Making organisational decisions in a volatile, uncertain, complex and ambiguous world

Literature review

penguinjunk.github.io

1st September 2023

Contents

1 Introduction

We know that the world is becoming increasingly **volatile, uncertain, complex and ambiguous (VUCA)** and that this affects our long-term and day-to-day decisions on how we organise. This review considers the science and practice of decision-making, drawing out key themes and areas of focus to enable effective organisational decisions.

2 What is decision-making?

Economics has tended to view decision-making as a optimisation over all choices and all their outcomes by individuals who are "rational, selfish and [with] tastes [that] do not change" (Bruno Fray, quoted in Kahneman, 2011). However, psychological analyses have determined that we use rather different approaches. Studies in laboratory settings have uncovered many biases in decision-making and heuristics that short-cut decisions (Cyert *et al.*, 1956; Simon, 1990; Gigerenzer, 2004; Kahneman, 2011). Studies of decision-making in natural settings, especially looking at how experts make decisions under pressure, have identified approaches that rely on the recognition of a situation and then a rapid identification of a first-best solution (**Recognition-Primed Model**; Klein, 2017).

All decisions require an understanding of the situation (often called **sensemaking**) which relies on a 2-system approach. Here **System 1** performs a rapid and unconscious assessment of the situation that is passed to **System 2**, which can be engaged for slower more analytical thinking (Stanovich and West, 2000; Kahneman, 2011). These systems are subject to heuristics and biases. However, the development of experience and expertise under different settings can alter how the heuristics and biases affect our recognition and mental analysis of each setting (Kahneman and Klein, 2009; Kahneman, 2011; Blettner *et al.*, 2023). This does not mean that we do not perform any form of optimisation over choices, but this is usually only when we consciously engage our analytical thinking (System 2) and it is still both highly influenced by our personal heuristics and biases (Kahneman and Klein, 2009) and, due to limits to our cognitive capacity, not over all possible options (Simon, 1990).

3 Key themes and concepts in decision-making

Research and literature on decision-making take a variety of perspectives from theories about ideal approaches to detailed studies of individuals' and organisational decision-making. The following five themes express the most pertinent ways of thinking about, talking about and analysing decision-making both in individuals and organisations.

3.1 Models of decision-making

Decision-makers need information about current conditions and have a projection or projections of how they may develop (Klein, 2017). Weick *et al.* (2005) called the state of gathering and interpreting information "sensemaking", the process of asking "what is going on here?" and "what do I do next?". In most discussions of decision-making, it is sensemaking that dominates since our understanding of a problem and the environment in which it manifests is central to how we decide to act.

A basic model is **Sensemaking–Decision-making–Action taking** (Figure 1; Marlow,

2023a). An interesting military parallel to this is the **OODA (Observe-Orient-Decide-Act) Loop** (Figure 2; Boyd, 2012). This model helpfully splits what others understand as sensemaking into two components: observe - the sensing of information - and orient - the making sense of what has been observed. This split nods to discoveries about the psychology of decision-making studied by psychologists (see Section 3.3) and practitioners (see Section 3.4).

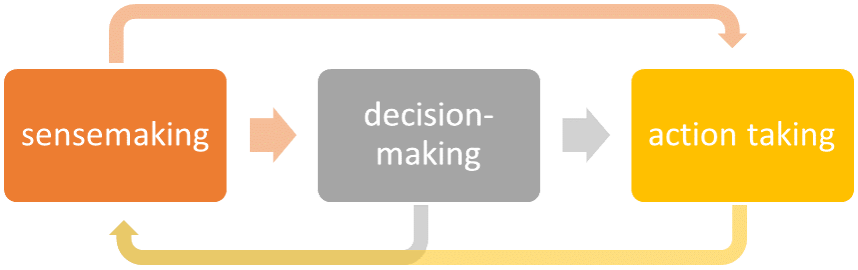

Figure 1: A simple model of decision-making in which *sensemaking* is the process by which information is gathered, *decision-making* applies this information and *action taking* implements the decision. A more complex version considers feedback from decision-making and action taking to sensemaking as well as action taking that occurs directly in response to sensemaking.

