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Research Article

A conceptual framework for agility in sociotechnical contexts

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ABSTRACT
Organisational agility is crucial for organisations to thrive in dynamic business environments. While the Information Systems (IS) discipline recognises the need for IS to support organisational agility, current IS research has not sufficiently explained how organisations achieve agility given their sociotechnical contexts. Some scholars and practitioners propose scaling agility-building approaches from small software development teams to the enterprise level, and others argue that agility is not a predetermined outcome of linear processes, but instead emerges from intricate organisational contexts. Previous research proposed a conceptual model that identified the structural components of agility in IS. However, this structural perspective does not address the dynamic aspects of agility. To address this gap, two systematic literature reviews (SLR) were conducted to develop a conceptual framework for agility in sociotechnical contexts, which is the contribution this research makes to the IS field. The first SLR investigated frameworks that enable organisational agility. Consequently, the Cynefin framework was adopted to explain the dynamics of contextualised decision-making and agility. The second SLR identified the influence of heuristics on decision-making and dynamic capabilities. The resulting framework integrates the structural and dynamic aspects of agility in IS and explains how heuristics could potentially be managed to improve sociotechnical agility.

Keywords agility, sociotechnical, complex adaptive systems, dynamic capabilities, Cynefin, critical systems heuristics

Categories • **CCS ∼ Social and professional topics, Professional topics, Management of computing and information systems**

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1 INTRODUCTION

Unpredictable disruption, hypercompetition, and turbulence result in uncertainty in the business environment, requiring enterprises to successfully manage such uncertainty, which is a key feature of organisational agility (Teece et al., 2016). Agility enables businesses to adapt swiftly to unpredictable internal and external changes in a highly dynamic environment by

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effectively managing and adapting their operations and processes beyond normal levels of flexibility (van Oosterhout et al., 2006). However, achieving and maintaining agility is expensive, is not relevant to all organisational situations and can sometimes be counterproductive to the organisation's success (Teece et al., 2016; Walter, 2021).

Agile software development approaches aim to help small software development teams deliver increased business value faster in short prioritised iterations (Boehm & Turner, 2004). However, what it means to be "agile" in sociotechnical contexts remains elusive (Baham & Hirschheim, 2022). Sensing and responding capabilities are central themes for agility in strategy, management, and IS literature (Tallon et al., 2019). Decision-making capability and dynamic capabilities enable organisational agility by enabling managers in organisations to sense, decide and act in high-speed predictable and unpredictable contexts (Park et al., 2017; Pavlou & El Sawy, 2011; Teece et al., 2016). However, agility is an emergent phenomenon at the team level (Werder & Maedche, 2018), and problems arise in attempts to scale agility to the enterprise level (Limaj & Bernroider, 2022), as simply having more Agile teams does not produce organisational agility (Sidky, 2017). According to Denning (2016), large-scale Agile frameworks, such as the Scaled Agile Framework (SAFe), regularly fail because they attempt to "align" Agile teams with corporate goals relating to shareholder interests and achieving quarterly business targets. Instead, Agile practices should focus on delivering value to the business in short iterations. This divergence results in the ongoing tension between the enterprise and the Agile team levels in the organisation (Denning, 2016).

Previous research has identified the structural components of agility in IS (Lillie et al., 2023; Park et al., 2017). However, this structural perspective does not address the dynamic aspects of agility to explain how organisations can achieve agility in their IS. This presented a gap in scientific IS literature that this study aimed to address by developing a conceptual framework for agility in sociotechnical contexts. This study adopts the definition of a framework as a model (graphical representation and description of components and their relationships) and a method (goal-oriented activities and guidelines) for its implementation (Kotze et al., 2015; March & Smith, 1995). The method used to develop a conceptual framework for agility in sociotechnical contexts was to systematically review scientific literature for existing constructs that can explain the dynamics of, and the underlying influences on, agility in organisations.

The rest of this manuscript is structured as follows: Section 2 provides background about the agility problem in sociotechnical contexts. In order to explain the dynamic aspects of agility, an SLR of frameworks, including models and methods that enable agility in complex organisational contexts, was conducted in Section 3 to answer the first research question: What scientific frameworks, models or methods enable agility in complex organisational contexts? The results of this first SLR initiated the development of the conceptual framework for agility in sociotechnical contexts, and identified the Cynefin framework, grounded in complex adaptive systems theory, which could be used to explain the dynamics of contextualised decision-making and agility in complex and complicated organisational environments.

However, complex organisational situations challenge decision-making because uncertainty is constant and brings the risk that desired outcomes may not be achieved due to actor

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biases (Tversky & Kahneman, 1974). Additionally, the intricate interplay between human organisation and IS's technical aspects can lead to unintended and undesirable outcomes (Cecez-Kecmanovic et al., 2014). In situations of uncertainty – where problems are unclear, multiple solutions exist, and probabilities of outcomes are unknown – humans typically rely on heuristics to make decisions based on incomplete information (Gigerenzer & Gaissmaier, 2011). Acknowledging the role of heuristics in decision-making raised the second research question, which was addressed by the SLR in Section 4, concerning how to enhance the framework for agility in sociotechnical contexts: How do heuristics influence dynamic capabilities in organisational contexts?

In Section 5, the resulting framework is presented as the contribution of this study, a conceptual framework (a model and a method) for agility in sociotechnical contexts. This framework integrates the structural and dynamic aspects of agility, explaining how heuristics could potentially be managed to improve agility in sociotechnical contexts.

2 BACKGROUND

The organisational sense-response framework, proposed by Park et al. (2017), acknowledges that sense-respond capabilities are foundational to agility in IS, and support organisational agility (Sambamurthy et al., 2003; Tallon et al., 2019). The model of agility in IS proposed by Lillie et al. (2023) offers three categories for the characteristics of agility in IS:

1. sociotechnical contexts are complex and complicated,
2. dynamic capabilities operate at the managerial level to govern team and individual actions, and
3. agility features manifest in the actions of teams and individuals.

Even though these constructs imply organisational levels in an agility-generating sense-response process flow, they do not explain the dynamic aspects of agility and how the different components relate across the levels of organisational context, managerial capabilities and individual and teams' sociotechnical actions.

In IS research, systems involving technical and social components are considered complex, and Social Science involves "social systems" (Gregor, 2009). Thus, sociotechnical contexts should be considered from a systems perspective and take into account theories related to systems theory and complex systems theory to explain the dynamic processes of complex and complicated sociotechnical contexts. Meadows (2008, p. 205) defines a "system" as "*[a] set of elements or parts that is coherently organized and interconnected in a pattern or structure that produces a characteristic set of behaviour.*" Systems theory in organisational science is an antecedent of dynamic capabilities theory and understands organisations as social systems comprising subunits that interrelate congruously and harmoniously, supporting the organisation's effectiveness (Teece, 2018).

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Complicated problems in organisations can be solved when the required expertise is available and utilised by applying rules and routines, and through command-and-control approaches that rely on embedded organisational processes and hierarchies (Nason, 2017). However, the daily realities of organisational life are complex as they are rife with multiplicity, contingency and emergence (Feldman & Orlikowski, 2011), and change is the prevailing organisational state (Tsoukas & Chia, 2002). Organisational change, such as an improved state of agility (Teece et al., 2016), can be achieved when managers use dynamic capabilities to govern the activities and actions of their teams (Teece, 2014).

Organisations that include social agents cannot be explained or described as aggregations of coexisting micro-situations, nor are macro-processes the aggregated product of interactions at the micro-level despite the profound implication of embodied behavioural patterns at the micro-level (Giddens, 1984). Agility is an emergent phenomenon (Werder & Maedche, 2018), and interactions at the micro-level allow collective constructs to change over time (Eisenhardt et al., 2010). In other words, nonlinear evolutionary processes and interactions at a micro-level emerge phenomena, such as agility, at a macro-level.

Meyer et al. (2005, p. 471) explain that "*[n]onlinear systems cannot be understood without conceptualizing and studying them at multiple levels. …[o]rganizations are entangled in an ecology in which one agent's actions help construct another agent's environment, generating forces that connect social structures at different levels.*" Therefore, Meyer et al. (2005) encourage researchers to apply a complex adaptive systems (CAS) lens to organisational studies and advocate an approach to organisational research that takes a contextual, coevolutionary, processual, multi-level and emergent perspective. Therefore, this study identified a need to explain the dynamic components of agility in sociotechnical contexts both as a model and a method that provides a scientifically grounded conceptual framework that can be applied to and tested in real-world sociotechnical contexts to develop the framework's practicality further. Thus, this study aimed to develop practical explanations for the conceptual model's constructs so that these could potentially be applied to case study or action research in real-world contexts.

3 AGILITY IN COMPLEX AND COMPLICATED ORGANISATIONAL CONTEXTS

The structural components of agility in IS represented as a conceptual model of agility in IS developed by Lillie et al. (2023) is based on the organisational sense-response process loop by Park et al. (2017), and served as the starting point for this study. The conceptual model of agility in IS (Lillie et al., 2023) incorporates three organisational levels:

1. the sociotechnical context level, which is the organisational environment within which IS strategy and leadership steer the organisation towards achieving agile IS as a strategic objective;
2. the dynamic capabilities level, comprising managerial capabilities that govern the organisation's IS operations and initiatives/projects towards achieving agility; and

3. the team and individual action level where IS work practices can achieve agility in operational and project/initiative activities.

The conceptual model of agility in IS (Lillie et al., 2023) proposed that the agility features of competence, responsiveness, speed, reusability, flexibility, leanness, and scalability manifest in the actions of teams and individuals. This study adopted these seven agility features identified from the literature by Lillie et al. (2023), which are summarised in Table 1.

Table 1: Features associated with agility in IS (based on Lillie et al. (2023, pp. 158–159)

Feature	**Association with agility in IS**
Competence	Having the knowledge, skills, abilities, and technical capabilities that enable the organisation to adapt, innovate and seize opportunities in rapidly changing business environments, resulting in effective responses to change, thereby supporting strategic agility.
Responsiveness	Refers to proactive adaptation whereby an organisation can react positively to changes in its competitive and regulatory environment. Organisational agility is enhanced by its ability to sense and respond appropriately and timeously to opportunities and threats.
Speed	The rate of change whereby an organisation can proactively adapt, embrace change, and respond effectively to opportunities and threats in its internal and external environment. To achieve agility, speed should be appropriately pursued because a slower, more suitable response is sometimes better than a rushed, unsuitable response.
Reusability	Implies the strategic practice of leveraging existing IT capabilities to address new business challenges, fostering operational agility, and potentially reducing costs.
Flexibility	Implies the readiness and propensity of an organisation's IT capabilities to adapt to perpetual environmental changes, scale with demand, and align dynamically with business strategy, thereby enabling organisational agility.
Leanness	Refers to the strategic practice of contributing to value delivery through economy, quality, and simplicity. The cost of change should be considered, as agility often comes at the cost of efficiency.
Scalability	Having the sociotechnical capacity to adapt to an increased workload while benefiting from economies of scale, thus supporting agility by enabling growth while limiting constraints on resources. Scalability can be achieved at any level in an organisation, and is enhanced when avoiding functional siloes, and standardising IT practices for cross-functional use.

