent in contributions is fundamental to the story. In the same way that the individual kinetic energies of molecules in a gas aggregates into a macroscopic thermodynamic property called “heat”, so this individual scale perception of risk – and its attendant discomfort – aggregates into a group tension or discomfort. I labelled this aggregated group property emergent social discomfort or ESD; teams shift into complex states away from equilibrium as the ESD builds, and then back towards equilibrium as ESD is deliberately or accidentally dissipated through humour, social grooming or convenient quasi-solutions.

The complex dissipative teams perspective adds dynamics to the Uncertainty Landscape, explaining the drivers for how and why teams move around the various states in the landscape. Taken together, these two present a hitherto new language and theoretical understanding for complex team dynamics.

3. Implications for practice

With more than twenty years of experience in consulting into leadership teams, I am well acquainted with the perspective of practice. For members of leadership teams, the Uncertainty Landscape could be a useful tool to help them understand how and why their team may respond to different types of challenges. They may grow to recognise and then anticipate the state shifts they experience when assaying a complex issue, and it is hoped that with time recognition and anticipation will lead to an ability to respond better.

Complex dissipative teams – dealing as it does with discomfort and anxiety and how it turns into group ESD – might help teams change their relationship with discomfort. Dealing with complex issues could naturally involve some personal risk, and this risk could be felt as discomfort. This discomfort need not be regarded as something to run from; instead, teams can learn to be productive in it.

Finally, this thesis offers a roadmap for improving how a team might deal with complexity. The roadmap is not a simple three-step recipe; rather, it is the steady acquisition of dynamical expertise (see Karakul & Qudrat-Ullah (2008) as well as Spector (2008)) through repeated deliberate practice (Ericsson, 2006). At the end of this road is an ability to be more productive in the discomfort.

4. Studying complex teams

This study was positioned firmly in the middle ground between large populations (the domain of the models) and individual leaders (the domain of metaphors): at the scale of teams. In constructing the work at this meso-scale (Hackman (2003) and Dooley and Lichtenstein (2008)), I found it useful to select elements from both the modelling and metaphorical approaches to complexity. The group debriefs after the exercises, the researcher reflections and the narrative analysis would be recognized by scholars from the metaphorical tradition of complexity studies. The simulation sandboxes (self-models), the hard team data and some of the cross-group analyses might earn a nod from researchers in the modelling approach to complexity.

Arrow et al. (2000) argue that cross-group analyses are easier to control for conditions and variables, and hence are much more common in the social sciences than within-group analyses. They then posit that researching complex groups should have both cross-group analyses and intra-group analyses. The primary research in this thesis was structured precisely in that way, with narrative sensemaking driving the intra-group analysis, alongside a variety of inter-group analysis techniques. This interplay between the intra- and inter-group analyses was successful in that it provided greater insight than either focus may have done alone. In this sense, this research may be seen as confirming Arrow et al.'s (2000) hypothesis above.

I chose to adopt the persona of the separate experimenter during the team exercises, but then joined the team in sensemaking during the debrief discussions. The effect of this positioning was twofold:

ii) by positioning myself outside the group in the simulation, I removed a potential source of variance across the groups (my contributions), facilitating better inter-group analysis, and

iii) by positioning myself inside the group in the debrief, I was able to use "my 'self' to intuitively tune into what is happening… to help us all make sense together" (von Sommaruga Howard, 2012, p. 239). This improved the collaborative sensemaking in the debriefs, and facilitated the researcher's reflection that contributed to the intra-group narrative analysis.

Neither of those positionings is new to general organisational research, although within the field of organisational complexity they may be adopted separately by the two approaches: subjective, immersive positioning more at home in the metaphorical approach; and objective, separated positioning more at home in the modelling approach.

7.3. The story from here

The process of researching and ultimately writing a PhD dissertation can involve frustration, boredom, stress, isolation, imposter syndrome and ultimately euphoria (Phillips & Pugh, 2015). But ultimately a successful PhD "means that you have something to say that your peers want to listen to" (Phillips & Pugh, 2015, p. 26). It is my hope here that after all the trials, stress, frustration, breakthroughs and ultimately joy of producing this document there is something in here that my peers wish to engage with, and perhaps take further. Below are my thoughts on where this research might be taken further.

Reliability

To the best of my knowledge at the time of writing, this is the only study to have been undertaken in this way, with this mixture of sandbox simulation, co-constructed sensemaking and reflective narrative, in the field of organisational complexity. The ultimate test of reliability is repeatability, and so one obvious direction for further research is for further groups to be assessed in a similar fashion. The exercises that comprise the simulation section of the methodology are readily replicable and may be run with an increased number of different teams. Then, since the researcher is positioned as subjective and inside the group for the reflexive debriefs, and then contributes a reflective narrative, having this part of the methodology undertaken by different researchers would also increase the validity of the results obtained.

Further evidence of conditional behaviour

In the results and discussion chapters of this thesis it was noted that eye contact was an indicator of the social sensitivity that marked contingent behaviour. Although beyond the scope of this thesis, it is suggested that future studies of this type might invest more time and focus into acquiring and discussing more detail about the signals at the individual, dyadic and triadic levels that signify the shift into complex states marked increased attention between team members.

Control groups and the Markov property

In section 6.1.1 of this thesis I noted:

> “It is not the objective, nor within the scope of this thesis, to attempt to justify the observed behaviour of each team as a function of its history. In fact, we

> will use the initial data on each team for a comparative purpose: to show how different the teams are at the start."

This deliberate design choice has left open the opportunity for future studies to include control variables with respect to individual and group histories and memories, personality and other individual characteristics, and well as prior dyadic social ties. Such a future study could thereby obtain a richer picture of how these team historical characteristics might potentially influence how a team responds to the exercises in this study.

In addition one might wish to use a team as its own "control group", that is to subject the same team to the exercises multiple times to investigate variation, or perhaps change only one or two team members to discover how the team responses change with membership. Alternatively, teams with very similar backgrounds, contexts and memberships might be studied, using one such team as a control group.

Complex dissipative teams

Secondly, there is an opportunity to further develop the application of thermodynamics concepts to the theory of complex dissipative teams. The theory was presented here as a way to explain the observed team dynamics, but at this stage it is somewhere between what Hazy would call "metaphor" and "nascent theory" (Hazy, 2014). It would require significant further development and confirmation to be regarded as a full theory.

In particular, it would be interesting to test the 3D Uncertainty Landscape in real-time observations of teams, away from the sandbox simulation. Do teams working with real problems in real contexts consistently meet the two attractor states found and described in this research? How does the real-work context affect the level of risk and discomfort felt by participants in complex states? As a consequence, how consistently strong is the pull towards the equilibrium or baseline state? What more can we understand about the dynamics of the metastable attractor that operates far from equilibrium?

The effect of expertise or practice

In explaining how team 5 was able to stay in this metastable, far from equilibrium complex state longer than other teams, I hypothesised that they may have attained a level of specialist expertise in complex decision making through more deliberate practice. This was an unexpected discovery, and is deserving of further research on its own. It would be interesting to observe teams who report different levels of previous practice working in complex scenarios tackle a complex challenge. The effect of any “fitness” expertise for sitting in group discomfort could then be further compared and explored.

Hybrid research model

Finally, there is an opportunity to engage with the hybrid research methodology used in this study, particularly in the application of complexity thinking to team dynamics. Do other researchers find the mixing of narrative sensemaking with simulations useful in their work? And what of the positioning of the researcher as inside the study rather than occupying the traditional external observer role? Is there something about this specific inquiry that lent itself to this combination of tools, or is it a template that could be applied more broadly?

In the end, we return to the beginning

In the Introductory chapter to this thesis, I reviewed a recent personal case of a leadership team wrestling with difficult decisions. When we left the case, a senior commercial leader and significant player in the room had just thrown a challenge to the dominant thinking of the group. After the comment, the room went quiet, activity stopped, and participants started looking from one senior figure to another and back again. The energy and tension in the room had increased, the ambiguity and uncertainty had increased. Where would they go next?

We now have a richer understanding of what was happening in that room. Attention in the room had swung from the plan on the wall to participants in the room, eye contact had increased, the “team temperature” in the room had increased: the team had shifted into a complex state away from the previous equilibrium. Ahead of us the future for that group bifurcated: one path led back to the equilibrium attractor state via the dissipative action of a tension-relieving joke or a bit of social grooming and placation. The other path led to maintaining that metastable, far from equilibrium attractor state, increasing the communication pace and taking the risk to stay “in the discomfort”. The second path would not be easy, but there may have been a greater pay-off at its end.

Knowing what we now know, which path would you now take?