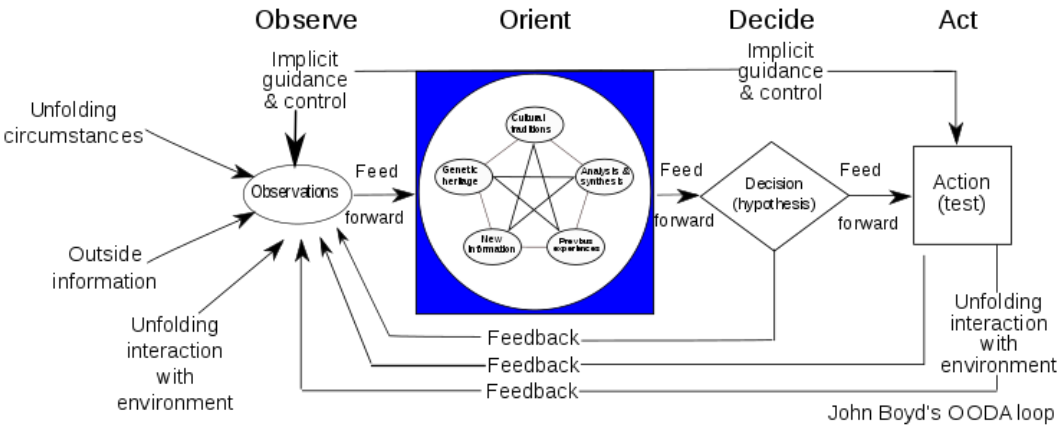

Figure 2: The *OODA Loop* describing the process of the loops through *Observe*, *Orient*, *Decide* and *Act*, with feedbacks between these elements, some of which interact with the environment.

3.2 Wicked environments and wicked problems

Where information is good, often decisions "make themselves" because the best course of action is easy to identify. Therefore, we are only exercised by our decision-making when there is uncertainty. We experience uncertainty when information is missing, unreliable, ambiguous or complex, or it is difficult to draw inferences from the information about current conditions or how they will develop (Klein, 2017) - in other parlance, when conditions are VUCA. In reality, the most important decisions are situated in environments that are extremely difficult to appraise and forecast, and easy to misinterpret (Kahneman and Klein, 2009). Here, there are no options to test proposed solutions and the outcomes that follow decisions, even by highly experienced decision-makers, have a large helping of luck (Kahneman and Klein, 2009).

There are many different terms for aspects of this phenomenon: "Radical Uncertainty" (Kay and King, 2020), "Deep Uncertainty" (Lempert *et al.*, 2003), "low-validity" (environments that are difficult to learn from; Kahneman and Klein, 2009), "discontinuous change" (Teece, 2022), even "Extremistan" (the realm of the Black Swan; Taleb, 2007). One term that is increasingly popular is "wicked", used to describe both the complex and ambiguous environments and the problems that manifest within them (Rittel and Webber, 1973; Grint, 2010). Grint (2010) differentiated problems that are wicked from those that are tame - problems that can be solved by applying a process - and Critical - problems, usually crises, that need immediate action and their solutions are usually self-evident (Figure 3).

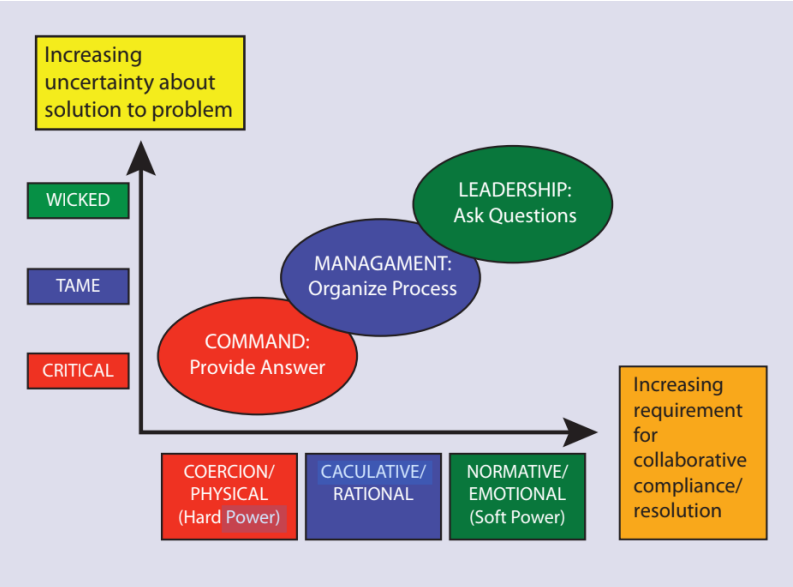

Figure 3: Grint (2010)'s typology of problems and the power/authority styles needed to address them.

Solutions to wicked problems are *not* simple, rapid or elegant (Buchanan and Denyer, 2013; Grint, 2010). Instead they are iterative, evolutionary and "clumsy", they feel more like "muddling through", perhaps requiring a "wild orchestration" (Grint, 2010; Nelson and Winter, 1982; Teece, 2022; Zollo *et al.*, 2002; Buchanan and Denyer, 2013; Kay and King, 2020). Both Grint (2010) and Ranger and Garbett-Shiels (2011) recommend searching for common ground and "no regrets" solutions, when there are conflicting needs. Also, solutions may prove to be "bad" - but this is only evident in hindsight and more due to poor sensemaking than decision-making itself (Weick *et al.*, 2005; Klein, 2017). Accepting that errors will occur, Klein (2017) recommends designing for easy identification and diagnosis (but recommends avoiding solutions that attempt to automatically adjust for error).