The model of agility in IS proposed by Lillie et al. (2023) does not address the dynamic aspects of agility, that is, how these can be enabled. An SLR was conducted to answer the first research question:

What scientific frameworks, models, or methods enable agility in complex organisational contexts?

3.1 Method: a systematic literature review of frameworks for enabling agility in complex organisational contexts

The systematic literature search and review of frameworks, models, methods and strategies that enable agility in complex organisational contexts was directly shaped by the keywords "framework", "model", method", or "strategy" (to find implementable constructs), "sense" and "respond" (implies agile capabilities in organisations), and "complexity", "uncertainty" or "unpredictability" (all relate to complex organisational contexts). Scopus was selected as the research database for its advanced search options and inclusion of mainly peer-reviewed literature from top-rated IS journals.

The following search expression was applied to title, abstract and keyword fields, and it limited the results to journal articles in English from the Social, Computer, and Business Sciences:

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TITLE-ABS-KEY (
  (("sense-respond" OR "sense and respond" OR ("sense" AND "respond"))
   AND
   ("strategy" OR "framework" OR "model" OR "method")
   AND
   ("complex" OR "complexity" OR "uncertainty" OR "unpredictability")))
  AND (LIMIT-TO (SRCTYPE, "j"))
  AND (LIMIT-TO (SUBJAREA, "SOCI")
      OR LIMIT-TO (SUBJAREA, "COMP")
      OR LIMIT-TO (SUBJAREA, "BUSI"))
  AND (LIMIT-TO (LANGUAGE, "English")
)
```

This search returned 175 articles from which works on computational models/frameworks/ methods/strategies for sensing and responding, technological frameworks, and articles not relevant to organisational sensing and responding in complex organisational contexts were excluded. Highly cited, seminal, peer-reviewed articles from prominent authors were included in the final set of 13 articles, which were then analysed to answer the research question. The SLR process was based on the guidelines proposed by Okoli (2015) and is presented in Figure 1.

3.2 Analysis and findings

Using Webster and Watson's (2002) concept-centric approach, the articles found through the SLR process were summarised based on the concepts' relevance to how agility can be enabled in complex organisational contexts, considering:

1. the construct's objectives or goals,
2. the construct's theoretical foundations,
3. the construct's applicable contexts (what "complexity" means to the construct),

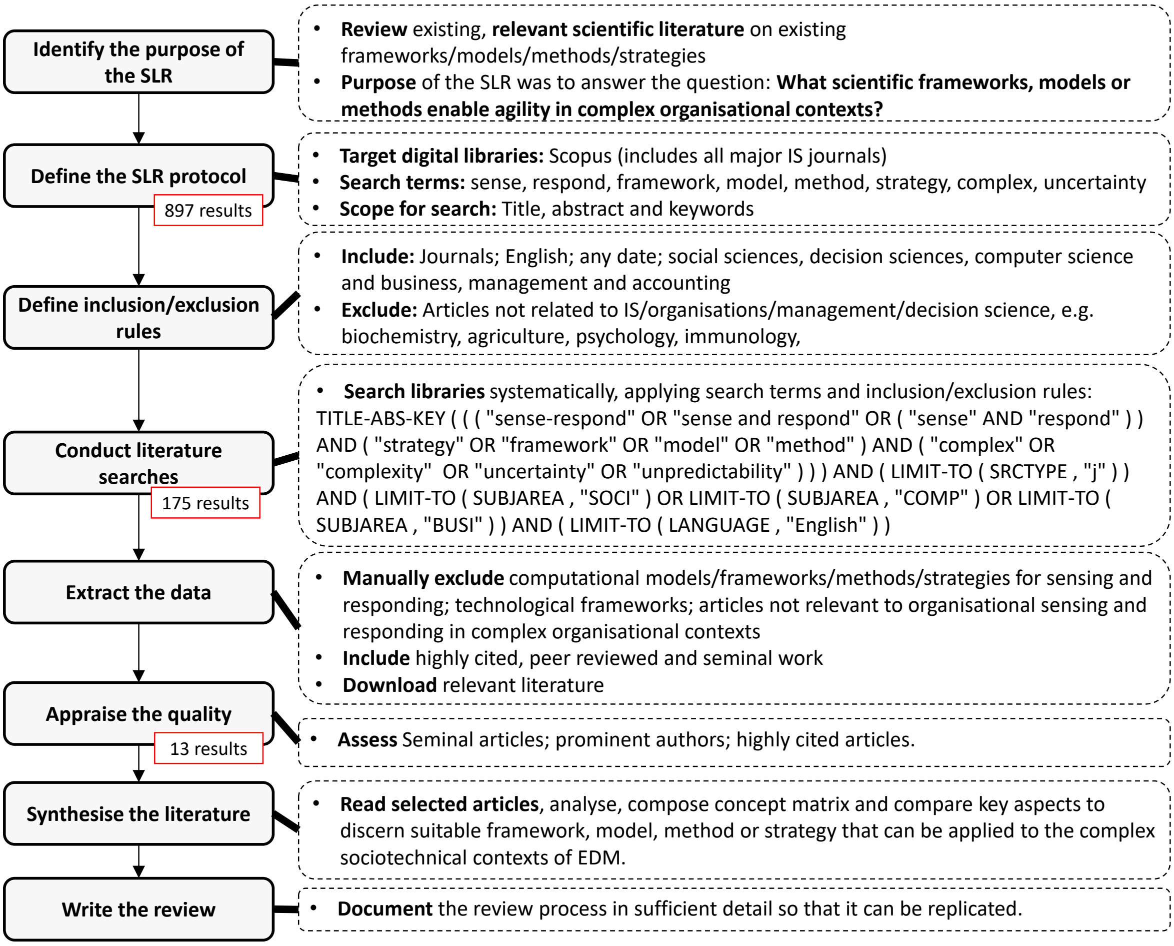

Figure 1: Systematic literature review process to find existing frameworks, models, methods and strategies for enabling organisational agility (based on Okoli (2015, pp. 883–884))

4. the construct's components (descriptions of components, relationships and processes), and
5. the construct's scope of application within organisational contexts.

Table 2 presents a summary of the findings in a concept matrix. The most relevant points were selected from each article and are highlighted in Table 2 using a coloured background to emphasise pertinence to the components of the conceptual model of agility in IS proposed by Lillie et al. (2023): complex and complicated sociotechnical contexts, dynamic capabilities (sensing, learning, coordinating and integrating), and agility features in IS. The various types of constructs found were framework (F), model (M), strategy (S) and tool (T), as indicated in the first column.

Table 2: Frameworks, models, methods and strategies for enabling agility in complex organisational contexts

Type	Construct objectives	Theoretical foundations	Contexts to which the construct applies	Construct components	Scope of application for the construct
Ramnath and Landsbergen (2005)					
S	Enable unified IT and organisation sense and respond strategy.	Evolutionary theory of economic change; Public Administration Theory	Change, uncertain demand, and reduced budgets	Strategic plan and execution process	IT and city government departments, taking a "fractal" view of "organisations-within-organisations"
Mathiassen and Vainio (2007)					
F	Approach to understanding dynamic capabilities in small software firms; proposes principles for managers to apply the framework.	Dynamic capabilities	Highly complex and turbulent	Capabilities and principles for sense-and-respond	Small software firms
Snowden and Boone (2007)					
F	Enable leaders at any organisational level to sense and decide on appropriate action in a prevailing operative context.	Complex systems	Complex, complicated, clear & chaotic	Describes dynamics between complex, complicated, clear and chaotic domains with awareness of the context	Contextualised application to any organisation/ part of an organisation
Collins et al. (2010)					
F	Enable a deeper understanding of relationships between knowledge management capabilities, supply chain technology investments, and overall firm performance enabling managers to adapt to changing environments effectively.	Not specified	Supply chain complexity	Resources, keys to effective utilisation, operational result, strategic result; output measures	Firms with complex supply chains
Strachan (2011)					
S	Question strategy as being underpinned by an actionable plan providing long-term predictability. Avoid conflating strategy with grand-strategy.	Theories of strategy and contingency	Uncertainty	Infinite flexibility; embrace contingency and long-term interests; strategy requires context and awareness of the effect on stakeholders	Military and national security contexts
Thiel et al. (2012)					
M	A sensemaking model that enables leaders to make ethical decisions.	Sensemaking	Complex and high-stakes situations	Sensemaking strategies based on personal, situational, and environmental constraints	Leadership in organisations
Liu (2013)					
M	Enable sustainable competitive advantage by integrating manufacturing strategy, transformational leadership, and technology.	Resource based view of the firm	Dynamic, complex, and turbulent business environments	Manufacturing strategy, technology strategy, dynamic decisions, sense & respond, transformational leadership	Manufacturing operations

[continued ...]

Table 2: [… continued]

Type	Construct objectives	Theoretical foundations	Contexts to which the construct applies	Construct components	Scope of application for the construct
Brookfield (2018)					
F	Enable risk mitigation through adaptation of the organisation from the interactions between accounting technologies and risk as an environmental factor.	Theory of the firm	Uncertainty as a general representation of risk; complexity	Nature of the firm, accounting as risk management IT, transaction cost economics	Financial risk management in organisations
Tilabi et al. (2019)					
T	Enable decision-making and strategy-making about firms' technologies for product and process development.	Miles and Snow Typology; Resource based view of the firm; Competitive advantage	Uncertainty and turbulence	Prospector, analyser, defender, and reactor. Responsiveness, agility, leanness, and flexibility. Quality, time, and cost.	High-tech startup organisations in large mass-production industries
Øvrelid and Sanner (2020)					
M	Lightweight IT extends digital infrastructure and enables organisations to sense and respond continuously to the effects of process innovation.	Dynamic complexity in information infrastructures	Complex organisational settings	Sense-able process innovation to digitalise, visualise, manage, and re-evaluate information infrastructures	General hospital as a complex organisational setting
Lane et al. (2021)					
F	Enable pragmatic leadership with a sense-making framework to "act-probe-sense-respond" in time-critical crisis situations.	Complex systems	Volatility, uncertainty, chaos, and ambiguity (VUCA)	Describes act-probe-sense-respond actions in chaotic healthcare contexts	Complex and time-critical medical emergency scenarios
Heino and Kalalahti (2021)					
F	Enable understanding of experts' decision-making in critical situations, considering the potentially detrimental effects of relying on pre-established procedures.	Naturalistic decision making; Cognitive task analysis	Complexity, uncertainty, and ambiguity	Notice unusual circumstances, identify the bigger picture, make decisions, improvise to overcome obstacles, start immediate action	Expert professional first responders in unexpected situations
Mero and Haapio (2022)					
M	Enables effectual decision-making in executing dynamic capabilities under unexpected uncertainty.	Effectuation; Dynamic capabilities	Unexpected uncertainty	Describes activities for reconfiguration of organisational capabilities and processes	Business-to-business firms

The construct objectives of five of the articles were found to be relevant to the characteristics of agility in IS, as proposed by Lillie et al. (2023). The other eight articles proposed constructs applicable to a narrow scope of organisational situations such as small software firms, supply chain technology investments, ethical decision-making, and manufacturing strategy. The Cynefin framework proposed by Snowden and Boone (2007) is underpinned by complexity theory and systems thinking, and enables leaders at any level in the organisation to sense the nature of the ongoing context and decide on an appropriate course of action.

Theoretical foundations: The theoretical foundations of the construct in five of the found studies are relevant to agility in IS as they incorporate dynamic capabilities or organisational complexity, which are structural components of agile IS (Lillie et al., 2023).

Contexts for construct application: In some of the reviewed articles, the context to which the construct was applied was narrowed down to a specific scope, thus less generalisable, such as reduced budgets (Ramnath & Landsbergen, 2005), supply chain complexity (Collins et al., 2010) and unexpected uncertainty (Mero & Haapio, 2022). The framework proposed by Snowden and Boone (2007) differentiates between complex, complicated, clear and chaotic domains within which leaders at all levels of an organisation must make sense of the operative contexts to decide and respond appropriately.

Construct components: Most of the constructs reviewed provided descriptive representations, including strategic plans and process steps (Ramnath & Landsbergen, 2005), capabilities and principles (Mathiassen & Vainio, 2007), required resources and measurable results (Collins et al., 2010), sensemaking strategies based on constraints (Thiel et al., 2012), and activities for the reconfiguration of organisational capabilities and processes (Mero & Haapio, 2022). Snowden and Boone's (2007) Cynefin framework specifically described the dynamics of navigating the complex, complicated, chaotic and clear domains of organisational contexts for effective decisions and responses.

Scope of application of the construct: The constructs proposed by the authors were, in most cases, applicable to a specific organisational context, for example, military and national security contexts (Strachan, 2011), high-tech startup organisations in large mass-production industries (Tilabi et al., 2019), business-to-business firms (Mero & Haapio, 2022), and firms with complex supply chains (Collins et al., 2010). Ramnath and Landsbergen (2005) provide an interesting "fractal" perspective of "organisations-within-organisations". The Cynefin framework proposed by Snowden and Boone (2007) offers a broad scope for contextualised application of their framework to any type of organisation or any part of an organisation.

3.3 The Cynefin framework applied to agility in sociotechnical contexts