Glossary of terms

Adaptive, Self-organising: In complex *adaptive* systems, agents learn from their interactions (creating more feedback loops). As a result, complex adaptive systems tend to self-organise, evolving towards local order characterised by locally low entropy (which in turn is why they must operate far from equilibrium).

Agent-based model: A computational model that simulates the interactions of agents within a complex system and the resulting evolution of the system itself over time.

Agents: The individuals that interact with one another in a complex system are generally referred to as agents. Agents might be cellular automata or “bots” in computer models, individual insects in a swarm or hive, birds or fish in a flock or school, or in this study individual humans in a team.

Attractors and attractor states: Attractors are features of complex or chaotic dynamical systems. An attractor is a state (or a set of states) towards which a complex system might spontaneously tend to evolve, despite the system’s starting conditions. As an example, consider a system consisting of a ball set rolling in a smooth bowl or cup. This system has a single stable “point attractor”: the ball at rest at the bottom of the bowl. Regardless of the initial position or velocity* of the ball in the bowl, the ball-and-bowl system will evolve over time towards the same fixed point attractor (*provided the velocity of the ball isn’t sufficient for it to roll out of the bowl, breaking the system!). Structural attractors bring the attractor concept from the realm of mathematical formalism into discussions of complex social systems. They can be spatial, temporal or social in nature, and can be correlated with positive or negative agent emotional states.

Autopoiesis means “self-creation”, and was originally applied to biological cells, which are open systems, exchanging resources with their environment and capable of self-creation and replication. The concept has since been applied to social systems of people, describing how they might engage in the generation and co-creation of communication, sensemaking and behavioural patterns such as culture.

Complex adaptive system: A complex system that, in response to its environment, adapts, and “self-organizes”; that is, organises without directed intelligence.

Complex system: A system of interconnected and interacting “agents” with “conditional behaviour instructions”.

Conditional behaviour: In a complex system, the behaviour of any individual agent is conditional on the behaviour of those nearby. That means that the individual agents pay attention to those around them, and modify their own behaviour based on their perception of the behaviour of those around them. This is a key transitional feature for complex systems: when the behaviour of agents is conditional, the system can exhibit complex behaviour; when it is not conditional (for example if agents are not paying attention to each other) it cannot.

Cybernetic systems: These are equilibrium-seeking systems. Air conditioning is a classic example of a cybernetic system.

Dynamics: The study or description of how a unit, system or group of units or systems evolves over time. Contrasted with descriptions of the state of systems or units at a specific point in time (“statics”).

Emergence: Group or system level behaviour *emerges* from the interactions of the agents. Emergent behaviour is not a simple sum of individual interactions, and can't be located in any single individual agent – it emerges from the interactions. Emergence can happen at multiple levels of interaction, including group level, and can provide for novel and unexpected behaviour.

Entropy: A concept from classical thermodynamics, entropy is a measure of the disorder, uncertainty or randomness in a system. The second law of thermodynamics states that in any closed system entropy never reduces; to generate order in a system (reducing the disorder or entropy), energy must be imported into the system to offset the local reduction in entropy. For teams, this means that teams do not stay in structured ordered states for ever without the constant application of work or energy.

Epistemological pluralism: Utilising more than one way (a plurality of ways) to know about a field, hence enriching one's understanding of that field. In this study, elements of the narrative/metaphorical epistemology and the computational modelling epistemology were used to paint a more detailed picture of complex teams.

Equilibrium state: A state (set of conditions) for a system in which it is in equilibrium with its environment, and hence not exchanging energy with that environment.

Far from equilibrium, dissipative: An "equilibrium" system is steady or stable with respect to its local environment; by contrast, complex systems operate away from equilibrium. As a consequence complex systems require energy to be sustained; that is, they are "dissipative": they use or dissipate energy, and require more to stay steadily away from equilibrium.

Fundamental uncertainty: Uncertainty that is a fundamental property of a system and can't be removed. Addition of information does not reduce fundamental uncertainty, and may in some cases make it worse. The archetypal example is the Heisenberg Uncertainty Principle, which sets a fundamental limit on the precision with which we might be able to know both where a quantum particle is and how it is moving. Increasing the precision in knowledge of one of those two variables merely increases the uncertainty in the complementary variable.

Group dynamics: The study of how the interactions of people in groups evolves over time.

Leadership team: A formal structure within an organisational context, a leadership team is a group of individuals who are responsible for leading a function, division, centre, business, company or other organisational unit of people. Sometimes abbreviated to LT. Other equivalent (or more specialised) designations include the Executive Leadership Team (ELT – the most senior team in an organisation), Top Management Team (TMT), Senior Leadership or Management Team (SLT or SMT), Extended Leadership Group (ELG) or simply Leadership or Management Team (LT or MT).

Locality: In complex systems, the interactions between agents are short range (agents usually interact with neighbours, but not across systems). Complexity scholars call these interactions "local". In larger organisational groups of humans, locality is network locality rather than spatial or physical locality. For instance my "local" neighbours may be part of a leadership team that works at a similar senior level within an organisation, but may sit on different floors in a building (or in a pandemic world, we may sit in different cities or countries!). Furthermore, each agent usually responds to its understanding of its own locality (in organisations this means its local group's sensemaking) rather than an understanding of the system as a whole.

Macro-level group analysis is focused on the group and its embedding context (for example the wider organisation in which it is located).

Memory and the Markov property: The Markov property is a “memoryless” property exhibited by stochastic processes where each event in the process is discrete and disconnected from the others. By contrast, agents in complex systems, and the systems themselves, have history trajectories and “memory”; their future is always (at least partly) a function of the collective past.

Meso-level group analysis is focused on the characteristics of the group as a whole.

Metastable: A metastable system is temporarily stable, but fluctuations might disturb that system away from its stability. An example is a ball perched at the top of a rounded, smooth hill. The ball can stay at the top of the hill (appear stable) provided it is not disturbed; if disturbed, it will roll down the hill. This is because the hill (the system) reinforces the disturbance: once the ball starts rolling, the incline speeds it up. The ball can stay metastable at the top of the hill with the application of energy – working to nudge the ball back to the hilltop when it begins to roll away, or simply holding it there. In this way, the ball is away from its equilibrium state, which is obviously the bottom of the hill.

Micro-level group analysis: focused on characteristics of individual group members.

Modelling approach to organisational complexity is an epistemological discipline within the field that holds that one can learn about complex systems of people through the application of agent-based models of those people.

Narrative approach to organisational complexity is an epistemological discipline within the field that rejects the plausibility of modelling, arguing that humans are too complex in and of themselves to modelled as reductionist agents. Instead, this school applies concepts from formal complexity sciences in a narrative or sensemaking fashion in organisational contexts.

Noise: Researchers, particularly those who come from a computer-based or agent-based modelling perspective, use the term "noise" to describe unpredictability in the behaviour of individual agents. This noise can result from random behaviour, errors made by individual agents, or the exercise of free will, and it has the effect of making complex systems non-deterministic. Whilst non-linearity drives system or team level behavioural uncertainty, random noise introduces uncertainty into individual behaviour.

Non-determinism: Deterministic systems are wholly predictable; their causal links are knowable. By contrast, non-deterministic systems include random factors or noise. In human systems the exercise of free will makes a system non-deterministic, and introduces fundamental uncertainty into the system.

Non-linearity: A consequence of conditional behaviour, the interactions between agents can be non-linear; that is, they can drive system behaviour that can be extremely sensitive to initial conditions and not necessarily proportional. There are feedback loops in the interactions between agent and agent (agent behaviour is modified by their perception of other agents' behaviour) and between agent and local system (agent behaviour is modified by their perception of the local group emergent behaviours; that is, local norms or local cultures).

Open systems: Complex systems are open systems: they freely interchange information and energy (resources) with the environment. The agent population is not fixed: the system imports, transforms and exports agents ("recombination").

Phase diagram: Phase diagrams are well known in physics and chemistry. To plot a phase diagram, one must first understand how the state of the system under investigation changes as the function of two or more variables. Possibly the most well-known phase diagram is that for water, which most of us met in high school science class. This diagram shows the state of water (solid, liquid or gas) as a function of temperature and pressure. In this study, phase diagrams were plotted for teams showing the different states the teams were in as a function of time and level of discomfort.

Quasi-experiments may be distinguished from standard experiments in two main ways: firstly, unlike a true experiment, a quasi-experiment does not have randomised selection; and secondly, quasi-experiments either don't have the same control groups as true experiments or don't have control groups at all.

Reducible uncertainty: Uncertainty that results from gaps in our knowledge or understanding. Reducible uncertainty can be reduced or removed by the addition of information to the system.

