

# Managerial Information Processing in the Era of Big Data and AI - A Conceptual Framework from an Evolutionary Review

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**Abstract** Information processing forms an essential part of managerial behavior in the decision-making process. With big data and intelligent technologies available, business environment becomes ever dynamic and challenging, e.g. the impact of the COVID-19 pandemic, the rise of misinformation and disinformation, etc., this paper aims to examine the emerging patterns of managerial information processing from both individual and organizational perspectives. This research identifies three driving forces based on an evolutionary review of studies and theories related to information processing behavior and develops a theoretical framework, which provides valuable implications on managerial information processing and organizational responses and calls for reduction of information needs on routine tasks, a shift of managers' information attention towards uncertainties, and increased capabilities and responsibilities in analytics and AI within an effective digital governance framework.

**Keywords:** Information Processing, Information Processing Behavior, Human-Computer Interaction, Digital Governance

## 1. Introduction

Managers are faced with increasing complexity and dynamism of operational and strategic information to handle. Over the years, organizations adopted various approaches in coping with these challenges, range from business intelligence to data analytics, from decision support systems to AI systems (Duan, et al., 2019). In a globally networked society, with big data, information is becoming increasingly accessible. There is an increasing amount of trigger, speculative and current information including mis/disinformation (Petratos, 2021) that senior managers and organisations need to attend to. More information provision does not necessarily lead to better decision making, it runs the risk of exacerbating the long-lasting data overload problem. The new challenge is what to do with the huge volume of information as opposed to how to get that information, and how to make sense of it for action (Schildt, et al. 2020). The young

generation managers are mostly technical savvy, which renders them more prone to using technologies to acquire and process information, hence hypothetically, managerial information behavior could have shifted to a new pattern (Gullberg, 2011). This also requires organizational responses - i.e. collective cognition (Cristofaro, 2020) and digital governance (Vaia, et al. 2022). From decision support and organizational design perspectives, there is a need to ascertain if and how managerial information processing has been shaped by what driving forces, and if existing assumptions and theories on managerial / organizational information processing need to be updated.

Given the challenges, research into the above becomes imperative. This paper reports the driving forces and managerial information processing from both individual and organizational perspectives. A theoretical framework is proposed based on an evolutionary review of studies and theories related to information processing behavior.

## **2. Evolutionary Mapping of Managerial Information Processing**

Information processing behavior is derived from the concept of “information behavior”, which is defined from the information science perspective as “those activities a person may engage in when identifying his or her own needs of information, searching for such information in any way, and using or transferring that information” (Wilson, 1999, p.249). In information science, information behavior generally refers to information retrieval or information seeking behavior (Wilson, 2016), information processing behavior, and information use behavior (Taylor, 1991). Specific to management information processing, Mintzberg (1973, 1981) studied managerial behavior and suggested information behavior is an essential part of managerial activities. In this paper, managerial information processing behavior is defined from a process view including the following four interrelated activities of senior managers:

- *Information acquisition* - information seeking and receiving which are either solicited or unsolicited.
- *Information synthesizing* - structured data manipulation and analysis of raw data, typically using data analytic tools from simple tabulation, comparison, statistics to comprehensive analytics.
- *Information sensemaking* - the human cognition process of reasoning and interpreting.
- *Information usage* - actionable information is used for sharing, decision making, influencing and enhancing learning (individual and organizational).

Bawden and Robinson (2013) stated that information behavior is inherently individual. During this process, the individual identifies and selects information sources; articulates a query, question or topic; extracts the information; evaluates the information retrieved; filters the irrelevant information, and interprets the information. The goal of information processing is to make sense of it for action. Much of the information behavior research between 1960's and 1970's focused on a highly individualized view of human behavior,

represented by the work of pioneers such as Wilson and Mintzberg and Taylor. Organisational managerial information are relatively limited except Galbraith (1974) and Egelhoff's (1991) work on organizational information processing and design. Recent research has considered the power of intelligent machines and network-based analytics and distributed decision (Aversa, et al. 2018), as well as the importance of social processes, data governance and decision context as part of human information behavior (Gullberg, 2011). The sections below give a detailed account of the evolution.

### **2.1 Information behavior -Taylor's (1991) IUE Theory**

Taylor's Information Use Environments (IUE) extends early models on general information behavior and prescribes four determinants of general information seeking and using:

- Sets of people (information professionals who process information for users);
- Problem dimensions (ill structured vs well structured);
- Work settings (organizational environment, culture, style and structure);
- Problems resolution assumptions (perceived and anticipated ways to problem resolution)

The IUE also prescribes eight types of information usage - from enlightenment to understand the wide context of the problem/decision); problem understanding (why); instrumental (how); factual (what); conformational - verification of information; projective (what if scenarios); motivational, personal/political usage.

Taylor suggests that the focus is on how professionals (set of people) acquire and use information for direct solution or sense making (understanding). The only one common method of information seeking was discussion with colleagues - a human interaction process. Taylor's work considers specific situation as determinants affecting managerial and organizational information processing and usage, this has been adopted in this study.