The Cynefin framework proposed by Snowden and Boone (2007) offered the most relevant and generalisable explanation for the dynamics of sensing and responding, which are the key capabilities of organisational agility, in complex and complicated organisational contexts. Cynefin is a decision support framework that enables organisations to sense and respond effectively in complex, complicated, clear and chaotic contexts (Kurtz & Snowden, 2003; Snowden, 2021b; Snowden & Boone, 2007; Snowden & Rancati, 2021). Cynefin describes three primary types of systems: Ordered, Complex and Chaotic/un-ordered. An ordered system describes the clear and complicated domains (Snowden & Rancati, 2021). In a system where all events have an equal probability of occurring, all events are random, and nothing can emerge from its chaotic state (Juarrero, 2015a). Emergence is also irrelevant when a system is in perfect equilibrium where all events are perfectly predictable, and nothing can emerge from its clarity (Juarrero, 2015a). When actors in an organisational context are cognisant of the nature of the ongoing situation in terms of the domains proposed by the Cynefin framework, they can critically assess when and how to appropriately adopt or adapt methods and approaches for favourable outcomes (Snowden & Rancati, 2021). Figure 2 maps the components of the conceptual model of agility in IS (Lillie et al., 2023) onto the complex and complicated domains of Cynefin (Kurtz & Snowden, 2003; Snowden & Rancati, 2021).

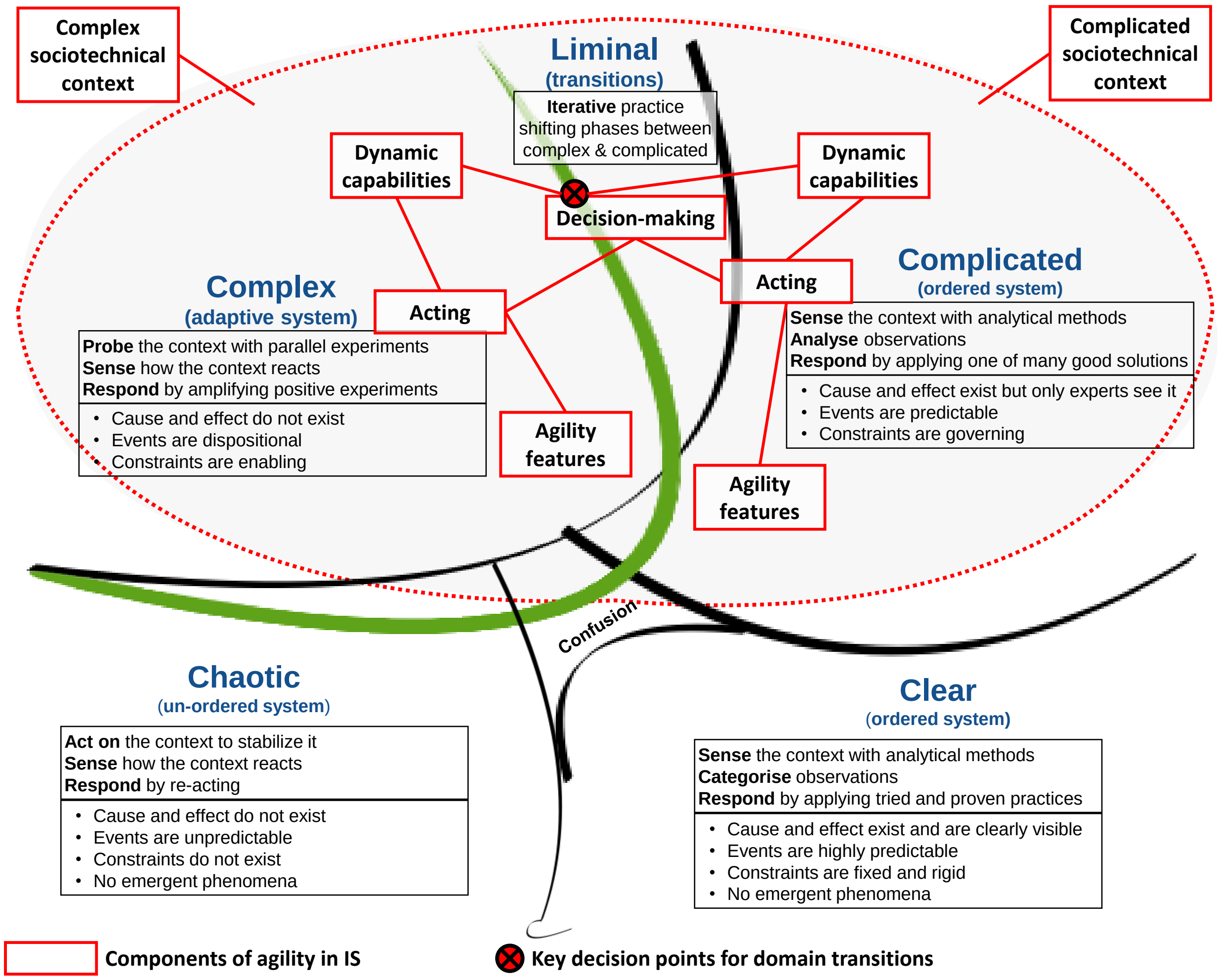

Figure 2: The components of agility in IS mapped to the Cynefin framework (based on Juarrero (2000); Kurtz and Snowden (2003, pp. 464–466); Lillie et al. (2023); Snowden and Rancati (2021, pp. 60–63)).

Complex and complicated organisational contexts: Systems involving human agents are invariably complex, comprising many interacting agents with multiple identities depending on their role in the unfolding context (Snowden, 2002). Kurtz and Snowden (2003) define complicated contexts as the domain of "known unknowns" where experts can solve problems. In contrast, they define complex contexts as the domain of "unknown unknowns", where uncertainty hinders expert approaches to solutions. Under conditions of certainty in organisations, the whole comprises the sum of the parts. However, in complexity, the whole is irreducible and transcends the sum of its parts (Simon, 1996). Thus, in the domain of order, the whole can be optimised by optimising the parts, and problems are solved using reductionist approaches (Kurtz & Snowden, 2003). In the complex domain, the sum of the parts can never add up to the whole because all attempts at characterisation, identification or intervention modify the system itself (Kurtz & Snowden, 2003; Simon, 1996). Therefore, suboptimal performance in complex contexts must be allowed for each component to optimise the whole, as problems can only be resolved through emergence (Kurtz & Snowden, 2003).

Decision-making and transitions between complex and complicated organisational contexts: Cynefin offers explanations for the dynamics of transitioning between the complex, complicated and clear domains through key decision points at the liminal boundaries between complex and complicated contexts. Stable patterns emerging from the continuous iterations between the complex and complicated domains can evolve sufficiently to be routinised for longer-term embedment in best practice, thus moving into the clear domain (Snowden, 2021b; Snowden & Rancati, 2021). Some patterns cannot be stabilised, resulting in continuous iteration between complex and complicated, for which the flow must be constantly navigated to keep the system moving towards a favourable state (Juarrero, 2000; Kurtz & Snowden, 2003; Snowden, 2021b; Snowden & Boone, 2007). The complex domain requires pattern management, and the patterns are the phenomena that emerge from the interactions of the agents in the system (Snowden, 2002). Cynefin defines a liminal area at the boundaries of its different domains, and transitioning from the complex to the complicated domain occurs when actors are still uncertain but stabilising patterns are emerging (Snowden & Rancati, 2021).

Transitioning from complicated to complex occurs when expert solutions (or "good practice") are called into question and are not providing the desired outcomes (Snowden & Rancati, 2021). Turner et al. (2022) emphasise that it is crucial to discern the need to apply different methods as the context transitions from one domain to another. Effective decisions can be made by assigning the situation to the appropriate Cynefin domain, enabling contextually appropriate interventions (Snowden & Boone, 2007). Snowden (2002), Kurtz and Snowden (2003), and Snowden and Rancati (2021) specifically include CAS theory, authored by Holland (1992), to underpin Cynefin for explaining the nature and dynamics of complex and complicated decision-making environments. Therefore, adopting Cynefin to explain the dynamics of agility in sociotechnical contexts naturally requires adopting CAS theory.

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3.4 Discussion: sociotechnical contexts as complex adaptive systems

When applying CAS models to strategic management, an approach unfolds whereby systems can be built to swiftly evolve effective adaptive solutions in a dynamic environment (Anderson, 1999). The Cynefin framework incorporates CAS as the theoretical foundation for the complex domain, and Systems Thinking guides understanding and navigation of the complicated domain (Kurtz & Snowden, 2003; Snowden, 2015; Snowden & Rancati, 2021). A CAS is a complex system that is an open dynamic system, continually reconfiguring its structure through self-organisation, requiring the exchange of energy and information (Juarrero, 1999; Snowden & Rancati, 2021; Turner & Baker, 2019).

Holland (2014, p. 24) explains that "*[CASs] are composed of elements, called agents, that learn or adapt in response to interactions with other agents.*" CAS theory provides a lens through which to perceive systems of interacting agents and how order emerges from the interactions in dynamic organisational environments that require responsiveness and adaptation, such as IS (Onik et al., 2017). "*[CASs] are understood from the bottom up, built from interactions of the individual elements*" (Teece, 2018, p. 362). A system is a CAS when it adapts to and evolves with changes in its environment (Holland, 2006), coevolving and continuously self-adapting towards a state of optimised fitness, producing stability and sustainability without being centrally controlled (Anderson, 1999). In socially complex systems, human agents can create their own "adjacent possibilities" and, through creativity stemming from their sentient nature, can consciously influence the dynamics of the complex system (Beckage et al., 2013). The remainder of this section synthesises the literature on mechanisms underlying a CAS's dynamics.

Constraints: Enabling constraints in a CAS are context-sensitive, operating bottom-up (or part-to-whole), supporting the emergence of phenomena and, on closure, expanding the probability space of the system (Juarrero, 2015b). In contrast, governing constraints in a CAS are restrictive and function top-down (or whole-to-part), incorporating isolated and independent components into a coherent unit, thus maintaining, regenerating and evolving the whole system (Juarrero, 2015b). Governing constraints act as rules that iteratively evolve emergent novelty towards adoption and embedment as good practice in the complicated domain (Snowden & Rancati, 2021). In contrast, enabling constraints are context-sensitive and flexible, adapting to the changing context (Snowden & Rancati, 2021), and allowing new phenomena and system states to emerge (Juarrero, 2000). Governing constraints are context-free, existing independently of the context of the system, and restrictive in that they increase the probabilities of certain events occurring as they are always consistently applied, for example, shared goals, purposes and understanding (Juarrero, 2015a). Governing constraints restrict the emergence of novelty, such as emerging new approaches to teamwork (Snowden & Rancati, 2021), because agents continue to operate under the same rules, creating interdependencies between the components (Juarrero, 2015b). However, transpiring interrelationships between the components in a complex dynamic system create a foundation for emergence in the system (Juarrero, 2015a). The recursive pro-

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cess of constraints stemming from intention and capacity, acting top-down from the global level of the CAS, keeps the system operating close to the boundary between complicated (more control) and complex (less control) (Cilliers, 1998; Juarrero, 2000; Kurtz & Snowden, 2003).

Feedback loops: Feedback loops in a CAS are dynamic mechanisms that offer opportunities to transition the system state between the complex and complicated domains (Snowden & Rancati, 2021). Heeding feedback loops in a CAS can shift the system state from the complex to the complicated domain as previous unknowns become knowable through improved experience and expertise gained within the current timeframe and context (Snowden & Rancati, 2021). Short iterative cycles of work execution increase the frequency of interaction among agents in a CAS, supporting a better understanding of stakeholder requirements and thus enhancing the integration of new knowledge in the process (Werder & Maedche, 2018). When seeking endurance and stability, cadence is more important than velocity (Snowden & Rancati, 2021).

Juarrero (2000, p. 26) explains that "*[CAS]s are typically characterized by positive feedback processes in which the product of the process is necessary for the process itself.*" Feedback and catalysts in a CAS influence how the components in a CAS interconnect and combine, providing the system with enabling constraints, and changing the probability landscape of future events (Juarrero, 2015b). Negative feedback suppresses large perturbations in a CAS, causing the system to stabilise, whereas positive feedback drives autocatalysis, amplifying even small fluctuations, thus moving the system far from equilibrium (Heylighen et al., 2007). Positive feedback allows for transformation in social systems when governing constraints can no longer exterminate or suffocate deviations, thus allowing them to amplify, leading to future transformations (Morin, 2007). Thus, feedback changes the probability landscape for subsequent transformations, shaping how change happens in a CAS (Juarrero, 2015b).

Transitions: During a transition in a CAS, the constraints operating in the preceding system state undergo a qualitative reconfiguration, renewing relationships among the system's internal components and between the system and its environment (Juarrero, 2000). When a CAS transitions between complexity and complicatedness, it is crucial for the organisation's survival to use the opportunity to switch management approaches in concert with the changes in the system (Snowden & Boone, 2007). The liminal area between complicated and complex contexts has a transitionary and iterative nature, where good practice can be established in the complicated domain through a transitionary process requiring energy to shift and adopt new emergent practices from the complex domain (Snowden & Rancati, 2021). By intentionally understanding the system's environment and changing attributes within its context, transition to a more manageable domain, for example, shifting from complex to complicated, is achievable (Turner et al., 2022).

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Emergence and evolution: Agility is an organisational phenomenon that emerges from complexity and evolves in complicatedness (Crick & Chew, 2020; Werder & Maedche, 2018). In complex contexts, multiple agents interact in nonlinear ways, and emergence occurs from the dynamics of these interactions (Snowden & Boone, 2007). Viewing an organisation as a CAS provides explanations for how organisational capabilities and routines emerge and evolve from self-organisation in teams (Werder & Maedche, 2018) and through organisational learning processes (Bleda, 2017).According to Crick and Chew (2020), sociotechnical organisational routines are repeatable patterns of interaction that apply existing organisational capabilities to execute business processes that evolve and embed in practice, intending to align with managerial goals. Complexity literature describes “emergence” as various phenomena in CAS whereby the system transforms into a new state by learning to adapt to its changing environment (Turner & Baker, 2019). The notion of “emergence” stems from the system’s nonlinear, rich and dynamic interactions, implying that the system’s behaviour cannot be predicted by inspecting its individual parts (Cilliers, 2000), and the system’s behaviour, as a whole, amounts to more than a simple aggregation of its parts (Holland, 2002). Emergence cannot be deduced from the qualities of its parts because it emerges from the complex system and its organisation as a whole (Morin, 2007). Juarrero (2000, p. 33) offers a summary of the emergence and evolution processes in a CAS: “*[CAS] exhibit true self-cause: parts interact to produce novel, emergent wholes; in turn, these distributed wholes as wholes regulate and constrain the parts that make them up.*”