3.3 Heuristics and biases

Since Herbert Simon pointed out that it is simply impossible to know, let alone to calculate, all the possible outcomes of all the possible choices for most decisions, it has been clear that we must use other approaches to making decisions. Simon (1990) referred to "satisficing" heuristics that enabled individuals to avoid a paralysis of calculation. Whilst he was also rather disparaging of research into the errors caused by individual's biases (Gigerenzer, 2004), more recent psychological research has identified an array of heuristics

and biases that short-cut our decisions. Several are worth highlighting as they will affect organisational decision-making:

Substitution - decisions can often be either ill-defined or difficult to resolve. To overcome this, we tend to unconsciously substitute them with a simpler decision (Kay and King, 2020; Klein, 2017; Kahneman, 2011). For example, without discipline, deciding who would be the best person to hire from a set of candidates may be substituted with "who do I most like?" (the substitution of a decision with a measure of emotional impact is known as **Affect Bias**, and **Halo Effect** describes how positive impressions of others lead us to favour them more generally)

What You See Is All There Is (WYSIATI) - probably due to our limited capacity to seek out and hold a wide range of information, we tend to use only that which is immediately in front of us. This is compounded by our tendency to read cause and effect into even limited information (Kahneman, 2011). For instance, if we saw improved sales after running a story in the media, we may assume that the story led to the improved sales. However, there are many other factors that may have improved sales. It is even possible that the apparent improvement may actually be marginal compared to our competitors' sales and thus not an improvement worth noting at all.

Hindsight Bias, Availability Heuristic, Gambler's Fallacy, Salience Bias - all lead us to make poor judgements of the likelihood of rare events. We tend to overweight those events that are most vivid to us (for instance, because they recently happened, such as a pandemic, since 2020) and underweight those events that we cannot easily imagine (such as a pandemic, in 2019) (Kahneman, 2011; Taleb, 2007).

Planning Fallacy - we tend to underestimate how long a task will take, no doubt because we haven't identified all the relevant information (WYSIATI) or possible unexpected events and because of Optimism Bias (Kahneman, 2011; Taleb, 2007). We all know of projects (including the one resulting in this document) that have suffered this.

For each of the above examples, it takes effort to engage with our thinking and test our underlying assumptions. Some practical solutions that overcome biases and engage analytical (System 2) thinking are suggested below, such as Comparability Analysis and Premortem exercise in Section 3.4.

3.4 Expertise

Decision makers with experience and expertise often see things that are invisible to novices, such as patterns, anomalies and opportunities. Studies of decision-making in high-stakes environments such as firefighting and nuclear power stations have demonstrated how much more rapidly experts can appraise the conditions and expected developments. This allows them to extract more information from a situation, potentially leading to better outcomes (Klein, 2017).

The problems addressed in these studies are probably more akin to critical than wicked or tame, but there are some very specific capacities that are heightened by expertise that are worth highlighting:

Recognition-Primed Model - expertise and experience enables a decision-maker to quickly recognise a situation and determine whether or not it is typical (Simon, 1992; Klein, 2017). This understanding of the situation allows experts to also determine what are

Figure 4: Klein (2017)'s mind map showing all the Sources of Power used in decision-making.

the plausible goals and then quickly evaluate possible courses of action. In critical environments, a decision may involve identifying only one course of action and then mentally adjusting this to fit the current circumstances. This mental activity uses analogy and mental simulation, among other analyses (see below; Klein, 2017).

Analogy and Metaphor - understanding a problem and finding a solution involves comparing with similar situations and recognising what may work in the current situation. This may be a wholly mental process but some groups have turned analogy into an organisational routine. For example, in 1971 the Wright-Patterson Air Force Base developed **Comparability Analysis** in which the reliability of any new system was forecast by using the known reliability of the most similar system. Importantly, this analytical process included steps for first defining the new system in detail and also for explaining in detail the rationales for choosing the similar system and for any adjustments made during the calculation of reliability (Klein, 2017). No doubt the application of detailed description overcome mental biases such as Substitution and WYSIATI.

Mental Simulation - experience in a given situation improves people's ability to mentally simulate both how the situation emerged but also possible developments in the situation. It also permits the "testing" of possible solutions by mentally running through their implementation and use, mentally making adjustments if required (Klein, 2017). Klein (2017) developed the **Premortem exercise** which exploits experts skills in mental simulation. This exercise is undertaken before a decision is acted on and encourages people with different perspectives to imagine all the possible ways

that the course of action could go wrong.