Risk, social and political: In group dynamics a "social risk" is the risk of damage to relationships in the group or loss of some forms of informal power and a "political risk" is a risk of damage to standing within the group, loss of formal power or possible exclusion from the group.

Social sensitivity: A measure of socialized "empathy" that has a formal definition as one third of the Social Skills Inventory (SSI). In complex social systems it describes the tendency of individuals to pay attention to their local neighbours' affect for cues on how to respond themselves. The tendency of affect to spread through complex networks has been called "emotional contagion".

State or phase: A complete description of a system at a given point in time.

References

Abramson, L. Y., Seligman, M. E., & Teasdale, J. D. (1978). Learned helplessness in humans: Critique and reformulation. *Journal of Abnormal Psychology*, *87*(1), 49.

Adams, B. D., & Webb, R. D. (2002). Trust in small military teams. In *7th International Command and Control Technology Symposium* (pp. 1–20).

Allen, P.M. and Strathern, M., (2003). Evolution, emergence, and learning in complex systems. *Emergence*, *5*(4), pp.8-33.

Allen, P. (2010). Editorial: To model or not to model? That is the question. *E:CO*, *12*(4), v–viii.

Anderson P. (1999). Complexity theory and organization science. *Organization Science*, Linthicum: May/June, *10*(3), 216–32.

Andrade, E. B., & Ariely, D. (2009). The enduring impact of transient emotions on decision making. *Organizational Behavior and Human Decision Processes*, *109*(1), 1–8.

Andriani, P., & McKelvey, B. (2009). From Gaussian to Paretian thinking: Causes and implications of power laws in organizations. *Organization Science*, *20*(6), 1053–1071.

Andriani, P., & McKelvey, B. (2011). From skew distributions to power-law science. In P. Allen, S. Maquire, & B. McKelvey (Eds.), *The SAGE handbook of complexity and management* (pp. 254–273). SAGE Publications.

Arrow, H., McGrath, J. E., & Berdahl, J. L. (2000). *Small groups as complex systems, formation, coordination, development, and adaptation*. SAGE Publications.

Ashby, W. (1956). *An introduction to cybernetics*. John Wiley & Sons.

Aula, P., & Siira, K. M. (2007). Towards social complexity view on conflict. In J. Hazy, J. Goldstein, & B. Lichtenstein (Eds.), *Complex systems leadership theory* (pp. 367–386). ICSE Publishing.

Axelrod, R. (1997a). Advancing the art of simulation in the social sciences. *Complexity*, *3*(2), 16–22.

Axelrod, R. (1997b). *The complexity of cooperation: Agent-based models of competition and collaboration* (Vol. 3). Princeton University Press.

Babich, B. (2017). Hermeneutics and its discontents in philosophy of science: On Bruno Latour, the “science wars”, mockery, and immortal models. In B. Babich (Ed.), *Hermeneutic philosophies of social science*. De Gruyter.

Bagwell, J. (2020). Leading through a pandemic: Adaptive leadership and purposeful action. *Journal of School Administration Research and Development*, *5*(S1), 30–34.

Bak, P. (1996). *How nature works: The science of self-organized criticality*. Copernicus.

Bak, P., Tang, C., & Wiesenfeld, K. (1989). Self organized criticality: An explanation of 1/f noise. *Physical Review Letters, 59*, 381–384.

Ball, P. (2005). *Critical mass: How one thing leads to another.* Arrow Books.

Bar-Yam, Y. (2004). A mathematical theory of strong emergence using multiscale variety. *Complexity*, *9*(6), 15–24.

Bar-Yam, Y. (2017). Why complexity is different. Retrieved January 13, 2020, from https://mystudentvoices.com/why-complexity-is-different-ecd498e0eccb

Bareil, C., Savoie, A., & Meunier, S. (2007). Patterns of discomfort with organizational change. *Journal of Change Management*, *7*(1), 13–24.

Baumeister, R. F. (2008). Free will in scientific psychology. *Perspectives on Psychological Science*, *3*(1), 14–19.

Bazeley, P. and Richards, L., (2000). *The NVivo qualitative project book*. Sage.

Beckham, D. (2001). Managing complexity. *Health Forum Journal*, *44*, 41–43.

Beekman, M., Sumpter, D. J., & Ratnieks, F. L. (2001). Phase transition between disordered and ordered foraging in Pharaoh's ants. *Proceedings of the National Academy of Sciences*, *98*(17), 9703–9706. Wiley-Blackwell.

Benini, A. (2000). *Construction of knowledge*. Gnome.

Bilal, L. (2021). Adaptive practices on global virtual teams. In Rasmussen H. T. (Ed.), *Adaptive leadership in a global economy: Perspectives for application and scholarship* (1st ed., p. 111). Routledge.

Bion, W. R. (1961). *Experiences in groups*. Tavistock.

Bloch, S., Browning, S., & McGrath, G. (1983) Humour in group psychotherapy. *British Journal of Medical Psychology*, *56*(1), 89–97.

Boisot, M., & McKelvey, B. (2011). Complexity and organization–environment relations: Revisiting Ashby’s law of requisite variety. In P. Allen, S. Maquire, & B. McKelvey (Eds.), *The SAGE handbook of complexity and management* (pp. 278–298). SAGE Publications.

Bolman, L. G., & Deal, T. E. (2017). *Reframing organizations: Artistry, choice, and leadership*. John Wiley & Sons.

Boschetti, F. (2011). Complexity and philosophy: Rationality, complexity and self-organization. *E:CO*, *13*(1–2), 133–145.

Bouwmeester, O. (2013). Consultant jokes about managing uncertainty: Coping through humor. *International Studies of Management & Organization*, *43*(3), 41–57.

Brown, B. (2011). Complexity leadership: An overview and key limitations. *Integral Leadership Review*, October.

Browning, L., & Boudès, T. (2005). The use of narrative to understand and respond to complexity. *E:CO*, *7*(3–4), 32–39.

Bruce, K., & Nylan, C. (2011). Elton Mayo and the deification of human relations. *Organization Studies*, *32*(3), 383–405.

Buchanan, D., & Huczynski, A. (2004). *Organizational behaviour.* Pearson Education Ltd.

Buhr, K., & Dugas, M. J. (2002). The intolerance of uncertainty scale: Psychometric properties of the English version. *Behaviour Research and Therapy*, *40*(8), 931–945.

Burns, S. (2010). *Move closer stay longer.* CreateSpace Independent Publishing Platform

Byrne, D., & Callaghan, G. (2013). *Complexity theory and the social sciences: The state of the art.* Routledge.

Cabrera, D. and Cabrera, L., (2019). Complexity and systems thinking models in education: Applications for leaders. *Learning, design, and technology: An international compendium of theory, research, practice, and policy*, pp.1-29.

Cabrera, D., Cabrera,L., and Gibson, H., (2020). Leapfrog Leaders: How lowlighting content, and highlighting cognitive structure and dynamics can leapfrog leaders to the next level. *Journal of Applied Systems Thinking* 20 (5).

Cabrera, D., Cabrera, L. and Powers, E., (2015). A unifying theory of systems thinking with psychosocial applications. *Systems Research and Behavioral Science*, *32*(5), pp.534-545.

Campbell, D. T., & Riecken, H. W. (1968). Quasi-experimental design. *International Encyclopedia of the Social Sciences*, *5*(3), 259–263.

Capra, F., & Luisi, P. L. (2014). *The systems view of life: A unifying vision*. Cambridge University Press.

Carleton, R. N., Mulvogue, M. K., Thibodeau, M. A., McCabe, R. E., Antony, M. M., & Asmundson, G. J. (2012). Increasingly certain about uncertainty: Intolerance of uncertainty across anxiety and depression. *Journal of Anxiety Disorders*, *26*(3), 468–479.

Carnot, S. (1824). *Reflections on the motive power of fire, and on machines fitted to develop that power*. Bachelier.

Carroll, N. (2014). *Humour: A very short introduction*. Oxford University Press.

Chalmers, D. (1996). *The conscious mind*. Oxford University Press.

Charmaz, K. (2006). *Constructing grounded theory*. SAGE Publications.

Chen, S., Yao, N., & Qian, M. (2018). The influence of uncertainty and intolerance of uncertainty on anxiety. *Journal of Behavior Therapy and Experimental Psychiatry*, *61*, 60–65.

Cianciolo, A. T., Matthew, C., Sternberg, R. J., & Wagner, R. K. (2006). Tacit knowledge, practical intelligence, and expertise. In K. Anders Ericsson and others (Eds.), *The Cambridge handbook of expertise and expert performance* (pp. 613–632). Cambridge University Press.

Cilliers, P. (1998). *Complexity and postmodernism: understanding complex systems*. Routledge.