Without constraints that govern and enable the system, there cannot be the emergence or evolution of phenomena in a CAS (Juarrero, 2015b; Snowden & Rancati, 2021). In a continual iterative process, enabling constraints allow the system to adapt and, at closure, emerge governing constraints that evolve the system through the embedment of knowledge, rituals and practices (Juarrero, 2015a, 2015b; Snowden & Rancati, 2021). As Juarrero (2015b) explains, the repeating dynamic iterations of constraint closure stabilise configurations in the system, enabling self-direction and autonomy of the system’s conscious, sentient and self-aware agents. With each iteration, newly emergent phenomena at the lower levels issue control and behavioural patterns that are then embodied at the global level of the CAS (Juarrero, 2015b, p. 520).

Hierarchy is a fundamental theme in complex systems architecture, meaning that any complex system is organised into multiple levels (Simon, 1962). CASs in organisations present fractal, thus multi-level, architectures that cannot be meaningfully investigated from a single-level perspective as this would contradict the fractal nature of complexity (Cilliers, 2001; Juarrero, 2015b; Ramos-Villagrasa et al., 2018; Salthe, 2012; Snowden & Rancati, 2021). A system is fractal when it has self-similarity across multiple levels. Self-similarity implies resemblance, as opposed to one-to-one equivalence, and similar but different variables operating at different levels can emerge and evolve changes bottom-up to higher levels in the system (Ramos-Villagrasa et al., 2018).

Salthe (2012, p. 351) proposes that a three-level hierarchy is suitable for modelling stability because "*a third level always anchors relations between the other two, and so the middle, focal level cannot be reduced either upward or downward by assimilation into a contiguous level.*" Crick and Chew's (2020) research on the microfoundations of agility in organisations applied Coleman's (1986) work on how individual action at the micro-level stimulates the emergence of phenomena at an organisation's macro-level. Similarly, Eisenhardt et al. (2010) applied Coleman's concept of individual actions influencing macrosocial functioning, proposing that organisational processes with shared heuristics emerge from the group and individual actions to improve firm performance. Sections 3.5 to 3.7 describe the three levels (macro-, meso-, and micro-level) of agility in sociotechnical contexts.

3.5 Macro-level: complex and complicated sociotechnical contexts

When organisational contexts are complex, organisational strategising, management routines, and planning can set a goal-based direction towards, but not control and guarantee, desired outcomes (Kurtz & Snowden, 2003; Park et al., 2017). When contexts are less complex and more complicated, and enough knowledge exists, experts can know how to predict and achieve desired outcomes (Kurtz & Snowden, 2003; Park et al., 2017). Thus, decision-making in complex and complicated contexts can have intended outcomes or unintended consequences for agility. Governing constraints at the overall level of a CAS constrains the system top-down, thereby maintaining and enhancing the system's state as a whole (Juarrero, 1999). Therefore, the overall sociotechnical contexts and strategic management at the macro-level exercise top-down constraints (whole-to-part) on the sociotechnical CAS as a whole.

3.6 Meso-level: dynamic capabilities in complex and complicated sociotechnical contexts

Teece (2023, p. 125) defines dynamic capabilities as "*a framework that recognizes complex interactions within a firm, with other firms, and with the business environment in a quest to understand long-run enterprise performance.*" Lillie et al. (2023) identified dynamic capabilities (sensing, learning, coordinating, and integrating) from the literature as characteristics of agility in IS. The original dynamic capabilities theory was authored by Teece et al. (1997), but was further explained for practical use in firm performance by Pavlou and El Sawy (2011). In an organisation, dynamic capabilities reside at the managerial level, where principles can be applied to trade-off agility for efficiency and represent higher-order capabilities that govern activities (Teece et al., 2016). For example, coordination capabilities are required to perform project management activities (Zheng et al., 2011), learning capabilities are needed to grow expertise and competence (Sambamurthy et al., 2003; Snowden & Rancati, 2021), a sensing capability is essential to make effective management decisions (Kurtz & Snowden, 2003; Teece, 2023), and integration capabilities are required to integrate deliverables into value-creating processes (Pavlou & El Sawy, 2011; Sambamurthy et al., 2003).

Entrepreneurial managers use dynamic capabilities to drive organisational change (Teece, 2014). Nijssen and Paauwe (2012, p. 3316) define the focus of dynamic capabilities as "*the process of transformation of organizations – as a result from changes in the environment – which leads to a break in routines and involves a shift in competencies and required knowledge.*" Eisenhardt et al. (2010, p. 1263) define the microfoundations of dynamic capabilities as: "*the underlying individual-level and group-level actions that shape strategy, organization, and, more broadly, dynamic capabilities, and lead to the emergence of superior organization-level performance.*" Therefore, dynamic capabilities are understood in this study to exercise top-down and bottom-up constraints (whole-to-part and part-to-whole) in complex and complicated sociotechnical contexts. The meso-level represents the sensing and seizing of opportunities for, and threats to, improving agility in complex and complicated sociotechnical contexts.

The options open to an organisation's paths through time are a function of its current position, shaped by its historical course and the possible trajectories towards a future state (Snowden, 2002; Teece et al., 1997). Dynamic capabilities are grounded in high-performance routines or patterns enacted within the organisation, shaped by the firm's history, and embedded in its processes (Teece & Pisano, 1994). The structural patterns of dynamic capabilities in an organisation vary depending on the level of volatility in the organisational environment. High-velocity environments exhibit semi-structured routinisation, whereas robust, structured patterns manifest in moderately dynamic organisational environments (Eisenhardt & Martin, 2000). Pavlou and El Sawy (2011) propose that the dynamic capabilities of sensing, learning, integrating and coordinating enable the creation and evolution of operational capabilities, reconfiguring them in response to changes in the environment.

Sensing in complex and complicated contexts: Turner et al. (2022, p. 1) define sense-making as the process of how "*we make sense of the world so we can act in it.*" Anticipatory awareness is a concept that is central to sense-making whereby complexity is approached by acknowledging that the future is unpredictable, thus considering what can be done in the present for a better future (Snowden, 2021a). In this study, the dynamic capability of "sensing" is enacted through sense-making. Understanding the present well enough to manage its evolutionary potential is crucial, thus navigating towards a favourable future state (Snowden, 2021a). Anticipatory schemata organise perception as the human agent anticipates new information as it is received and simultaneously integrates it with preexisting information (Giddens, 1984). According to Snowden (2021a), the message is to "do the next right thing", then scan the environment and repeat this process, thereby creating points to "stop and think" instead of formulating a plan upfront and expecting to execute it precisely from start to finish.

Learning in complex and complicated contexts: An organisation's capabilities are knowledge assets that must be gradually built up over time through organisational learning (Bleda, 2017). Transitioning the CAS from complex to complicated is an iterative learning process requiring energy to embed increased expert knowledge into practice (Snowden & Rancati, 2021). Feedback loops, adaptation, and evolution all pertain to a CAS's ability to learn (Turner & Baker, 2019). Learning is a process requiring time and space to allow

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for the emergence of new meaning (Snowden, 2002). Snowden (2002, p. 102) emphasises three changes required to the mindset for managing knowledge:

1. knowledge cannot be conscripted but only volunteered as it is impossible to tell whether someone is applying their knowledge, but their compliance to a process is assessable;
2. telling what we know requires less time than writing about it, and writing is a reflective process and cannot contain the exact and complete original thought or whole experience; and
3. "we only know what we know when we need to know it" – the context of someone's "knowing" must be recreated before one can ask meaningful questions about their knowledge or enable the use of their knowledge.

Thus, meaningful knowledge is contextual and requires interaction in its application in the real world (Juarrero, 2000).

Integrating in complex and complicated contexts: Giddens (1984, p. 28) defines integration in social systems as "*involving reciprocity of practices (of autonomy and dependence) between actors or collectivities*", thus complementing the distinction between reflective self-regulation and stable causal loops driven by an overall motivation to integrate routine practices in a CAS over space and time (Giddens, 1984, pp. 28, 64). Integration by mutual agreement of individual agents' efforts enables the team's effort to transcend the individual (Bolman & Deal, 2017). As Bolman and Deal (2017, p. 44) analogically explain, "*[a]ll rowers have to optimize their strokes for the benefit of the boat* ." Complexity studies revealed notable theoretical dynamics of emergence whereby unconnected and local forms of interaction evolve into interconnected forms, creating more institutionalised and integrated structures (Langley et al., 2013). However, the more complex an organisation's role structures become, where many people perform numerous diverse activities, the harder it becomes to sustain a tightly integrated, focussed organisation (Bolman & Deal, 2017).

Coordinating in complex and complicated contexts: Cooperation and coordination among diverse individuals are crucial for team performance because these enable synergy and synchronised motion, integrating individual efforts and transcending the individual (Bolman & Deal, 2017). Teams within a CAS are self-organising entities that adapt effectively by coordinating explicitly, such as sharing information and expertise within the team (Ramos-Villagrasa et al., 2018). The effectiveness of agents' coordination efforts across organisational boundaries depends on their skills and credibility in interacting with stakeholders (Bolman & Deal, 2017). By building informal networks that span across organisational silos, organisational teams' resilience when operating in complex contexts is enormously enhanced based on high levels of trust when working together (Snowden, 2002; Snowden & Rancati, 2021). Informal networks are context-specific entanglements that create very effective channels for information flow and coordination within the context of a specific need (Snowden, 2021a).