It may be that reliable recognition, comparison and mental simulation are more difficult in wicked environments (perhaps contributing to their wickedness). Indeed, bringing together their respective knowledge of Heuristics and Biases, and Expertise, Kahneman and Klein (2009) found that expertise can be highly over-rated in dynamic, human-driven, low feedback, low repeat (a.k.a. low-validity) environments.

Zollo *et al.* (2002) look at learning within organisations and identify 3 levels of knowledge processing, each enabling a greater dispersal of the knowledge than the previous level:

1. experience (tacit) accumulation
2. knowledge articulation
3. knowledge codification

The evidence from synthesising over 200 studies of organisational decision-making indicates that decision-makers using formally-learned domain expertise make better decisions than their counterparts who's experience is purely "on-the-job" (Blettner *et al.*, 2023). The authors of this study suggest this may be because they have gained codified knowledge with more explicit rules (Blettner *et al.*, 2023).

3.5 Individual and organisational characteristics

In an organisation, culture plays a crucial role in the decision process, in particular, in how information is obtained and used. Often decisions are taken by those in management and leadership roles. However, much of the vital information is only available on the "shop floor", working with processes, products and customers. Marlow (2023b) identifies what he called the **Double Disconnect** (Figure 5). This is where decision-makers at the "top" of an organisation make decisions that do not align with the experience of the sensemakers and action takers on the shop floor. This results in a series of pitfalls that range from a lack of information, which causes a failure to make decisions, to the enactment of decisions being either grudging or covertly non-compliant (Marlow, 2023b; Jiang, 2023). An example from the realm of technology is **shadow IT** - unofficial technology that staff implement to patch official technology and allow them to perform their roles more effectively (Schwarz, 2017).

Separation of decision-making from sensemaking and action taking is not inevitable, and is quite possibly a very modern condition. Research into the organisation of human societies has found that **Polycentric Governance**, whereby decisions are distributed across a network, is highly efficient (Ostrom, 2010). In these societies, those doing the sensemaking are also making decisions and taking action. Despite constant uncertainty, such systems were successful for 100s sometimes 1000s of years since the most successful and sustainable systems survived (which may be considered and evolution of culture). Individuals in such systems arguably all shared a common goal (a strategic objective, if you will) to balance current needs for survival with long term survival of their group and culture. Within critical environments, sharing a goal (such as the broad plan of action when extinguishing a house fire) enables teams to work effectively together without requiring constant decisions at every subtle change - another form of distributed decision-making. When studying military teams, Klein (2017) observed how vital the clear **communication of intent** was to the effectiveness of a team. He identified the information that is essential

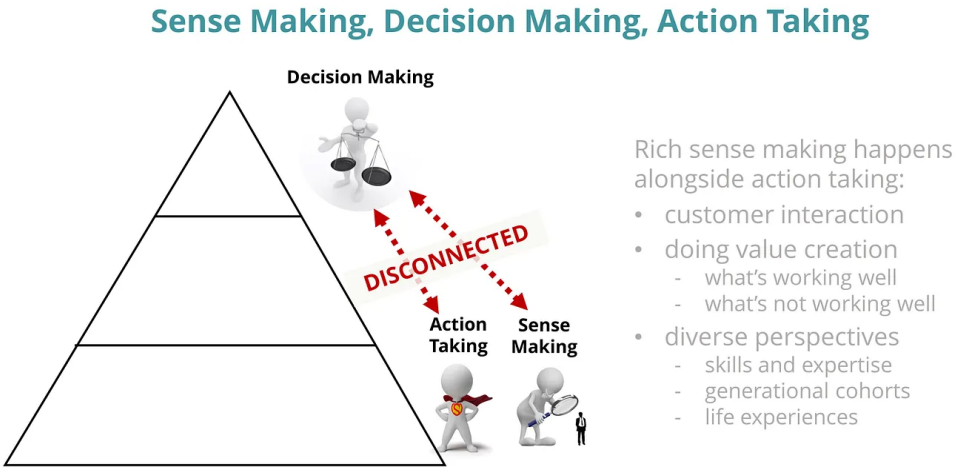

Figure 5: Marlow (2023b)'s Double Disconnect model arising from decision-making occurring separately to sensemaking and action taking.

when communicating intent:

1. Purpose of the task
2. Objective of the task
3. Sequence of steps in the plan
4. Rationale for the plan
5. Key decisions that may have to be made
6. Antigoals (unwanted outcomes)
7. Constraints and other considerations

Klein (2017) also suggested that communications can be much improved if "exercises [are set up] to provide feedback to leaders about how well their intent is understood" (Klein, 2017). Interestingly, there is evidence that decision-makers who exhibit more **Actively Open-minded Thinking (AOT)** make better management decisions because they actively search for and give fair treatment to possibilities other than the one they initially favour (Erceg, 2023).