Cilliers, P., DeVilliers, T., & Roodt, V. (2002). The formation of the self: Nietzsche and complexity. *South African Journal of Philosophy*, *21*(1), 1–18.

Cipresso, P., Bessi, A., Colombo, D., Pedroli, E. and Riva, G., (2017). Computational psychometrics for modeling system dynamics during stressful disasters. *Frontiers in psychology*, *8*, p.1401.

Clegg, S. R. (1993). Narrative, power and social theory. *Narrative and Social Control: Critical Perspectives*, *21*, 15–45.

Clegg, S. R., Courpasson, D., & Phillips, N. (2006). *Power and organizations*. SAGE Publications.

Coetzee, O., & Cilliers, F. (2012). Humour as defence against the anxiety manifesting in diversity experiences. *SA Journal of Industrial Psychology*, *38*(2), 22–31.

Coleman, J. (1988). Social capital in the creation of human capital. *American Journal of Sociology*, 94, 95–120.

Connors, M. H., Burns, B. D., & Campitelli, G. (2011). Expertise in complex decision making: The role of search in chess 70 years after de Groot. *Cognitive Science*, *35*(8), 1567–1579.

Cook, T. D. (2015). Quasi-experimental design. In Cary L. Cooper (Ed.), *Wiley Encyclopedia of Management* (pp. 1–2). (https://doi.org/10.1002/9781118785317.weom110227)

Costikyan, G. (2013). *Uncertainty in games*. MIT Press.

Crowley, K., & Head, B. W. (2017). The enduring challenge of “wicked problems”: revisiting Rittel and Webber. *Policy Sciences*, *50*(4), 539–547.

Cummings, S., Bridgman, T., & Brown, K. G. (2016). Unfreezing change as three steps: Rethinking Kurt Lewin’s legacy for change management. *Human Relations*, *69*(1), 33–60.

Dalal, F., (1998). *Taking the group seriously: Towards a post-Foulkesian group analytic theory*. Jessica Kingsley Publishers.

De Jager, W., Cilliers, F., & Veldsman, T. (2003). Leadership development from a systems psychodynamic consultancy stance, *SA Journal of Human Resource Management*, *1*(3), 85–92.

De Landa, M. (1997). *A thousand years of non-linear history*. Zone Books.

Den Hartigh, R., Gernigon, C., Van Yperen, N., Marin, L., & Van Geert, P. (2014). How psychological and behavioral team states change during positive and negative momentum. *PLoS ONE*, *9*(5), e97887. https://doi.org.10.1371/journal.pone.0097887

Dervin, B., (1992). From the Mind's Eye of the User: The Sense-Making Qualitative-Quantitative Methodology. *Qualitative Research in Information Management*, 9, pp.61-84.

Devaney, R. L. (1989). *An introduction to chaotic dynamical systems* (Vol. 13046). Addison-Wesley.

Dooley, K. J., Corman, S. R., McPhee, R. D., & Kuhn, T. (2003). Modeling high-resolution broadband discourse in complex adaptive systems. *Nonlinear Dynamics, Psychology, and Life Sciences*, *7*(1), 61–85.

Dooley, K. J., & Lichtenstein, B. B. (2008). Research methods for studying the complexity dynamics of leadership. In M. Uhl-Bien, & R. Marion (Eds.), *Complexity leadership Part I: Conceptual foundations* (pp. 269-90). Information Age Publishing.

Dorigo, M., & Gambardella, L. (1997). Ant colonies for the traveling salesman problem. *Biosystems*, *43*(2), 73–81.

Döring, T. F., & Chittka, L. (2011). How human are insects, and does it matter? *Formosan Entomol*, *31*, 85–99.

Driebe, D. J., & McDaniel, R. R. Jr. (2005). Complexity, uncertainty and surprise: An integrated view. In R. R. Jr.,McDaniel, & D. J. Driebe (Eds.), *Uncertainty and surprise in complex systems*. Springer.

Eisenhardt, K. M. (1989). Making fast strategic decisions in high-velocity environments. *Academy of Management Journal*, *32*(3), 543–576.

Eisenhardt, K. M. (2021). What is the Eisenhardt Method, really? *Strategic Organization*, *19*(1), 147–160.

Eisenhardt, K. M., & Piezunka, H. (2011). Complexity theory and corporate strategy. In P. Allen, S. Maquire, & B. McKelvey (Eds.), *The SAGE handbook of complexity and management* (pp. 506-23). SAGE Publications.

Elias, N. (2000). *The civilising process: Sociogenetic and psychogenetic investigations*. Oxford University Press.

Eliat, A., & Noble, D. (1999). Educating prospective managers in the complexity of organizational life. *Management Learning*, *30*, 321–342.

Elliot, A. J., & Devine, P. G. (1994). On the motivational nature of cognitive dissonance: Dissonance as psychological discomfort. *Journal of Personality and Social Psychology*, *67*(3), 382–394.

Elsenbroich, C., & Verhagen, H. (2016). The simplicity of complex agents: A contextual action framework for computational agents. *Mind & Society*, *15*(1), 131–143.

Eoyang, G. (2011). Complexity and the dynamics of organizational change. In P. Allen, S. Maquire, & B. McKelvey (Eds.), *The SAGE handbook of complexity and management* (pp. 317–332). SAGE Publications.

Epstein, J. (2008). Why model?, *Journal of Artificial Societies and Social Simulation*, *11*(4), 12.

Ericsson, K. A. (2006). The influence of experience and deliberate practice on the development of superior expert performance. In K. Anders Ericsson and others (Eds.), *The Cambridge handbook of expertise and expert performance* (pp. 683–705). Cambridge University Press.

Farmer, J. D., & Foley, D. (2009). The economy needs agent-based modelling. *Nature*, *460*, 685–686.

Fehlhaber, K. (2013). Social grooming: It’s not just for monkeys and prairie voles! *Knowing Neurons*. Retrieved November 9, 2021 from, https://knowingneurons.com/2013/02/20/social-grooming-its-not-just-for-monkeys-and-prairie-voles/

Fernández, N., Maldonado, C., & Gershenson, C. (2014). Information measures of complexity, emergence, self-organization, homeostasis, and autopoiesis. In M. Prokopenko (Ed.), *Guided self-organization: Inception* (pp. 19–51). Springer.

Ferilli, S., & Angelastro, S. (2016). Mining chess playing as a complex process. In Appice, A., Ceci, M., Loglisci, C., Masciari, E. and Raś, Z.W. (eds).,*New Frontiers* *in Mining Complex Patterns: 5th International Workshop, NFMCP 2016, Held in Conjunction with ECML-PKDD 2016, Riva Del Garda, Italy, September 19, 2016, Revised Selected Papers* (Vol. 10312). (pp. 248–262). Springer.

Firestone, J.M. and McElroy, M.W., (2012). *Key issues in the new knowledge management*. Routledge.

Fisher, B. A. (1970). Decision emergence: Phases in group decision making. *Speech Monographs*, *37*, 53–66.

Fleming, P., & Spicer, A. (2014). Power in management and organization science. *Academy of Management Annals*, *8*(1), 237–298.

Flood, M. M., Dresher, M., Tucker, A. W., & Device, F. (1950). Prisoner's dilemma: Game theory. *Experimental Economics*, 54

Flyvbjerg, B. (2002). *Making social science matter*. Cambridge University Press.

Ford, H., & Crowther, S. (1924). *My life and work*. William Heinemann.

Franklin, C. E. (2018). *A minimal libertarianism: Free will and the promise of reduction*. Oxford University Press.

Franz, T. M. (2012). *Group dynamics and team interventions: Understanding and improving team performance*. John Wiley & Sons.

Freeston, M. H., Rhéaume, J., Letarte, H., Dugas, M. J., & Ladouceur, R. (1994). Why do people worry? *Personality and Individual Differences*, *17*(6), 791–802.

French, S. (2013). Cynefin, statistics and decision analysis. *Journal of the Operational Research Society*, *64*, 547.

Freud, S. (1961). *Letters of Sigmund Freud*. Hogarth.

Frey, C. B., & Osborne, M. A. (2017). The future of employment: How susceptible are jobs to computerisation? *Technological Forecasting and Social Change*, *114*, 254–280.

Fried, J. (2016). *Of education, fishbowls, and rabbit holes: Rethinking teaching and liberal education for an interconnected world*. Stylus Publishing.

Frost, P. J., & Stablein, R. E. (Eds.). (1992). *Doing exemplary research*. SAGE Publications.

Gabbard, G. O. (2017). *Long-term psychodynamic psychotherapy: A basic text*. American Psychiatric Association Publishing.