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3.7 Micro-level: teams and individuals acting in complex and complicated sociotechnical contexts

The cognitive processes of rationalisation, motivation and reflection underlie all human action and relate directly to human intention (Giddens, 1984). Processes of structuration in organisations generate routines from agents' actions that construct progressively coherent patterns of interaction, shared governance, collective awareness and information sharing (Meyer et al., 2005). However, technology affordances are not always predictable and controllable, making contexts where social and technological agents are entangled, brittle and ephemeral, resulting in intended and unintended consequences of agents' actions (Orlikowski, 2007). Meyer et al. (2005) explain that, in the entangled ecology of organisations, one agent's actions contribute to the construction of another agent's context, catalysing forces that form networks of social structures across different levels.

The individuals in organisational contexts act with awareness, purpose, and reflexivity, routinely and continually monitoring the flow of their own and others' actions as well as their enactments' physical and social contexts (Giddens, 1984; Orlikowski, 2002). Orlikowski (2002) views social agents, in addition to being reflexive, as knowledgeable and able to provide a rational account of their actions. Agents use opportunities and motivation to modify their practices by learning through reflection, improvisation and experimentation, whereby their "knowing" changes in concert with their practices (Orlikowski, 2002). However, Giddens (1984) points out that most agents' knowledge is practical, not theoretical, further distinguishing discursive knowledge as verbalisable from practical knowledge, which is tacit by nature. Therefore, the relationship between what agents know and how they apply what they know in their actions is not always discernible.

At the micro-level, agents' motivation, skills and interpretation of the organisational routines are enacted in their practices. Nevertheless, routines are subject to the agents' interpretation and are, therefore, subject to adaptation and workarounds as the agents sense and respond to constraints in the operative context (Crick & Chew, 2020). Actions at the micro-level contribute to collective organisational change over time (Eisenhardt et al., 2010) and emerge collective action at the macro-level (Meyer et al., 2005). Thus, actions and interactions at the micro-level exercise bottom-up constraints (part-to-whole). However, Giddens (1984) explains that, despite the significant influence of micro-level behavioural patterns on the overall system, it is not meaningful to understand the macro-processes of social organisations as aggregations of coexisting micro-situations or as aggregated products of interactions occurring at the micro-level.

3.8 Transitions: decision-making and heuristics in sociotechnical contexts

Lapalme et al. (2016) suggest that coordinated decision-making and acting are essential to cope with complexity and uncertainty. If agents acting in a system were perfectly rational and possessed complete knowledge to inform their choices at all times, they would be fully adaptable, fast and intelligent in taking the most beneficial action to achieve an optimal outcome

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for all situations (Waldrop, 1992). By allowing decisions to be made at the organisational level where understanding of the ongoing context is highest, and instilling a sense in the actors that they are part of a larger context, individuals and teams are empowered and enabled to cope with complexity (Lapalme et al., 2016). Nijssen and Paauwe (2012) emphasise that because dynamic environments are fast-paced, it is crucial that employees build a shared understanding of the objectives and goals of the organisation, and that they are involved in rapid decision-making processes to contribute to the quality of the decisions taken. Therefore, this study views effective decision-making as occurring at the macro-, meso-, and micro-level in complex and complicated organisational contexts.

Challenges to decision-making for action in complexity: CASs present difficulties for decision-makers because the different levels of the CAS feed different types of information back through the system, producing nexuses of contingencies through multiple levels in the system, resulting in agents constraining each other mutually even when not interacting directly with one another (Salthe, 2012). When faced with real-world complexity, organisational processes unfold to find "good enough" answers in response to questions for which the best answers are unknowable because what people cannot do, they will not do even when highly motivated to do it (Simon, 1996). As Hannan and Freeman (1984, p. 151) point out, "*even when actors strive to cope with their environments, action may be random with respect to adaptation as long as the environments are highly uncertain or the connections between means and ends are not well understood.*"

Simon's (1972) Theory of Bounded Rationality considers the psychology of the decision-maker. Bounded rationality is different from utility-maximising rationality, which assumes that results can be predicted without regard for the decision-making process used by the individual (Simon, 2000). Simon (2000, p. 25) defines bounded rationality as "*the idea that the choices people make are determined not only by some consistent overall goal and the properties of the external world, but also by the knowledge that decision makers do and don't have of the world, their ability or inability to evoke that knowledge when it is relevant, to work out the consequences of their actions, to conjure up possible courses of action, to cope with uncertainty (including uncertainty deriving from the possible responses of other actors), and to adjudicate among their many competing wants.*"

Intentionality: The reasons humans have for their actions are seldom the best rationale and are rarely consistent across the entire range of available choices (Simon, 2000). Despite the cognitive processes of rationalisation, motivation and reflection underlying all human action and relating directly to human intention (Giddens, 1984), "*wisdom varies as the occasion requires*", meaning that human behaviour is contextually and temporally embedded (Juarrero, 2000, p. 24). Human uncertainty about the present and future state of an environment, and their uncertainty about the behaviours of others involved in the context, must be considered if the dynamics of a given context are to be taken seriously (Simon, 2000).

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Sociotechnical organisational routines stem from the agents' interaction patterns, and these emerging and evolving practices intend to, but often fail to, align with managerial objectives (Crick & Chew, 2020). In complex contexts, agility cannot emerge through deliberate intentions and actions, but sensing and utilising opportunities to move the system out of complexity towards a complicated state can enable the organisation to become more agile and resilient (Snowden & Rancati, 2021).

Heuristics and decision-making: Human beings have evolved to continuously assess and scan the environment for problems that must be solved to survive within dynamic contexts: "*How are things going? Is there a threat or a major opportunity? Is everything normal? Should I approach or avoid?*" (Kahneman, 2011, p. 76). Lissack (2019) explains that questioning and understanding ground the enactment of human agency, providing a foundation for taking action. Thus, when we act, we ascribe our will to act to a fleeting "certainty" in recognising and being prepared to act on an available, acceptable choice despite the complexities of the ongoing context (Lissack, 2019). However, uncertainty is ever-present in complex situations and introduces a risk that, due to actor biases, the desired outcomes might not be generated (Tversky & Kahneman, 1974). Furthermore, unintended, undesirable outcomes can emerge from the complex intertwining of human organisation and the technical aspects of IS (Cecez-Kecmanovic et al., 2014). Bolman and Deal (2017, p. 22) advise that when dealing with uncertainty and fearing ambiguity and loss of control, "*develop creativity, risk-taking, and playfulness in response to life's dilemmas and paradoxes, and focus as much on finding the right question as the right answer, on finding meaning and faith amid clutter and confusion.*"

The literal meaning of the word "heuristics" is "the art (or practice) of discovery", derived from the Greek word "heuriskein" that means "to find or discover" (Ulrich, 2005, p. 1). Humans typically use heuristics when they must make decisions based on incomplete information in conditions of uncertainty to address unclear problems for which there are multiple solutions and the probabilities of the potential outcomes are unknown (Gigerenzer & Gaissmaier, 2011). Simon's (2000) decision-making strategy of "satisficing" proposes that agents should strive to find "good enough" answers instead of aspiring to find optimal solutions to problems in uncertain environments. A heuristic can only be effective if it matches the context within which it is applied (Artinger et al., 2015).

Artinger et al. (2015) emphasise the importance of heuristics because their influences traverse organisational hierarchies across the individual and organisational levels. Shared understanding and experience of environmental features spanning organisational levels imply that insights informing heuristics at the managerial level hold value at the individual level and vice versa (Artinger et al., 2015). However, not all agents are perfectly adapted to the given context. Thus, a heuristic is functional, having a particular contextualised purpose, but does not necessarily align perfectly with the real world (Gigerenzer & Gaissmaier, 2011). Nonetheless, heuristics can effectively inform decision-making for enhanced outcomes in complex organisational contexts (Artinger et al., 2015; Schilke et al., 2018).

The following section used an SLR to investigate heuristics for their influence on dynamic capabilities.

4 MANAGING HEURISTICS TO ENABLE AGILITY IN SOCIOTECHNICAL CONTEXTS

Sociotechnical contexts in organisations are complex and complicated and require effective and coordinated decision-making to achieve agility (Park et al., 2017; Teece et al., 2016). However, despite decision-making processes, agents in such contexts rely on heuristics to enable quick responses to opportunities and threats (Artinger et al., 2015; Schilke et al., 2018). Heuristics are schemata, simple "rules of thumb" that are quick and easy for an organisation's social agents to use, efficiently guide actions, and allow for the flexible adjustment of other actions in real-time across an organisation's strategic, managerial and operative levels (Eisenhardt et al., 2010). Complete knowledge and control for decision-making are not achievable in complex contexts (Artinger et al., 2015; Gigerenzer & Gaissmaier, 2011; Simon, 2000). Because of these challenges to decision-making, and the role of heuristics in complex organisational contexts, a method needs to be developed for the conceptual framework for agility in sociotechnical contexts that considers how heuristics influence dynamic capabilities. In this section, an SLR was conducted to address the second research question:

How do heuristics influence dynamic capabilities in organisational contexts?

4.1 Method: a systematic literature review of heuristics influencing dynamic capabilities

The systematic search and review of literature on heuristics influencing dynamic capabilities in organisations was directly shaped by the keywords contained in the research question: "heuristics" and "dynamic capabilities". The following expression was applied in Scopus to search title, abstract and keyword fields, and limited the results to journal articles in English from the Business, Decision, Computer, and Social Sciences:

```
TITLE-ABS-KEY (
   ("dynamic capabilities")
   AND
   ("heuristic" OR "heuristics"))
   AND
   (LIMIT-TO (SRCTYPE , "j"))
   AND
   (LIMIT-TO (SUBJAREA , "BUSI")
      OR LIMIT-TO (SUBJAREA , "DECI")
      OR LIMIT-TO (SUBJAREA , "COMP")
```

```
      OR LIMIT-TO (SUBJAREA , "SOCI"))
   AND
   (LIMIT-TO (LANGUAGE , "English")
)
```

Articles dealing with statistical or computational heuristics, and articles not relevant to dynamic capabilities and heuristics in organisational contexts were manually excluded.

Figure 3 presents the SLR process that adopted the guidelines proposed by Okoli (2015).

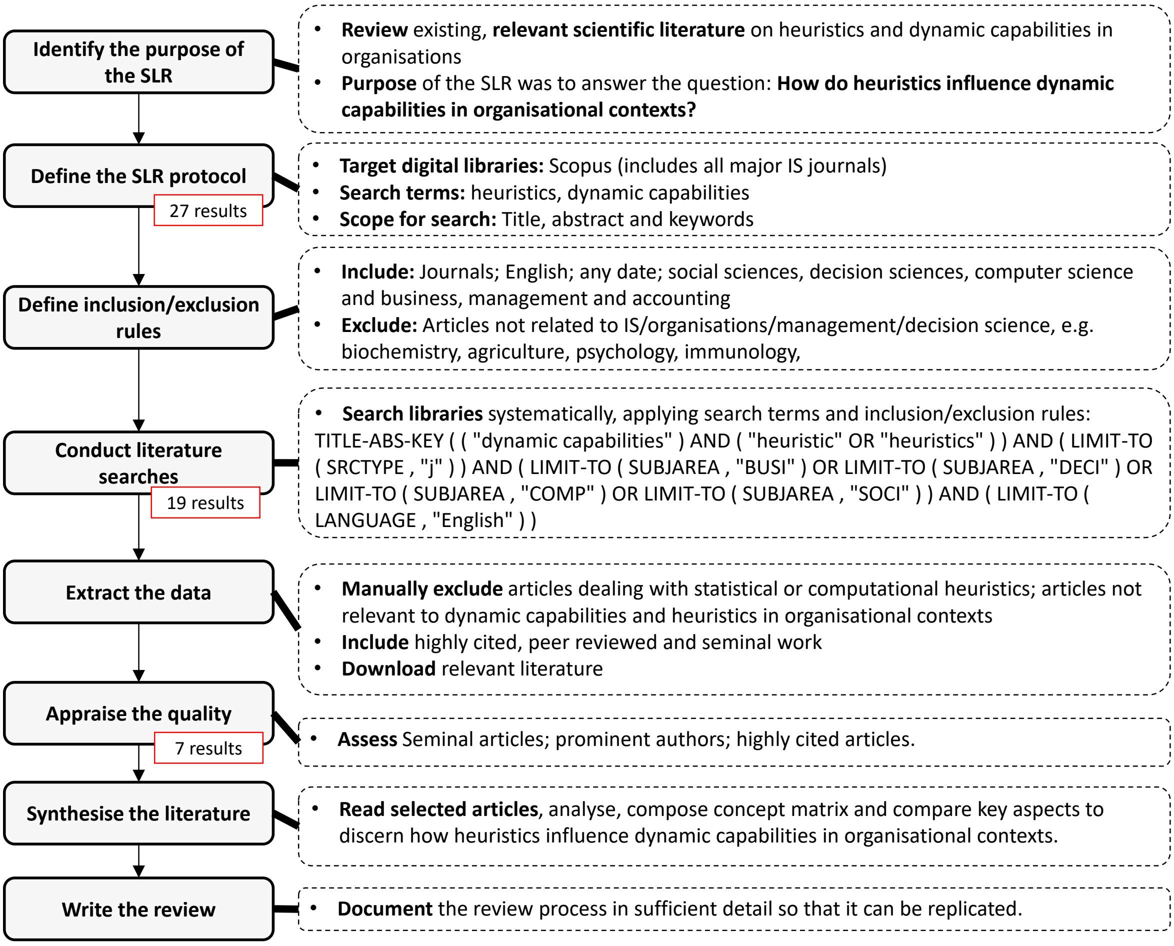

Figure 3: Systematic literature review process to find existing knowledge of how heuristics influence dynamic capabilities in organisations (based on Okoli (2015, pp. 883–884))

4.2 Synthesis and findings

The found articles were reviewed, summarised and synthesised based on the concepts relevant to how heuristics influence dynamic capabilities and agility (see agility features summarised in Table 1 in organisational contexts. Based on the approach proposed by Webster and Watson (2002), the following concepts were identified to create a conceptual structure to analyse the articles' relevance to the research question's topic:

1. the organisational level where heuristics were applied in the article,
2. the purpose, effects and value of heuristics,
3. the implications of using heuristics in decision-making, and
4. dynamic capabilities influenced by heuristics.

The organisational level where heuristics were applied: Five of the seven articles described heuristics as functioning across organisations' strategic, managerial and team/individual levels (Ajgaonkar et al., 2022; Bingham & Haleblian, 2012; Eisenhardt et al., 2010; Espejo, 2015; Nijssen & Paauwe, 2012). Only one of the seven articles considered heuristics at the strategic level and not at the lower levels in the organisation (Bingham & Eisenhardt, 2011).

The purpose, effects, and value of heuristics: Heuristics enable fast organisational learning (Nijssen & Paauwe, 2012), thereby influencing the agility features of speed and competence, and can be practised to develop organisational knowledge and capabilities that can be exploited in the future (Pandza et al., 2003). Bingham and Haleblian (2012) explain that valuable heuristics can be learnt at the overall organisational level from suboptimal outcomes spanning hierarchical and functional levels in the organisation. As experts reflect on and share lessons learned, a collective understanding of organisation-specific heuristics is created instead of depending on individuals' experiential knowledge of heuristics (Bingham & Eisenhardt, 2011) (influencing scalability, flexibility and reusability).

Heuristics are strategically important in dynamic environments as they enable high-performance strategic processes (Eisenhardt et al., 2010). Eisenhardt et al. (2010) further explain that heuristics allow for flexible real-time adjustments to actions in response to events, mitigating organisations' tendency to favour efficiency over flexibility (influencing flexibility and responsiveness). Heuristics are "rational" in unpredictable contexts and, therefore, essential to strategy (Bingham & Eisenhardt, 2011) (enabling leanness and responsiveness). Bingham and Eisenhardt (2011) propose that:

1. organisations learn heuristics explicitly;
2. learnt heuristics have a typical structure across organisations because each type of heuristic addresses a specific aspect of opportunity capture. Opportunity-capture heuristics are "simple rules" of strategic value (enabling responsiveness and scalability);
3. heuristics specific to capturing opportunities are learnt in a particular developmental order by first capturing single opportunities one at a time and progressing to capturing multiple opportunities simultaneously, thus increasing in cognitive difficulty thereby developing expertise through experience; and

4. organisations practice simplification cycling whereby heuristics are pruned and added in a continual fine-tuning process (enabling competence, leanness, reusability and flexibility).

Nijssen and Paauwe (2012) propose that heuristics support organisational agility when effectively applied to identify organisational practices as determinants of organisational agility and to evaluate their ongoing effectiveness in supporting such agility. Heuristics should support a scalable workforce, fast organisational learning, and highly adaptable organisational structures (Nijssen & Paauwe, 2012). Heuristics further support organisational agility by allowing for autonomy, adaptation, and cohesion, enabling self-regulation and self-organisation in organisational systems that must achieve more with fewer resources (Espejo, 2015) (enabling flexibility, responsiveness and leanness). Ajgaonkar et al. (2022) emphasise the importance of heuristics that consider the drivers of workforce agility: external resources available for hire, internal resources available, and pressure to achieve workforce agility.

Implications of using heuristics in decision-making: Heuristics are suitable for most strategic decisions as they involve highly unpredictable situations, high levels of heterogeneity, and actors with limited relevant experience (Bingham & Eisenhardt, 2011) (enabling responsiveness and speed). Managers are the dominant decision-makers in organisations, but often base their decisions on incomplete or incorrect information, thus necessitating heuristics (Nijssen & Paauwe, 2012).

Efficiency (exploiting routines and well-known methods) and flexibility (exploring opportunities presenting novelty) can be balanced through cognitive processing mechanisms practised by groups and individuals (Eisenhardt et al., 2010). Agility comes at the cost of efficiency, and organisations need to develop robust sensing, seizing and transforming capabilities in their management functions so that they may know when and how to manage deep uncertainty (Teece et al., 2016). Eisenhardt et al. (2010, p. 1271) explain that "*[e]fficiency will always be about the quick, economical, mistake-free execution of specific opportunities, whereas flexibility will always be about the fluid, extemporaneous execution of varied opportunities.*" This view reflects Snowden and Boone's (2007) suggestion that different approaches are required for decision-making in complex and complicated situations, respectively. Heuristics enable strategists to balance efficiency and flexibility effectively by applying simple rule strategies in key strategic processes. Managerial reflection, understanding, learning, and attention are required for making decisions and taking actions that balance efficiency and flexibility (Eisenhardt et al., 2010). Pandza et al. (2003) propose that valuable capabilities are not the result of rational decision-making driven by predetermined goals to develop or adopt best practices or improved capabilities. Instead, decisions made using available options are subject to uncertainty due to the incomplete knowledge of decision-makers and the inherent complexity of organisational contexts. Heuristics allow for autonomy in decision-making (Espejo, 2015) and impact the speed of decision-making in strategic processes (Nijssen & Paauwe, 2012). However, heuristics influence the speed of, quality of, buy-in for, employee contribution to, and effect of coercive and normative mechanisms on decision-making (Nijssen & Paauwe, 2012). Informal communication enables decision-making through quick discussion and assessment of available options, and promotes learning and adoption of heuristics across groups and hierarchies (Bingham & Haleblian, 2012).