A study of NASA demonstrates how the Challenger disaster, which in retrospect was preventable had the sensemakers (engineers) been able to convey their suspicions, has been learned from to create a more effective organisation with a "commitment to tracking small failures, ability to recognise and understand complex issues, real attention to front-line workers, the ability to learn from and rebound from errors, and the ability to improvise effective response to crisis ... the overarching culture was one of open exchange, honouring of diverse options, and the embrace of the right to dissent..." (Davenport and Manville, 2012 quoted in Kay and King, 2020).

Most organisations have defined structures and trigger points for decision-making under expected scenarios. These processes are excellent for addressing tame problems, such as decision points that have been experienced before and have predictable outcomes (Grint,

2010). Yet, some view more competitive "dragons' den"-type governance can be "passive", "judgmental", disengaged and unsuitable for the uncertain reality of organisational decision-making (Schwarz, 2017). There is also recognition that organisational structures and individual behaviours and personality traits, such as power dynamics (Moallemi *et al.*, 2023; Buchanan and Denyer, 2013) or narcissism and overconfidence (Blettner *et al.*, 2023), can impact decision-makers' efficacy

Grint (2010) suggested that "the leader's role with a Wicked Problem, is to ask the right questions rather than provide the right answers because the answers may not be self-evident and will require a collaborative process to make any kind of progress". He also recognised that within hierarchical organisations, this style of leadership can be difficult to apply because asking questions does not feel like making decisions. Solutions to wicked problems can feel "clumsy" because they are imperfect and don't appeal to a single explanation of the problem. Practitioners and researchers identify that in such a role, it is normal for the leader to experience discomfort, not only with uncertainty (Grint, 2010) and disagreement (Maniam, 2021), but also with a conflict between the need to decide and the need to reflect (Schwarz, 2017; Grint, 2010).

4 Areas of focus for improving decision-making

Given the above literature, there are five areas of focus for enhancing an organisation's decision-making capability. These are described below and abbreviated using 5 phrases: **Expertise**, **Embed**, **Analytical Thinking**, **Codify**, and **Accept and Adapt**.

4.1 Develop and Use Expertise

Team members who are supported to develop both deep experiential knowledge and wider domain expertise have a greater range of skills in recognition and mental analysis. This will allow them to quickly identify patterns and anomalies such as clues that things are running well or flags that something is going wrong. For example, the quick identification of the signs of effective team collaboration or, conversely, a problem with a data flowline, take skill. Expertise can also enable the pre-testing of solutions, such as mentally designing an algorithm and testing it against known situations before determining if it is worth coding, or assessing for danger, such as during a risk assessment. Such mental athletics not only enables the organisation to have a deeper understanding of the current situation but it allows us to be vigilant to possible futures and identify risks and opportunities.

4.2 Embed decision-making with sensemaking and action taking

Effective sensemaking often occurs in those areas that directly work with customers, products and processes. Often these are the same areas that take action after a decision and so will quickly identify if aspects of the decision no longer match the reality. Embedding decision-making with sensemaking and action taking means that the feedback between the changing outside world and the adapting-anticipating organisation is quick and responsive. This addresses Marlow (2023b)'s Double Disconnect and suggests that Grint (2010)'s questioning leader would facilitate deliberation over observations and opportunities. Further, a team that applies Klein (2017)'s recommendations for effective communication of intent can maintain a strong clarity of purpose. Other suggestions for

embedding decision-making with sensemaking and action taking include building an organisational equivalent of Ostrom (2010)'s Polycentric Governance.

4.3 Engage Analytical Thinking (System 2 thinking)

Whilst a strength of expertise and experience is that the automatic thinking of System 1 is better tuned to particular domains, it can also miss critical cues and fail to notice poor assumptions and biases. Analytical System 2 thinking takes effort to engage and it can therefore help to develop practises that activate and strengthen the recourse to analytical thinking. Training in techniques such as AOT, practising effective communication of intent, and applying methods such as Comparative Analysis and Premortem exercises all encourage the articulation of assumptions, rationale and help to identify possible outcomes. One of the pitfalls of planning in a VUCA world is that many of the risks and opportunities are extremely difficult to imagine and we will therefore underestimate their likelihood. Making such events more vivid, by describing in detailed possible future scenarios, can improve our ability to factor them in when making decisions.

4.4 Codify knowledge

Expertise and experience is not always enough. No single person can gain a wide range of experiences, certainly not if they are only exposed to a limited number of domains. Sharing knowledge brings the experience of others into one's own repertoire, and vice versa. However, even the accumulated knowledge of many people can be either limited or conversely be too complex to ensure that it is efficiently accessed when its needed.