Galam, S. (2012). *Sociophysics: A physicist's modeling of psycho-political phenomena*. Springer Science & Business Media.

Gardner, M. (1970). Mathematical games: The fantastic combinations of John Conway's new solitaire game "life". *Scientific American*, *223*, 120–123.

Gemmill, G., & Smith, C. (1985). A dissipative structure model of organization transformation. *Human Relations*, *38*(8), 751–766.

Gersick, C. (1988). Time and transition in work teams: Toward a new model of group development. *Academy of Management Journal*, *31*(1), 9–41.

Glaser, B. (1992). *Basics of grounded theory analysis*. Sociology Press.

Glaser, B., & Strauss, A. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Wiedenfeld and Nicholson.

Gleick J. (1987). *Chaos: Making a new science*. Penguin.

Gleick, J. (2011). *Chaos: Making a new science* (Enhanced ed.). Open Road Media.

Goldstein, J. A. (1995). Using the concept of self-organization to understand social system change: Strengths and limitations. In Albert, A. (Ed.), *Chaos and society* (pp. 49–62). IOS Press.

Goldstein, J. (2007). A new model for emergence and its leadership implications. In J. Hazy, J. Goldstein, & B. Lichtenstein (Eds.), *Complex systems leadership theory* (pp. 61–92). ICSE Publishing.

Goldstein, J. A. (2008). Conceptual foundations of complexity science. In M. Uhl-Bien, & R. Marion (Eds.), *Complexity leadership Part I: Conceptual foundations* (pp. 17-48). Information Age Publishing.

Gorman, J. C., Dunbar, T. A., Grimm, D., & Gipson, C. L. (2017). Understanding and modeling teams as dynamical systems. *Frontiers in Psychology*, *8*, 1053.

Grosskinsky, S. (2013). Interacting stochastic particle systems. In R. Ball, V. Kolokoltsov, & R. S. MacKay (Eds.), *Complexity science: The Warwick master's course* (pp. 125-209). Cambridge University Press.

Grugulis, I. (2002). Nothing serious? Candidates' use of humour in management training. *Human Relations*, *55*(4), 387–406.

Guastello, S. J. (2011). Nonlinear dynamical systems applications to psychology and management. In P. Allen, S. Maquire, & B. McKelvey (Eds.), *The SAGE handbook of complexity and management* (pp. 543-56). SAGE Publications.

Guastello, S. J., Pincus, D., & Gunderson, P. R. (2006). Electrodermal Arousal Between Participants in a Conversation: Nonlinear Dynamics and Linkage Effects. *Nonlinear Dynamics, Psychology, and Life Sciences, 10*(3), 365–399.

Gully, S. M., Incalcaterra, K. A., Joshi, A., & Beaubien, J. M. (2002). A meta-analysis of team-efficacy, potency, and performance: Interdependence and level of analysis as moderators of observed relationships. *Journal of Applied Psychology*, *87*(5), 819–832.

Guzman, G. A. C., & Wilson, J. (2005). The “soft” dimension of organizational knowledge transfer. *Journal of Knowledge Management*, *9*, 59–74.

Hackman, J. R. (2003). Learning more by crossing levels: Evidence from airplanes, hospitals, and orchestras. *Journal of Organizational Behavior*, *24*, 905–922.

Hannah, D. P., & Eisenhardt, K. M. (2018). How firms navigate cooperation and competition in nascent ecosystems. *Strategic Management Journal*, *39*(12), 3163–3192.

Harte, J. (1988). *Consider a spherical cow*. University Science Books.

Harvey, J. B. (1974). The Abilene paradox: The management of agreement. *Organizational Dynamics*, *3*, 63–80.

Hatfield, E., Cacioppo, J.T., Rapson, R.L., (1993). Emotional contagion. *Current Directions in Psychological Science*. 2 (3): 96–99

Hawking, S. W. (1985). Arrow of time in cosmology. *Physical Review D*, *32*(10), 2489.

Hawking, S. W. (1988). *A brief history of time.* Bantam Books.

Hazy, J. K. (2014). Is this “thermodynamic inquiry” metaphor or more? *Consulting Psychology Journal: Practice and Research, 66*(4), 300–305.

Hazy, J.K., (2019). How and why effective leaders construct and evolve structural attractors to overcome spatial, temporal, and social complexity. In *Embracing complexity in health* (pp. 225-236). Springer, Cham.

Hazy, J.K. and Boyatzis, R.E., (2015). Emotional contagion and proto-organizing in human interaction dynamics. *Frontiers in psychology*, *6*, p.806.

Hazy, J., Goldstein, J., & Lichtenstein, B. (2007). Complex systems leadership theory: An introduction. In J. Hazy, J. Goldstein, & B. Lichtenstein (Eds.), *Complex systems leadership theory*, (pp. 1-13). ICSE Publishing.

Heifetz, R. A., & Linsky, M. (2002a). A survival guide for leaders. *Harvard Business Review*, *80*(6), 65–74.

Heifetz, R., & Linsky, R. (2002b), *Leadership on the line: Staying alive through the dangers of leading*. Harvard Business Review Press.

Heisenberg, W. K. (1927). Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik. *Zeitschrift für Physik*. *43*(3–4), 172–198 (English translation available at Nasa Technical Report Server. Retrieved May 18, 2017, from https://ntrs.nasa.gov/search.jsp?R=19840008978.)

Helbing, D. (2010). *Quantitative sociodynamics, stochastic methods and models of social interaction processes* (2nd ed.). Springer-Verlag.

Helbing, D. (2012). Social self-organization: Agent-based simulations and experiments to study emergent social behavior. In Helbing, D. (Ed.), *Social self-organization* (pp. 25–70). Springer-Verlag.

Helin, J., Hernes, T., Hjorth, D., & Holt, R. (Eds.). (2014). *The Oxford handbook of process philosophy and organization studies*. Oxford University Press.

Hernes, T. (2007). *Understanding organization as process: Theory for a tangled world.* Routledge.

Hirsh, J., Mar, R., & Peterson, J. (2012). Psychological entropy: A framework for understanding uncertainty-related anxiety. *Psychological Review*, *119*, 304–320. https://doi.org.10.1037/a0026767

Hodgson, G. (2011). Complexity, habits and evolution. In P. Allen, S. Maquire, & B. McKelvey (Eds.), *The SAGE handbook of complexity and management* (pp. 590–603). SAGE Publications.

Hölldobler, B., & Wilson, E. O. (2009). *The superorganism: The beauty, elegance, and strangeness of insect societies*. WW Norton & Company.

Hollingshad, N., Svenkeson, A., West, B., & Grigolini, P. (2013). Time to consensus. *Physica A*, *392*, 2302–2310.

Houglum, D. T. (2012). Myth-busters: Traditional and emergent leadership. *Emergence: Complexity and organization*, *14*(2), 25–39.

Ihatsu, T. (2021). Violence resembling terrorism: Adaptive challenges and technical problems in first responder collaboration. *Security Dimensions. International and National Studies*, *37*, 94–122.

Jantsch, E. (1980). *The self-organizing universe* (Vol. 205). Pergamon Press.

Josephson, J. R., & Josephson, S. G. (1995) (Eds.). *Abductive inference: Computation, philosophy, technology*. Cambridge University Press.

Juarrero, A. (2000). Dynamics in action: Intentional behavior as a complex system. *Emergence*, *2*(2), 24–57.

Karakul, M., & Qudrat-Ullah, H. (2008). How to improve dynamic decision making? Practice and promise. In H. Qudrat-Ullah, J. M. Spector, & P. I. Davidsen (Eds.), *Complex decision making* (pp. 3–24). Springer.

Kauffman, S. (1995). *At home in the universe*. Oxford University Press.

Kaufman, M., Diep, H. T., & Kaufman, S. (2019). Sociophysics of intractable conflicts: Three-group dynamics. *Physica A: Statistical Mechanics and Its Applications*, *517*, 175–187.

Kellert, S. H., Longino, H. E., & Waters, C. K. (2006) (Eds.). *Scientific pluralism* (Vol. 19). University of Minnesota Press.

Kilburg, R. R., & Donohue, M. D. (2014). Leadership and organizational behavior: A thermodynamic inquiry. *Consulting Psychology Journal: Practice and Research, 66*(4), 261–287.

Kirk, J., & Miller, M. (1985). *Reliability and validity in qualitative research*. SAGE Publications.

Kleidon, A., & Lorenz, R. (2005). Entropy production by earth system processes. In A. Kleidon, & R. Lorenz (Eds.), *Non-equilibrium thermodynamics and the production of entropy* (pp. 1–20). Springer.