Dynamic capabilities influenced by heuristics: The structures of dynamic capabilities are complex, interrelated and have collective value (Espejo, 2015). Heuristics are essential to effective sensing and responding capabilities in uncertain organisational contexts (Eisenhardt et al., 2010). Dynamic capabilities provide flexibility under conditions of uncertainty (Pandza et al., 2003). Heuristics applied as 'simple rules' are crucial to enabling and developing dynamic capabilities: sensing and responding (opportunity capture) and learning (leaders' ability to learn and develop effective heuristics) (Bingham & Eisenhardt, 2011). Heuristics promote learning from adverse outcomes across organisational levels and functions, and enable coordination at the collective level using informal communication and tacit knowledge (Bingham & Haleblian, 2012) (enabling competence). The experiences of individuals and groups emerge shared heuristics in organisational processes whereby groups and individuals develop distinctive heuristics that exploit their heterogeneous knowledge (Eisenhardt et al., 2010) (enabling competence, reuse and scalability).

Espejo (2015) describes dynamic capabilities as the unfolding outcomes of processes, enabling ongoing improvement of organisational processes. Heuristics enable organisational agility by informing and developing the organisation's sensing, learning, coordinating, and integrating capabilities (Nijssen & Paauwe, 2012). The heuristic framework proposed by Ajgaonkar et al. (2022) promotes sensing, seizing, and continual renewal of capabilities to achieve workforce agility.

4.3 Managing heuristics in organisational contexts

Based on the SLR findings, it was established that heuristics influence organisations' dynamic capabilities, agility features and decision-making to the benefit or detriment of organisational performance. Therefore, developing a conceptual framework for agility in sociotechnical contexts required a practical, scientifically-grounded construct to explain how to manage heuristics for knowing, deciding and acting at the boundaries between complex and complicated sociotechnical contexts for an improved state of agility. It is, therefore, proposed here that a practical technique for effectively managing heuristics in real-world organisational contexts is an integral aspect of a framework for agility in sociotechnical contexts that is relevant and implementable in the real world. To find a suitable method or technique to manage heuristics, critical systems heuristics (CSH), authored by Ulrich (2000), was abductively adopted as a suitable scientific theory, as it explicitly provides "sources of influence" (knowledge, power, motivation and legitimation) as theoretical constructs.

Heuristics are intrinsic to professional practice that deals with qualitative, ill-defined issues, such as what changes would constitute an improvement for an identified problem to be solved for which there is no right or wrong solution (Ulrich, 2005). For example, "achieving agility" is an "improvement" but does not have a "right" or "wrong" solution, as it is subject to variances in stakeholder understanding and intentions of how agility can and should be generated in the ongoing sociotechnical context. The liminal space in the Cynefin framework presents a boundary where the iterative processes of adaption and adoption continuously shift the system to a new state based on agents' decisions and responses (Snowden & Rancati, 2021). CSH is a scientific theory that has its roots in Critical Systems Thinking (CST) and practical philosophy, and includes not only decision-makers but all stakeholders in the process of "critical reflection" on a situation (Ulrich, 2005). CSH is a theory offering a viable approach to "reflective practice" (practising boundary critique) that asks how a "system of interest" (such as a sociotechnical CAS) "ought to be" and how it "actually is" (Ulrich, 2000).

The practice of boundary critique prescribed by CSH (Ulrich & Reynolds, 2020) arguably offers a practical technique for managing heuristics in sociotechnical contexts for favourable agility outcomes because it aims to identify the sources of influence and related boundary judgements that underlie agents' heuristics that can move a system towards an improved state. This approach allows the stakeholders of the "system of interest" to negotiate how the system can be moved towards an improved state, for example, improved agility in sociotechnical contexts.

Figure 4 summarises the boundary categories and critique questions defined for this study of agility in sociotechnical contexts based on Ulrich (2000) and Ulrich and Reynolds (2020).

Boundary judgements, as adopted in this study for their influence on agility in sociotechnical contexts, comprise four categories, as shown in Figure 4:

1. **sources of motivation** relate to the agents' impetus based on what they are motivated to effect, with or without intent;
2. **sources of power** relate to control based on what empowers, overrides and guides the agents;
3. **sources of knowledge** refer to agents' abilities and resourcefulness to do what can or should be done; and
4. **sources of legitimation** relate to the amplitude of agents' stakeholder perspective. Boundary judgements underlie agents' heuristics, influencing their actions in a system of interest.

The concept in CSH of "moving the system to an improved state" (Ulrich, 2000) aligns with the Cynefin framework's concept of "moving to a more favourable adjacent possible state" at the boundaries where key decision points can transition the system between the complex and complicated domains (Snowden & Rancati, 2021). In addition, agents' sense-making processes and their responses to governing (context-free) constraints (in complicatedness) and enabling (context-sensitive) constraints (in complexity) can be improved because practising boundary critique brings an understanding of the underlying boundary judgements that agents are using in their heuristics. Through this approach, the practice of boundary critique can change the

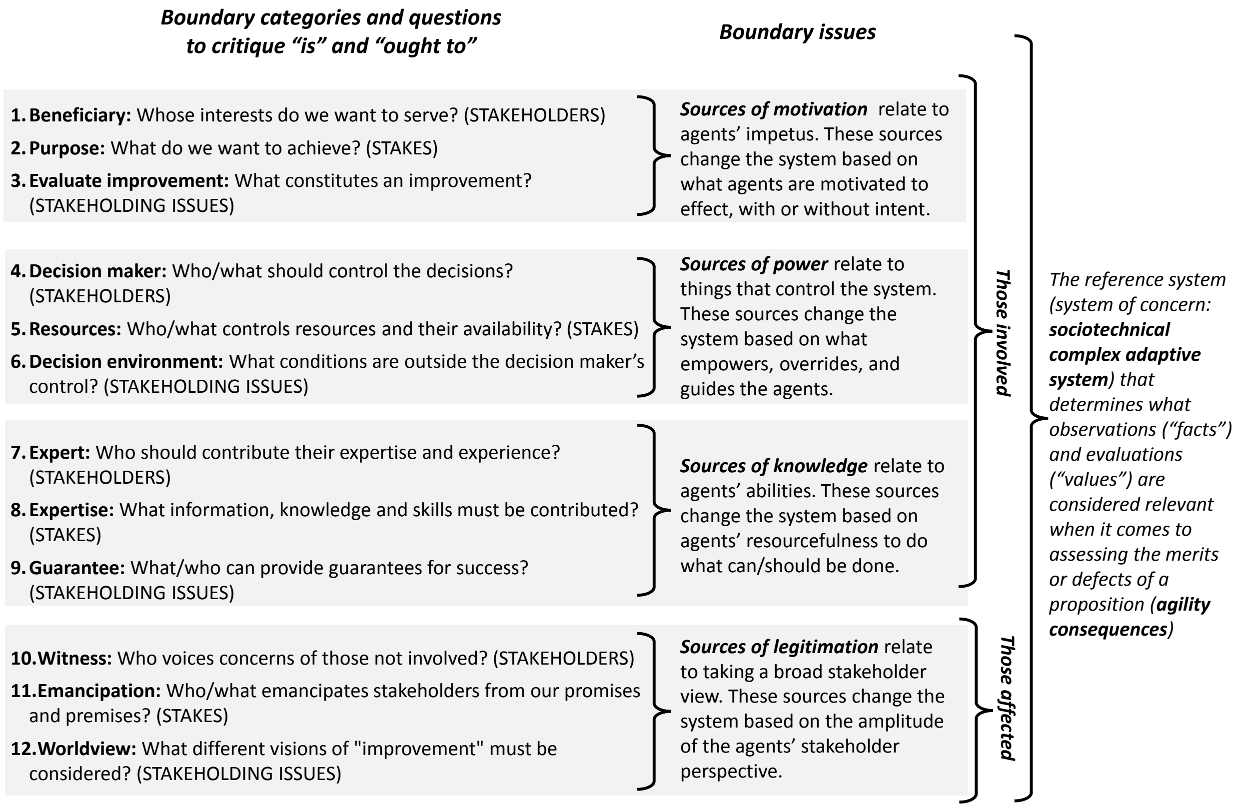

Figure 4: Boundary categories and questions for practising CSH boundary critique in a socio-technical CAS (based on Ulrich (2005, p. 10); Ulrich and Reynolds (2020, pp. 256, 290)

quality of the system's interactions iteratively by influencing how agents sense, learn, coordinate and integrate, thereby continuously providing opportunities to move the system at the micro-, meso- and macro-levels towards a more favourable agility state. Therefore, this study proposes the practice of boundary critique from CSH as a practical technique to identify the underlying boundary judgements to manage the heuristics that influence actions (governed by dynamic capabilities) with emerging and evolving agility outcomes and consequences.

5 A CONCEPTUAL FRAMEWORK FOR AGILITY IN SOCIOTECHNICAL CONTEXTS

In organisational and IS science, sensing and responding are the overarching concepts for achieving agility in organisations (Park et al., 2017; Sambamurthy et al., 2003; Tallon et al., 2019). The Cynefin framework explains how effective decision-making in complex and complicated contexts can transition the CAS towards improved outcomes from the sensing and responding capabilities and actions of the organisation's agents (Snowden & Boone, 2007).

This study of the dynamics of agility in sociotechnical contexts defines thriving agility as the sustained functional emergence and evolution of constraints that iteratively create and enhance agility features. In contrast, faltering agility is defined here as the emergence and evolution of constraints that iteratively disintegrate agility features with consequential loss of the system's overall agility coherence.

Continuous adaptation iterations across levels in the system emerge non-repeatable agility, whereas iterations of adoption across levels in the system evolve repeatable agility as patterns stabilise (Eisenhardt & Martin, 2000; Juarrero, 2000; Snowden & Rancati, 2021). Both thriving and faltering agility can emerge and evolve intentionally or unintentionally. The constraints form and shape the behaviour of the CAS (Holland, 2002) and are those things that govern, enable or cause tension in the coordination and integration (Teece et al., 1997) of agents' activities. CSH provides a theoretical keystone that enables an empirical investigation of how heuristics can influence interactions to change the system's agility state during phase-shifting between complicated and complex contexts in such a way as to continuously emerge and evolve favourable agility features in a sociotechnical CAS.