By codifying the organisation's experience can produce an expanding set of examples to draw on as analogies and can even be use to create quick reference models that generalise the experience of many, such those taught in formal training (as identified by Blettner *et al.*, 2023).

For example, uncertainties over making decisions, such as whether to develop a new product for a new customer, can be reduced by understanding trends over many similar cases. This is best achieved by identifying and labelling the core components of decisions including the underlying conditions, actions and outcomes. This can also include the activities of other organisations to broaden understanding of the possible outcomes under different conditions. Such a database of examples is also resilient to the turnover of staff (Zollo *et al.*, 2002) and may even be drawn on for machine-assisted approaches to decision-making (such as Case-Based Reasoning).

4.5 Accept and Adapt to Inelegance, Error and Fate

Decision-making in an increasingly uncertain world is not only difficult, it is uncomfortable. A number of practitioners suggest that the discomfort is a good sign, indicating that decision-makers are aware of their imperfections and of the challenges to their assumptions. As identified in Section 3.2, decision-making under these conditions will be inelegant: iterative and feel like muddling through, and at best will implement no regrets solutions.

Given that the evidence is that the outcomes of many business scenarios are largely down chance, that the actual decisions are not as influential as we like to think. This indicates that

there is not always such a thing as a good or bad decision. Instead, decisions will be made and acted on and will be followed by improvements or further problems or a combination of both. Therefore, more important than decisions are the constant monitoring activities, including monitors that allow human or automatic alarms to trigger swift action, buffers to prevent worst-case scenarios and recovery plans for when conditions have worsened too quickly (Kay and King, 2020).

4.5.1 Paradox

There are a number of paradoxes that emerge from the literature on decision-making. On the one hand, there are claims that it is possible to make decisions that have better outcomes, I have highlighted the main themes that align to this. On the other, the environment is so wicked and the world so VUCA, that decisions are largely irrelevant and what matters is being adaptive to circumstance and not clinging too dearly to any particular approach. There is also a paradox between the importance of expertise, or the use of knowledge codification, and the understanding that there are many circumstances when these are close to useless. No doubt there is much to learn from the work into "Organisational Paradox Theory" and that holding two opposing views at once may support effective leadership under complex conditions (Halttunen *et al.*, 2022; Wilson and McCalman, 2017).

5 Next steps

Ham *et al.* (2021) identify 14 factors for which they find evidence that the factors affect the performance of team decision-making. These pertain to the situation, decision, team, individual and organisation. Much of the detailed decision-making literature that I have reviewed to date pertain to individuals' decision-making characteristics. Such work is foundational since no decision occurs without the influence of individual characteristics. Also, Klein (2017) demonstrated how the team mind is analogous to an individual's mind, with similar functions and abilities to learn.

Yet, further work is needed to develop a deeper understanding of decision-making in organisations and under VUCA conditions, an area that appears to have a fair body of work. For example Heracleous *et al.* (2023) recently researched how NASA has transformed in response to political and technological change, and Hongchai and Weber (2023) reviewed multiple studies to find key characteristics of leadership in a VUCA world. As there does not appear to be a great deal of overlap between work in economics, management, psychology or practice spheres, it is likely that I only scratched the surface in any of these.

The five areas of focus arising from this review are a strong basis for discovering how well different areas of an organisation perform against indicators for the 5 areas: Expertise, Embed, Analytical Thinking, Codify, and Accept and Adapt. This could take the form of social research into routines and processes, as well as behaviours and beliefs within the organisation pertaining to each of these areas of focus.

Bibliography

Blettner, Daniela *et al.* (2023). "Unfinished business: integrating individual decision-makers' experience and incentives to organizational performance feedback theory". In: *Frontiers*

in Psychology. URL: https://www.frontiersin.org/articles/10.3389/fpsyg.2023.1166185/full.

Boyd, John R. (2012). *The Essence of Winning and Losing*. Ed. by Chet Richards and Chuck Spinney. URL: https://fasttransients.files.wordpress.com/2010/03/essence_of_winning_losing.pdf.

Buchanan, David A. and David Denyer (2013). "Researching Tomorrow's Crisis: Methodological Innovations and Wider Implications". In: *International Journal of Management Reviews* 15 (2): *: Research Methods and Research Practice: History, Themes and Topics*. Ed. by Bill Lee and Catherine Cassell. DOI: 10.1111/ijmr.12002. eprint: https://onlinelibrary.wiley.com/doi/epdf/10.1111/ijmr.12002. URL: https://onlinelibrary.wiley.com/doi/10.1111/ijmr.12002.

Cyert, Richard M. *et al.* (1956). "Observation of a Business Decision". In: *The Journal of Business* 29.4, pp. 237–248. ISSN: 00219398, 15375374. URL: http://www.jstor.org/stable/2350807 (visited on 06/25/2023).