Klein, G., Moon, B. and Hoffman, R.R., (2006). Making sense of sensemaking 2: A macrocognitive model. *IEEE Intelligent systems*, *21*(5), pp.88-92.

Kolb, D. A., & Frohman, A. L. (1970). Organizational development through planned change: A development model. *MIT Working Paper Series*: pp. 453–470. MIT.

Kotter, J. P. (1995). Leading change: Why transformation efforts fail. *Harvard Business Review*, March–April, 59–67.

Kurtz, C. (2014). *Working with stories in your community or organization: Participatory narrative inquiry* (3rd ed). Kurtz-Fernhout Publishing.

Kurtz, C. F., & Snowden, D. J. (2003). The new dynamics of strategy: Sense-making in a complex and complicated world. *IBM Systems Journal*, *42*(3) 462–483.

Lane, D. A., & Down, M. (2010). The art of managing for the future: Leadership of turbulence. *Management Decision*, *48*, 512–527.

Langley, A., & Abdallah, C. (2011). Templates and turns in qualitative studies of strategy and management. In Donald D. Bergh, & David J. Ketchen Jr. (Eds.), *Building methodological bridges*. Emerald Group Publishing Limited.

Langley, A., & Tsoukas, H. (Eds.). (2017). *The SAGE handbook of process organizational studies*. SAGE Publications.

Lawless, W. F. (2017). The physics of teams: Interdependence, measurable entropy, and computational emotion. *Frontiers in Physics*, *5*, 30.

Lewin, K. (1947). Frontiers in group dynamics: II. Channels of group life; social planning and action research. *Human Relations*, *1*(2), 143–153.

Lichtenstein, B. B., & McKelvey, B. (2011). Four types of emergence: A typology of complexity and its implications for a science of management. *International Journal of Complexity in Leadership and Management*, *1*(4), 339–378.

Lichtenstein, B. B., Uhl-Bien, M., Marion, R., Seers, A., Orton, J. D., & Schreiber, C. (2006). Complexity leadership theory: An interactive perspective on leading in complex adaptive systems. *Emergence: Complexity and Organization*, 8:4, pp. 2-12.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. SAGE Publications.

Lingard, L., Albert, M., & Levinson, W. (2008). Grounded theory, mixed methods, and action research. *BMJ*, Aug 7(337), a567.

Lippitt, R., Watson, J., Westley, B., & Spalding, W. B. (1958). *The dynamics of planned change: A comparative study of principles and techniques*. Harcourt Brace.

Lorenz, E. N. (1963). Deterministic nonperiodic flow. *Journal of the Atmospheric Sciences*, *20*(2), 130–141.

Lorenz, E. N. (1972, December 29) *Predictability: Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?* [Presentation]. Meeting of the American Association for the Advancement of Science, Washington, DC, USA.

Luhmann, N. (1982). The world society as a social system. *International Journal of General Systems*, *8*(3), 131–138.

Luhmann, N. (1986). The autopoiesis of social systems. *Sociocybernetic Paradoxes*, *6*(2), 172–192.

Luhmann, N. (1995). *Social systems*. Stanford University Press.

Maguire, S., McKelvey, B., Mirabeau, L., & Öztas, N. (2006). Complexity science and organization studies. In S. Clegg, C. Hardy, W. Nord, & T. Lawrence (Eds.), *Sage handbook of organization studies* (pp. 165–214). SAGE Publications.

Mahmoodi, K., Grigolini, P. and West, B.J., (2018). On social sensitivity to either zealot or independent minorities. *Chaos, Solitons & Fractals*, *110*, pp.185-190.

Mahmoodi, K., West, B.J. and Grigolini, P., (2018). Self-organized temporal criticality: bottom-up resilience versus top-down vulnerability. *Complexity*, *2018*.

Mahmoodi, K., West, B.J. and Grigolini, P., (2019). Complexity matching and requisite variety. *arXiv preprint arXiv:1806.08808*.

Mandelbrot, B. (1983). *The fractal geometry of nature*. W. H. Freeman & Co.

Marion, R. (2008). Complexity theory for organizations and organizational leadership. In M. Uhl-Bien, & R. Marion (Eds.), *Complexity leadership Part I: Conceptual foundations* (pp. 1-15). Information Age Publishing.

Marion, R., & Uhl-Bien, M. (2001). Leadership in complex organizations. *The Leadership Quarterly*, *12*(4), 389.

Marion, R., & Uhl-Bien, M. (2007). Paradigmatic influence and leadership: The perspectives of complexity theory and bureaucracy theory. In J. K. Hazy, J. A. Goldstein, & B. B. Lichtenstein (Eds), *Complexity systems leadership theory*. ICSE Publishing.

Maschler, M., Solan, E., & Zamir, S. (2013). *Game theory* (Z. Hellman, Trans.; Mike Borns, Ed.). Cambridge University Press.

Maturana, H., & Varela, F. (1980). *Autopoiesis and cognition: The realization of the living*. D. Reidel Publishing.

Mayer, R. C., Davis, J. H., & Schoorman, F. D. (1995). An integrative model of organizational trust. *Academy of Management Review*, *20*(3), 709–734.

Mayo, E. (1945). Hawthorne and the Western Electric Company. In E. Mayo, *The social problems of an industrialized civilisation* (pp. 1-7). Harvard University Press.

McDaniel, R. R., & Driebe, D. J. (2005). 1 Uncertainty and surprise: An introduction. In R. R. Jr. McDaniel, & D. J. Driebe (Eds.), *Uncertainty and surprise in complex systems*. Springer.

McGrath, J. E. (1991). Time, interaction, and performance (TIP): A theory of groups. *Small Group Research*, *22*(2), 147–174.

McKelvey, B. (1997). Quasi-natural organization science. *Organization Science*, *8*(4), 352–380.

McKelvey, B. (1999). Complexity theory in organization science: Seizing the promise or becoming a fad? *Emergence*, *1*(1), 5–32.

McKelvey, B. (2002). Managing coevolutionary dynamics. In *18th EGOS Conference*, Barcelona, Spain (pp. 4–6).

McLeod, J., & Childs, S. (2013). The Cynefin framework: A tool for analyzing qualitative data in information science? *Library & Information Science Research*, *35*(4), 299–309.

Meadows, D. (2008). *Thinking in systems: A primer*. Chelsea Green.
Merali, Y., & Allen, P. (2011). Complexity and systems thinking. In P. Allen, S. Maquire, & B. McKelvey (Eds.), *The Sage handbook of complexity and management* (pp. 31-52).SAGE Publications.

Miles, S. A., & Watkins, M. D. (2007). The leadership team. *Harvard Business Review*, *85*(4), 90–98.

Miller, E., & Rice, A. (1967). *Systems of organization: The control of task and sentient boundaries.* Tavistock.

Miller J., & Page S. (2007). *Complex adaptive systems: An introduction to computational models of social life.* Princeton University Press.

Miller, P. (2010). *The smart swarm: How understanding flocks, schools, and colonies can make us better at communicating, decision making, and getting things done*. Avery Publishing Group, Inc.

Miller, T. R., Baird, T. D., Littlefield, C. M., Kofinas, G., Chapin III, F. S., & Redman, C. L. (2008). Epistemological pluralism: Reorganizing interdisciplinary research. *Ecology and Society*, *13*(2), 46.

Milliken, F. J. (1987). Three types of perceived uncertainty about the environment: State, effect, and response uncertainty. *Academy of Management Review*, *12*(1), 133–143.

Morgan, G. (1997). *Images of organization* (2nd ed.). SAGE Publications.

Morse, J., & Richards, L. (2002). *Readme first for a user's guide to qualitative methods*. SAGE Publications.

Mowles, C. (2014). Complex, but not quite complex enough: The turn to the complexity sciences in evaluation scholarship. *Evaluation*, *20*(2), 160–175.

Mowles, C. (2015). *Managing in uncertainty: Complexity and the paradoxes of everyday organizational life*. Routledge.

Mowles, C. (2016). *Rethinking management: Radical insights from the complexity sciences*. Routledge.

Mowles, C. (2017). Experiencing uncertainty: On the potential of groups and a group analytic approach for making management education more critical. *Management Learning*, *48*(5), 505–519.

Mowles, C. (2022). *Complexity: A key idea for business and society*. Routledge.

Muluneh, G. S., & Gedifew, M. T. (2018). Leading changes through adaptive design: Change management practice in one of the universities in a developing nation. *Journal of Organizational Change Management*, 31(6), pp.1249-1270.

Neuman, L. (2003). *Social research methods: Qualitative and quantitative approaches*. Pearson Education.

Newton, I. (1687). *Philosophiae naturalis principia mathematica*; As translated in I. B. Cohen, & A. Whitman (1999). *The Principia, A new translation*. University of California Press.