A model: Figure 5 presents the model of the proposed conceptual framework for agility in sociotechnical contexts. As found in the two SLRs conducted for this study, the dynamic components of agility in sociotechnical contexts interact across three levels:

1. The **macro-level** represents complex and complicated sociotechnical contexts and is based on the Cynefin framework, underpinned by CAS theory, with transitions through key decision points at the complex and complicated domain boundaries.
2. The **meso-level** represents the oversight/managerial level (managing and governing activities), comprising the dynamic capabilities of sensing, learning, coordinating and integrating in complex and complicated sociotechnical contexts.
3. The **micro-level** is where heuristics influence how activities are being/should be done for improved agility. The practice of boundary critique, adopted from CSH, explains how sources of influence, revealed in agents' boundary judgements, influence agility outcomes and consequences as thriving or faltering agility features in complex and complicated sociotechnical contexts.

The iterations of the sociotechnical agents' continuous actions, interactions and heuristics have outcomes and consequences for agility in sociotechnical contexts. In the top part of the model presented in Figure 5, iterations in complex sociotechnical contexts are represented by multiple dashed, dispersing lines, illustrating the dissipative, discontinuous and dispositional nature of complexity. In contrast, the bottom part of the model shows the more predictable, governable and repeatable nature of complicated contexts as solid-lined iterations. Transitions between complexity and complicatedness occur when heuristics, undergirded by boundary judgements, influence the sociotechnical agents' dynamic capabilities, resulting in intended outcomes and unintended consequences for the overall agility of sociotechnical contexts.

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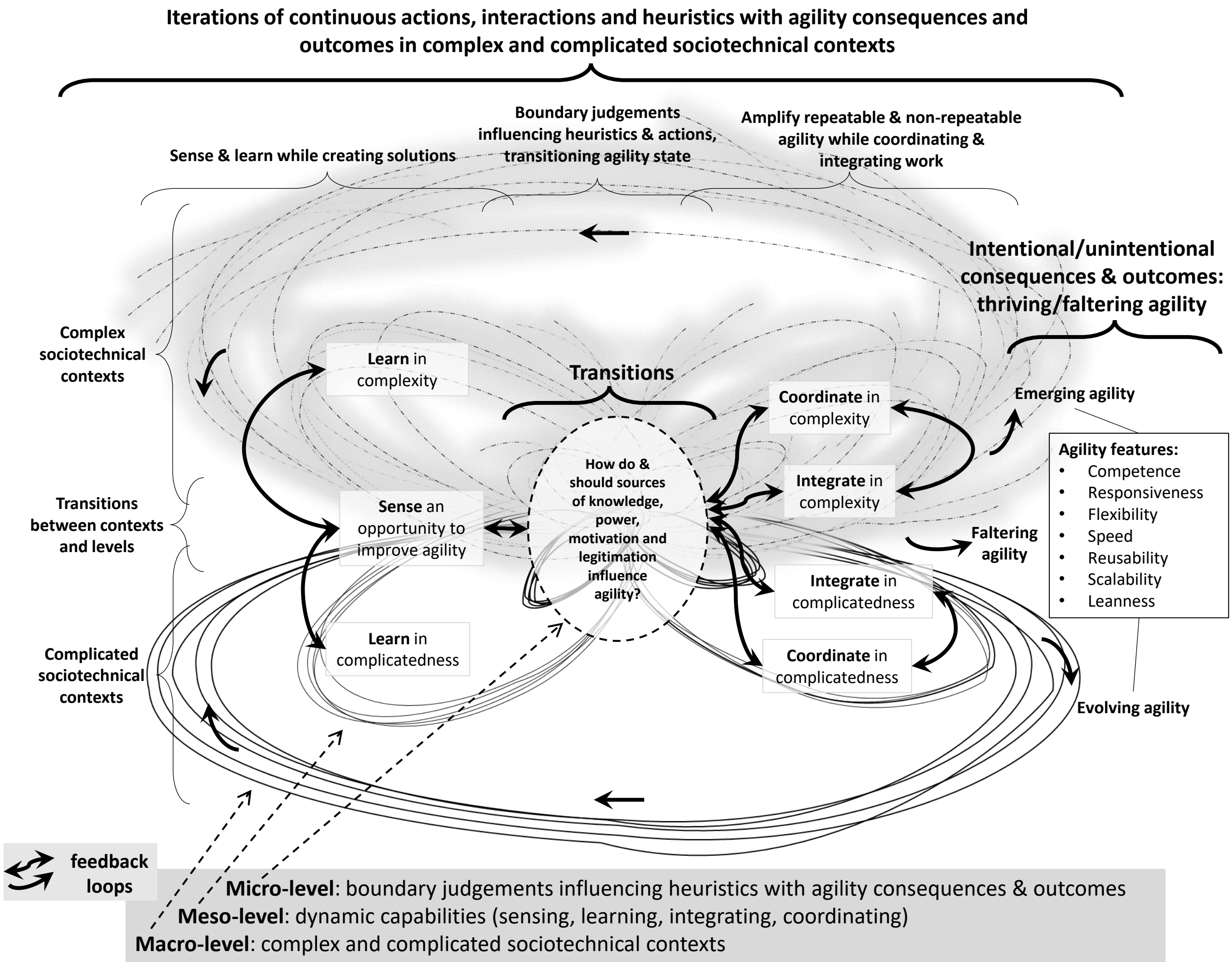

Figure 5: A conceptual framework for agility in sociotechnical contexts (based on Kurtz and Snowden (2003); Lillie et al. (2023); Salthe (2012); Ulrich and Reynolds (2020))

A method: Practising boundary critique at the liminal boundary between complexity and complicatedness provides a mechanism to evaluate the next thing to do that would amplify the emergence and evolution of agility features in sociotechnical contexts. By practising boundary critique, the agents involved must then use the opportunity to consider what can and should change in the subsequent work iterations to amplify the desired agility features in sociotechnical contexts, locally and collectively. Boundary judgements can be revealed by collaboratively asking and critiquing the answers to the 12 questions (see Figure 4) in the "is" (descriptive) and "ought" (normative) modes. However, these questions can only be meaningfully asked and answered in a real-world context and represent context-sensitive and context-free constraints because of their potential to influence the system towards thriving agility consequences and outcomes (Juarrero, 2000; Ulrich, 2000).

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Additionally, there is no theoretical limit to the size of the sets of possible answers for each of the 12 boundary questions. It is, therefore, prudent to test the use of boundary critique as defined by CSH theory in a real-world sociotechnical context to further develop and refine the proposed conceptual framework for agility in sociotechnical contexts. Practising boundary critique presents opportunities to discover "unknown unknowns" (in complexity) and to question and debate "known knowns" (in clarity) and "known unknowns" (in complicatedness) (Snowden & Boone, 2007), thereby taking a broader, contextualised view of what can or should be coordinated and integrated to influence improved agility consequences and outcomes. For example, possibilities for reuse, scaling or repurposing might be overlooked when imposing a deterministic linear process on a sociotechnical context at hand because opportunities for discussions are closed down *a priori*.

6 FUTURE RESEARCH

The conceptual framework for agility in sociotechnical contexts was developed by starting with the structural components of the conceptual model of agility in IS proposed by Lillie et al. (2023), and then conducting two SLRs that incorporated scientific literature and the well-established theories of CAS (Holland, 1992), dynamic capabilities (Teece et al., 1997) and critical systems heuristics (Ulrich, 2000) to explain the dynamic components of agility in sociotechnical contexts. By using the framework's structural and dynamic components as units of analysis, future research could apply the proposed conceptual framework for agility in sociotechnical contexts to case study research to test and further develop the framework for its practical application in organisations. Such research could refine the conceptual framework, and develop a practical framework for achieving agility in a specific sociotechnical real-world context. Alternatively, action research could offer an effective method to apply the proposed conceptual framework to a real-world context because action researchers work with practitioners to address a significant practical problem (Järvinen, 2007).

Due to the generalisability of CAS (Holland, 1992), dynamic capabilities (Teece et al., 1997) and critical systems heuristics (Ulrich, 2000), the ubiquitousness of decision-making in organisations (Kurtz & Snowden, 2003), and the broad consensus in IS research that sociotechnical contexts are complex (involve uncertainty) and complicated (require expertise) (Crick & Chew, 2020; Gregor, 2009; Park et al., 2017), the proposed conceptual framework could potentially be used to study emergent phenomena other than agility in sociotechnical contexts. However, it should be noted that the proposed framework is conceptual and has not been tested in real-world contexts.

7 CONCLUSION

The research problem was identified using the existing scientific literature that indicated that organisations require their IS to be agile. Furthermore, current scientific knowledge of how organisations can achieve agility in their sociotechnical contexts is insufficient. The contribution of this study is a conceptual framework for agility in sociotechnical contexts that aimed to address this identified problem. The framework was developed by conducting two SLRs using Scopus. Scopus is recognised as the largest abstract and citation database of peer-reviewed research literature. However, despite the vast number of peer-reviewed articles indexed in Scopus, the risk remains that some important, relevant work was inadvertently excluded from this study. Thus, a limitation of this research is that Scopus was the only database used for data collection in the SLRs.

The two SLRs synthesised the literature, incorporating CAS (Holland, 1992), dynamic capabilities (Teece et al., 1997) and critical systems heuristics (Ulrich, 2000) to integrate the structural and dynamic components of agility in IS to produce a conceptual framework for agility in sociotechnical contexts. The first SLR investigated frameworks that enable organisational agility. Consequently, the Cynefin framework was adopted to explain the dynamics of contextualised decision-making and agility. The second SLR identified the influence of heuristics on decision-making and dynamic capabilities. This research contributes to the further understanding of agility in organisations and how organisations could achieve agility.

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