Davenport, Thomas H. and Brook Manville (2012). *Judgment Calls. Twelve Stories of Big Decisions and the Teams That Got Them Right*.

Erceg, Nikola (2023). "Decision-making skills and styles as predictors of managerial performance". PhD thesis. University of Zagreb, Faculty of Humanities and Social Sciences. URL: https://repozitorij.ffzg.unizg.hr/islandora/object/ffzg:8207.

Gigerenzer, Gerd (2004). "Striking a blow for sanity in theories of rationality". In: *Models of a man: Essays in memory of Herbert A. Simon*. Ed. by M. Augier and J. G. March. MIT Press, pp. 389–409. eprint: https://pure.mpg.de/rest/items/item_2101380/component/file_2101379/content.

Grint, Keith (2010). "Wicked Problems and Clumsy Solutions: The Role of Leadership". In: *The New Public Leadership Challenge*. Ed. by Stephen Brookes and Keith Grint. London: Palgrave Macmillan UK, pp. 169–186. ISBN: 978-0-230-27795-3. DOI: 10.1057/9780230277953_11. eprint: http://leadershipforchange.org.uk/wp-content/uploads/Keith-Grint-Wicked-Problems-handout.pdf. URL: https://doi.org/10.1057/9780230277953_11.

Halttunen, Krista *et al.* (2022). ""We don't want to be the bad guys": Oil industry's sensemaking of the sustainability transition paradox". In: *Energy Research & Social Science* 92, p. 102800. ISSN: 2214-6296. DOI: https://doi.org/10.1016/j.erss.2022.102800. URL: https://www.sciencedirect.com/science/article/pii/S2214629622003036.

Ham, Dong-Han *et al.* (2021). "Identifying key factors affecting the performance of team decision-making based on the analysis of investigation reports issued from diverse industries". In: *Reliability Engineering & System Safety* 206, p. 107304. ISSN: 0951-8320. DOI: https://doi.org/10.1016/j.ress.2020.107304. URL: https://www.sciencedirect.com/science/article/pii/S0951832020308000.

Heracleous, Loizos *et al.* (2023). "Logical Incrementalismas a Path to Strategic Agility: The Case of NASA". In: *California Management Review* 65.4, pp. 63–92. DOI: 10.1177/00081256231180878. eprint: https://journals.sagepub.com/doi/pdf/10.1177/00081256231180878. URL: https://doi.org/10.1177/00081256231180878.

Hongchai, Dahm Mongkol and Charles M. Weber (2023). "Leadership for Technology Management in a Volatile, Uncertain, Complex, and Ambiguous (VUCA) World: A Review of the Literature and a Research Agenda". In: *2023 Portland International Conference on Management of Engineering and Technology (PICMET)*, pp. 1–23. DOI: 10.23919/PICMET59654.2023.10216793. URL: https://ieeexplore.ieee.org/document/10216793.

Jiang, Gemma (2023). "Collaborative leadership in team science: dynamics of sense making, decision making, and action taking". In: *Frontiers in Research Metrics and Analytics* 8. DOI: 10.3389/frma.2023.1211407. URL: https://www.frontiersin.org/articles/10.3389/frma.2023.1211407/full.

Kahneman, Daniel (2011). *Thinking Fast and Slow*.

Kahneman, Daniel and Gary Klein (2009). "Conditions for intuitive expertise: A failure to disagree". In: *American Psychologist*. DOI: 10.1037/a0016755.

Kay, John and Mervyn King (2020). *Radical Uncertainty. Decision making for an unknowable future*. URL: https://www.johnkay.com/2020/02/12/radical-uncertainty/.

Klein, Gary A. (2017). *Sources of Power. How People Make Decisions*. The MIT Press. DOI: 10.7551/mitpress/11307.001.0001. URL: https://direct.mit.edu/books/book/3647/Sources-of-PowerHow-People-Make-Decisions.

Lempert, Robert J. *et al.* (2003). *Shaping the Next One Hundred Years. New Methods for Quantitative, Long-Term Policy Analysis*. ISBN: 978-0-8330-3275-1.

Maniam, Aaron (2021). "Decision-Making in an Age of Uncertainty: Futures and Strategy for Leaders". In: *SID Directors Bulletin* (Quarter 3), pp. 18–23. eprint: https://drive.google.com/file/d/1atjuFOpnZBJp74u3JyAxhNh9MtgKAf1Q/view. URL: https://www.sid.org.sg/images/PDFS/Publications/DirectorsBulletin/DirectorsBulletin_3Q2021.pdf.

Marlow, Geoff (2023a). *Making sense of sense making*. URL: https://geoffmarlow.substack.com/p/making-sense-of-sense-making (visited on 07/06/2023).