Nisbett, R. E., Borgida, E., Crandall, R., & Reed, H. (1976). Popular induction: Information is not necessarily informative. In J. S. Carroll, & J. W. Payne (Eds.), *Cognition and social behaviour.* Lawrence Erlbaum.

Nonaka, I. (1988). Creating organisational order out of chaos: Self renewal in Japanese firms. *California Management Review*, *30*, 57–73.

Nowak, M., & Highfield, R. (2011). *Supercooperators: Altruism, evolution, and why we need each other to succeed.* Simon & Schuster.

Nowak, M. A., & Sigmund, K. (1992). Tit for tat in heterogeneous populations. *Nature*, *355*, 250–253.

Paczuski, M., Maslov, S., & Bak, P. (1996). Avalanche dynamics in evolution, growth, and depinning models. *Physical Review E*, *53*(1), 414.

Panovska-Griffiths, J. (2020). Can mathematical modelling solve the current Covid-19 crisis? *BMC Public Health*, *20*(1), 1–3.

Panzar, C., Hazy, J. K., McKelvey, B., & Schwandt, D. R. (2007). The paradox of complex organizations: Leadership as integrative influence. In J. Hazy, J. Goldstein, & B. Lichtenstein (Eds.), *Complex systems leadership theory* (pp. 305–325). ISCE Publishing Company.

Parsons, T. (1951). *The social system*. Free Press.

Pauluis, O. M. (2005). Water vapor and entropy production in the Earth's atmosphere. In A. Kleidon, & R. D. Lorenz (Eds.), *Non-equilibrium thermodynamics and the production of entropy* (pp. 107–119). Springer.

Penrose, R. (2004). *The road to reality: A comprehensive guide to the laws of the universe*. Jonathan Cape.

Persaud, N. (2005). Humans can consciously generate random number sequences: A possible test for artificial intelligence. *Medical Hypotheses*, *65*(2), 211–214.

Phillips, E., & Pugh, D. (2015). *How to get a PhD: A handbook for students and their supervisors*. McGraw-Hill Education.

Pirolli, P. and Russell, D.M., (2011). Introduction to this special issue on sensemaking. *Human–Computer Interaction*, *26*(1-2), pp.1-8.

Plowman, D. A., & Duchon, D. (2008). Dispelling myths about leadership. In M. Uhl-Bien, & R. Marion (Eds.), *Complexity leadership Part I: Conceptual foundations* (pp. 129-54). Information Age Publishing.

Porter, M. (1985). *Competitive advantage: Creating and sustaining superior performance*. Simon & Schuster.

Portes, A., (1998). Social capital: Its origins and applications in modern sociology. *Annual review of sociology*, *24*(1), pp.1-24.

Prigogine, I, (1978). Time, structure, and fluctuations. *Science*, *201*(4358), 777–785.

Prigogine, I. (1997). *The end of certainty: Time, chaos, and the new laws of nature*. The Free Press.

Prigogine, I. (2005). Surprises in a half century. In R. R. McDaniel, & D. Driebe (Eds.), *Uncertainty and surprise in complex systems: Questions on working with the unexpected* (pp. 13-16). Springer.

Prigogine, I., & Lefever, R. (1973). Theory of dissipative structures. In Haken, H. (Eds.), *Synergetics* (pp. 124–135). Vieweg+ Teubner Verlag.

Putnam, R. D. (2001). *Bowling alone: The collapse and revival of American community*. Simon & Schuster.

Qudrat-Ullah, H., Davidsen, P. I., & Spector, J. M. (Eds.) (2007). *Complex decision making*. Springer.

Rapoport, A. (1953). Spread of information through a population with sociostructural bias: I. Assumption of transitivity. *Bulletin of Mathematical Biophysics*, *15*, 523–533.

Reichardt, C. S. (2009). Quasi-experimental design. *The SAGE handbook of quantitative methods in psychology*, *46*(71), 490–500.

Reichl, L. E. (2005). Fundamental “uncertainty” in science. In R. R. Jr. McDaniel, & D. J. Driebe (Eds.), *Uncertainty and surprise in complex systems*. Springer.

Reynolds, C.W., (1987). Flocks, Herds, and Schools: A Distributed Behavioral Model. *Computer Graphics*, *21*(4).

Richardson, K. A. (2011). Complexity and management: A pluralist view. In P. Allen, S. Maquire, & B. McKelvey (Eds.), *The Sage handbook of complexity and management*. SAGE Publications.

Rifkin, J. (2011). *The third industrial revolution: How lateral power is transforming energy, the economy, and the world*. Macmillan.

Rifkin, J. (2014). *The zero marginal cost society: The internet of things, the collaborative commons, and the eclipse of capitalism*. St. Martin's Press.

Riggio, R. E., (2014) The Social Skills Inventory (SSI): Measuring Non-Verbal and Social Skills, in Manusov, V.L. (ed)., *The sourcebook of nonverbal measures: Going beyond words*. Psychology Press.

Ritchey, T. (2013). Wicked problems. *Acta Morphologica Generalis*, *2*(1).

Rittel, H. W., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, *4*(2), 155–169.

Ross, L., & Anderson, C. A. (1982). Shortcomings in the attribution process: On the origins and maintenance of erroneous social assessments. In D. Kahneman, P. Slovic, & A. Tversky (Eds.), *Judgement under uncertainty: Heuristics and biases* (pp. 129-52). Cambridge University Press.

Rovelli, C. (2019). *The order of time*. Penguin.

Rubin, R. S., & Dierdorff, E. C. (2009). How relevant is the MBA? Assessing the alignment of required curricula and required managerial competencies. *Academy of Management Learning & Education*, *8*(2), 208–224.

Rumsey, M. G. (2013). Introduction: Leadership in five parts. In M. G. Rumsey (Ed.), *The Oxford handbook of leadership*. Oxford University Press.

Ruth, M. (2005). Insights from thermodynamics for the analysis of economic processes. In A. Kleidon, & R. Lorenz (Eds.), *Non-equilibrium thermodynamics and the production of entropy* (pp. 243-54). Springer.

Sarantakos, S. (2005). *Social research* (3rd ed.). Palgrave MacMillan.

Schein, E. H. (2010). *Organizational culture and leadership* (4th ed.). Wiley.

Schelling, T. (1971). Dynamic models of segregation. *Journal of Mathematical Sociology*, *1*(2): 143–186.

Schoenewolf, G. (1990). Emotional contagion: Behavioral induction in individuals and groups. *Modern Psychoanalysis*. 15: 49–61

Schumacher, E. F. (1977). *A guide for the perplexed.* Harper Perennial.

Schwartzman, D., & Lineweaver, C. H. (2005). Temperature, biogenesis, and biospheric self-organization. In A. Kleidon, & R. Lorenz (Eds.), *Non-equilibrium thermodynamics and the production of entropy* (pp. 207–221). Springer.

Sears, F. W., & Salinger, G. L. (1975). *Thermodynamics, kinetic theory, and statistical thermodynamics* (3rd ed.). Addison-Wesley.

Shabo, S. (2018). The two-stage luck objection. *Noûs*. https://doi.org.10.1111/nous.12243

Shannon, C. E. (1948). A mathematical theory of communication. *Bell Systems Technical Journal*, 27, 379–423, 623–656.

Shaw, P. (2003). *Changing conversations in organizations: A complexity approach to change*. Routledge.

Siegenfeld, A. F., & Bar-Yam, Y. (2019). An introduction to complex systems science and its applications. *arXiv preprint* arXiv:1912.05088.

Simonton, D. K. (2003). Scientific creativity as constrained stochastic behavior: The integration of product, person, and process perspectives. *Psychological Bulletin*, *129*(4), 475.

Skaburskis, A. (2008). The origin of “wicked problems”. *Planning Theory & Practice*, *9*(2), 277–280.

Smith, G. (2001). Group development: A review of the literature and a commentary on future research directions. *Group Facilitation*, *3*(Spring), 14–45.

Snowden, D. (2002). Complex acts of knowing: Paradox and descriptive self-awareness. *Journal of Knowledge Management*, *6*(2), 100–111.

Snowden, D. (2016, September 23). Freedom through constraints. *Cognitive Edge Blog*. http://cognitive-edge.com/blog/freedom-through-constraints/

Snowden, D. (2021). What Cynefin is in brief. In R. Greenberg, & B. Bertsch (Eds.), *Cynefin, weaving sense-making into the fabric of our world* (pp. 58-61). Cognitive Edge.

Solé, R. V. (2011). *Phase transitions*. Princeton University Press.