– (2023b). *The Double Disconnect*. URL: https://geoffmarlow.substack.com/p/the-double-disconnect (visited on 10/03/2023).

Moallemi, Enayat A. *et al.* (2023). "Knowledge co-production for decision-making in human-natural systems under uncertainty". In: *Global Environmental Change* 82, p. 102727. ISSN: 0959-3780. DOI: https://doi.org/10.1016/j.gloenvcha.2023.102727. URL: https://www.sciencedirect.com/science/article/pii/S0959378023000936.

Nelson, Richard R. and Sidney G. Winter (1982). *An Evolutionary Theory of Economic Change*. Cambridge, Mass.: Harvard University Press.

Ostrom, Elinor (2010). "Beyond Markets and States: Polycentric Governance of Complex Economic Systems". In: *The American Economic Review* 100.3. DOI: 10.1257/aer.100.3.641. URL: https://doi.org/10.1257/aer.100.3.641.

Ranger, Nicola and Su-Lin Garbett-Shiels (2011). *How can decision-makers in developing countries incorporate uncertainty about future climate risks into existing planning and policymaking processes?* London School of Economics and Political Science. eprint: https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2014/03/PP_climate-risks-policymaking_Ranger-etal.pdf. URL: https://www.lse.ac.uk/granthaminstitute/publication/how-can-decision-makers-in-developing-countries-incorporate-uncertainty-about-future-climate-risks-into-existing-planning-and-policymaking-processes/.

Rittel, Horst W. J. and Melvin M. Webber (1973). "Dilemmas in a General Theory of Planning". In: *Policy Sciences* 4.2, pp. 155–169. URL: https://www.sympoetic.net/Managing_Complexity/complexity_files/1973%20Rittel%20and%20Webber%20Wicked%20Problems.pdf.

Schwarz, Mark (2017). *A Seat at The Table. IT Leadership in the Age of Agility. IT Leadership in the Age of Agility*. ISBN: 978-194278-8119. URL: https://itrevolution.com/product/a-seat-at-the-table/.

Simon, Herbert A. (1990). "Invariants of Human Behavior". In: *Annual Review of Psychology* 41, pp. 1–19. DOI: 10.1146/annurev.ps.41.020190.000245. eprint: https://www.annualreviews.org/doi/pdf/10.1146/annurev.ps.41.020190.000245. URL: https://www.annualreviews.org/doi/10.1146/annurev.ps.41.020190.000245.

– (1992). "What is an "Explanation" of Behavior?" In: *Psychological Science* 3.3. DOI: 10.1111/j.1467-9280.1992.tb00017.x. URL: https://journals.sagepub.com/doi/10.1111/j.1467-9280.1992.tb00017.x.

Stanovich, Keith E. and Richard F. West (2000). "Individual differences in reasoning: Implications for the rationality debate?" In: *Behavioral and Brain Sciences* 23.5, pp. 645–665. DOI: 10.1017/S0140525X00003435. eprint: https://www.cambridge.org/core/services/aop-cambridge-core/content/view/2906AEF620B36C10018DD291F790BE97/S0140525X00003435a.pdf/individual-differences-in-reasoning-implications-for-the-rationality-debate.pdf. URL: https://www.cambridge.org/core/journals/behavioral-and-brain-sciences/article/individual-differences-in-reasoning-implications-for-the-rationality-debate/2906AEF620B36C10018DD291F790BE97.

Taleb, Nassim Nicholas (2007). *The Black Swan: The Impact of the Highly Improbable*. URL: https://www.penguin.co.uk/books/56380/the-black-swan-by-nassim-nicholas-taleb/9780141034591.

Teece, David J. (2022). *Evolutionary Economics, Routines, and Dynamic Capabilities*. UCL Institute for Innovation and Public Purpose. URL: https://www.ucl.ac.uk/bartlett/public-purpose/publications/2022/oct/evolutionary-economics-routines-and-dynamic-capabilities.

Weick, Karl *et al.* (2005). "Organizing and the Process of Sensemaking". In: *Organization Science* 16, pp. 409–421. DOI: 10.1287/orsc.1050.0133. URL: https://www.researchgate.net/publication/211395920_Organizing_and_the_Process_of_Sensemaking.

Wilson, Samuel and James McCalman (2017). "Re-imagining ethical leadership as leadership for the greater good". In: *European Management Journal* 35 (2), pp. 151–154. DOI: 10.1016/j.emj.2016.06.001. URL: https://www.sciencedirect.com/science/article/pii/S0263237316300597.

Zollo, Maurizio *et al.* (2002). "Deliberate Learning and the Evolution of Dynamic Capabilities". In: *Organization Science* 13.3, pp. 339–351. DOI: 10.1287/orsc.13.3.339.2780. URL: http://dx.doi.org/10.1287/orsc.13.3.339.2780.