Solé, R. V., & Valverde, S. (2001). Information transfer and phase transitions in a model of internet traffic. *Physica A: Statistical Mechanics and Its Applications*, *289*(3), 595–605.

Spector, J. M. (2008). Expertise and dynamic tasks. In H. Qudrat-Ullah, J. M. Spector, & P. I. Davidsen (Eds.), *Complex decision making* (pp. 25–37). Springer.

Stacey, R. (1996). *Strategic management & organisational dynamics* (2nd ed.). Pitman Publishing.

Stacey, R. D. (2001). *Complex responsive processes in organizations: Learning and knowledge creation.* Psychology Press.

Stacey, R. (2003). *Complex responsive processes in organizations: Learning and knowledge creation*. Routledge.

Stacey, R. (2010). *Complexity and organizational reality: Uncertainty and the need to rethink management after the collapse of investment capitalism*. Routledge.

Stacey, R. D. (2011). *Strategic management and organisational dynamics: The challenge of complexity* (6th ed.). Pearson Education.

Stacey, R. D. (2012). Comment on debate article: “Coaching psychology coming of age: The challenges we face in the messy world of complexity. *International Coaching Psychology Review*, *7*, 91–95.

Stacey, R (2018). *Ralph Stacey on complex responsive processes of relating at the Complexity and Management Conference.* Retrieved September 30, 2021, from https://www.youtube.com/watch?v=wCevq8o-AE4

Stacey, R. D., & Griffin, D. (Eds.). (2005). *A complexity perspective on researching organizations: Taking experience seriously*. Routledge.

Stacey, R., & Griffin, D. (2005). Experience and method: A complex responsive processes perspective on research in organizations. In R. D. Stacey, & D. Griffin, *A complexity perspective on researching organisations* (pp. 25–50). Routledge.

Stacey, R. D., Griffin, D., & Shaw, P. (2000). *Complexity and management: Fad or radical challenge to systems thinking?* Psychology Press.

Stern, P. N., & Porr, C .J. (2017). *Essentials of accessible grounded theory*. Routledge.

Stogdill, R. M. (1950). Leadership, membership and organization. *Psychological Bulletin*, *47*(1), 1–14.

Stokes, J., Fuehrer, A., & Childs, L. (1983). Group members' self-disclosures: Relation to perceived cohesion. *Small Group Behavior*, *14*(1), 63–76.

Surowiecki, J. (2005). *The wisdom of crowds*. Anchor.

Takano, M. (2018). Two types of social grooming methods depending on the trade-off between the number and strength of social relationships. Royal Society Open Science, 5(8). https://doi.org/10.1098/rsos.180148

Taylor, F. W. (1911). *Principles of scientific management*. Harper.

Taylor, K. B., & Baker, A. R. (2019). Examining the role of discomfort in collegiate learning and development. *Journal of College Student Development*, *60*(2), 173–188.

Thietart, R. A., & Forgues, B. (1995). Chaos theory and organization. *Organization Acience*, *6*(1), 19–31.

Tichy, N. M., & Devanna, M. A. (1986). *The transformational leader: The key to global competitiveness*. John Wiley & Sons.

Timofeeva, Y. (2013). Complexity and chaos in dynamical systems. In R. Ball, V. Kolokoltsov, & R. S. MacKay (Eds.), *Complexity science: The Warwick master's course*. Cambridge University Press.

Trist, E., & Bamforth, K. (1951). Some social and psychological consequences of the longwall method of coal-getting. *Human Relations*, *4*(1), 3–38.

Tsekeris, C. (2015). Contextualising the self in contemporary social science. *Contemporary Social Science*, *10*(1), 1–14.

Tsoukas, H. (1989). The validity of idiographic research explanations. *Academy of Management Review*, *14*(4), 551–561.

Tsoukas, H. (2017). Don't simplify, complexify: From disjunctive to conjunctive theorizing in organization and management studies. *Journal of Management Studies*, *54*(2), 132–153.

Tubbs, S. (1995). *A systems approach to small group interaction*. McGraw-Hill.

Tuckman, B. W. (1965). Developmental sequence in small groups. *Psychological Bulletin*, *63*, 384–399.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, *185*, 1124–1131.

Uhl-Bien, M., & Marion, R. (2008). Complexity leadership–A framework for leadership in the twenty-first century. In M. Uhl-Bien, & R. Marion (Eds.), *Complexity leadership Part I: Conceptual foundations* (pp. 6–24). Information Age Publishing.

Uhl-Bien, M., & Marion, R. (2009). Complexity leadership in bureaucratic forms of organizing: A meso model. *The Leadership Quarterly*, *20*(4), 631–650.

Uhl-Bien, M., Marion, R., & McKelvey, B. (2007). Complexity leadership theory: Shifting leadership from the industrial age to the knowledge era. *The Leadership Quarterly*, *18*(4), 298–318.

Ulanowicz, R. E., & Zickel, M. J. (2005). Using ecology to quantify organization in fluid flows. In A. Kleidon, & R. Lorenz (Eds.), *Non-equilibrium thermodynamics and the production of entropy* (pp. 57–66). Springer.

Vallacher, R., & Nowak, A., (2008). Dynamical social psychology, on complexity and coordination in human experience. In M. Uhl-Bien, & R. Marion (Eds.), *Complexity leadership Part I: Conceptual foundations.* Information Age Publishing.

Vallacher, R. R., Coleman, P. T., Nowak, A., & Bui-Wrzosinska, L. (2011). Rethinking intractable conflict: The perspective of dynamical systems. In P. Coleman, *Conflict, interdependence, and justice* (pp. 65–94). Springer.

Vaillant, G. E. (1992). *Ego mechanisms of defense: A guide for clinicians and researchers*. American Psychiatric Press.

Van Beurden, E. K., Kia, A. M., Zask, A., Dietrich, U., & Rose, L. (2011). Making sense in a complex landscape: How the Cynefin framework from complex adaptive systems theory can inform health promotion practice. *Health Promotion International*, dar089.

Van Velsor, E. (2008). A complexity perspective on leadership development. In M. Uhl-Bien, & R. Marion (Eds), *Complexity leadership Part I: Conceptual foundations* (pp. 333–346). Information Age Publishing.

Viejo, P., Gonzalez de Durana, J., Barambones, O., Hernández-Tejera, F., Hernandez, J. J., Évora Gómez, J., & Kremers, E. (2015). Criticality in complex socio-technical systems: An empirical approach. *Emergence: Complexity and Organization*, *17*(2), p.E1.

von Bertalanffy, L. (1950). An outline of general system theory. *British Journal for the Philosophy of Science*, *1*, 114–129.

von Sommaruga Howard, T., (2012). To stand sitting! Bi-cultural dilemmas in a large group in Aotearoa New Zealand. *Group Analysis*, *45*(2), pp.219-243.

Warren, P. A., Gostoli, U., Farmer, G. D., El-Deredy, W., & Hahn, U. (2017). A re-examination of "bias" in human randomness perception. *Journal of Experimental Psychology: Human Perception and Performance*. Advance online publication, retrieved February 10, 2018, from http://psycnet.apa.org.ezproxy.lib.uts.edu.au/record/2017-47517-001

Weick, K.E., (1995). *Sensemaking in organizations* (Vol. 3). Sage.

West, B. J., & Grigolini, P. (2010). *Complex webs: Anticipating the improbable*. Cambridge University Press.

Wheelan, S. A. (1990). *Facilitating training groups: A guide to leadership and verbal intervention skills*. Praeger.

Wheelan, S., Davidson, B., & Tilin, F. (2003). Group development across time: Reality or illusion? *Small Group Research*, *34*(2), 223–245.

Wiener, N. (1948). *Cybernetics: Or control and communication in the animal and the machine.* MIT Press.

Williams, B. and Hummelbrunner, R., (2010). Systems concepts in action. In *Systems Concepts in Action*. Stanford University Press.

Wissner-Gross, A. D, & Freer, C. E. (2013). Causal entropic forces. *Physical Review Letters*, *110*, 168702.

Wu, J., & Axelrod, R. (1995). How to cope with noise in the iterated prisoner's dilemma. *Journal of Conflict resolution*, *39*(1), 183–189.

Zeeman, E. (1976). Catastrophe theory. *Scientific American*, April, 65–70, 75–83.

Zeh, H. D., & Page, D. N. (1990). The physical basis of the direction of time. *American Journal of Physics 58*, 798. https://doi.org.10.1119/1.16366
Zimbardo, P. (2011). *The Lucifer effect: How good people turn evil*. Random House.

Zimmerman, B., & Hayday, B. (1999). A board's journey into complexity science: Lessons from (and for) staff and board members. *Group Decision and Negotiation*, *8*, 281–303.