### **2.2 Mintzberg's Managerial information behavior**

Mintzberg's (1980) theory on the nature of managerial work provides very useful insight into managerial behavior in information processing. One of the key managerial roles identified is informational role - as information monitor, information disseminator, and spokesman. Mintzberg observed that a manager as a monitor receives a variety of information from wide sources, both inside and outside his organization. With the information, the manager works as a disseminator to transfer information to subordinates, and as a spokesman to signal to the outside of the organization. Furthermore, the manager uses the information as a strategy-maker (decision roles) to detect changes, to identify problems and opportunities, to build up knowledge about his milieu, and to make models and plan. Mintzberg (1980) suggests that senior managers appear to favor verbal contact through personal networks to obtain information. Yet, there are no clear-cut sources and patterns have been identified. The informational role describes how a manager works

along a process of information handling, which is similar to the IUE process but with role specification specific to management information. Further insight from Mintzberg's (1980) observation reveals that managers clearly prefer to have information in the form of concrete stimuli or triggers, not general aggregations, they demonstrate a thirst for external information, and tend to ignore formal information system.

It can be argued that before the big data era, the conventional conception dominating managerial information behavior theory is that senior managers do not conform to formal information behavior models; instead, they are sporadically managing a mess, muddling through information as the business environment releases all kinds of signals and messages (Bartelings et. al., 2017).

### **2.3 Choo's model of human cognition in managerial information processing**

Choo (1998) extends Taylor's IUEs with a focus on managers' affective response and cognitive dimensions. It claims that an individual attempt to find information in order to bridge the situation gaps (cognitive needs) when he or she recognizes an inability to act or understand a situation. This is followed by an affective response resembled by indicating likes and dislike, pointing out doubt and uncertainty, channeling attention to certain issues (Brigham, 2017). Zajonc (1980) defines affect response as the first reaction to stimuli and that it drives human judgment. Affective evaluations result in predominantly positive, mixed, or negative affective state. It is the negative affective state that drives the collection and interpretation of cues, and triggers more information search (Maitlis, et al. 2013). Positive effective status is associated with seeking confirming data for cue - look for data that support prior assumptions and reinforce the prior affective state. When the decision maker collects confirming evidence, contentment arises because the situation is considered to be safe and having a high degree of certainty.

Centre to Choo's model is the human cognitive process that can lead to heterogeneous information behavior. Human cognition carries the risks of bias in processing managerial information. Information is often perceived selectively and subjectively. Martinsons (1994) asserts that it must be recognized that different managers will inevitably use different criteria, methodology to assess the attractiveness of various markets and products, and will come to different conclusions, even when working with a similar set of available data. We argue that human cognition and effective response form an intrinsic part of the process of managerial information handling. In order to minimize such risks, an organizational mechanism, i.e. collective cognition and governance will be needed.

### **2.4 The cognitive views of organisational information processing**

The aforementioned theories mainly focus on individual information processing, although organizational settings are considered as determinants in these models. Cognitive views of organizational information processing perceive organizations as systems that learn and interpret their environments (Daft and Weick, 1984) in order to

cope with uncertainty. Galbraith's (1973) theory on organizational design from organizational information processing view laid down the foundation for the later research and debates. The view rests on three important concepts: information processing needs, information processing capability, and the fit between the two to obtain optimal performance. Organizations need quality information to cope with environmental uncertainty and improve their decision making. Environmental uncertainty stems from the complexity - number of variables and dynamism - the frequency of changes of the variables. Organizations have two strategies to cope with uncertainty (1) reduce the effect of uncertainty by developing a buffer and (2) increase information processing capability by implementing structural mechanisms and enhancing lateral and vertical information flow. Galbraith elaborates further that where conditions are routine and simple, rules and programs can be used to absorb the relatively small amount of uncertainty facing the organization. Where uncertainty increases, exceptions must be referred up the hierarchical authority structure for decision making. When information-processing requirements threaten to overload the management structure, decentralized decision at lower levels in the organization shall take place, including the use of lateral relations allows more information processing to be decentralized so as to reduce the information-processing load on management. This includes for example more face-to-face communications, cross-functional committees, task forces, and matrix structures. When this is no longer adequate, various vertical information-processing systems can be attached to the hierarchical structure, which increase the organization's information-processing capacity. Galbraith's model links organizational design to organizational information-processing that shape individual information processing behavior.

Organisational information processing has also been considered from routine vs nonroutine information processing prospective (Daft and Macintosh 1981; Daft and Weick 1984), this is similar to the distinction between strategic vs. tactic information processing (Ansoff, 1979; Egelhoff, 1991). Routine information processing deals with relatively large volume, repetitive routine day-to-day problems and situations that can be automated. Non-routine information processing deals with high uncertainty situation that are either unique, dynamic, infrequent and heterogeneous. Information processing is complex yet strategically important, hence human judgement and heurism remains critical as effective mechanisms, as well as organizational systems such as collective cognition, advanced AI.

## **2.5 Performativity of intelligent systems in distributed decision making**

Aversa, et al. (2018) extend the debate on information-based decision making by arguing that cognition is not simply located in the (head of the) decision maker but is distributed across a variety of non-human entities. There is a shift of focus of decision-making for strategic purposes from the mind of the individual(s) making the decisions, to the network of artifacts and human beings involved in the practice of deciding. Using a

failure case of F1 racing real scenario with big data analytics, decision algorithms and instant/swift strategic decision requirement, the researchers proposed a three facets of information processing for decision making:

- Situated nature of decision making with big data - organization culture, e.g. blame vs accountability; the ergonomics of the decision situation - visual, audio environment;
- Distributed cognition in big data decision making - the collectives of human entities (HQ and control centres vs racing site team), non-human entities (technologies, networks, analytics, algorithms...); the cognitive division of labour between team members (social distribution) and the cognitive tasks are distributed across the time (material distribution).
- Performative dimension of decision making tools - capabilities as well as assumptions embedded in the decision algorithms, unexpected events modelled, decision responsibilities, and what is not include in the framework.

Aversa, et al.'s (2018) model considers cognitive tasks shared between people, and non-human artifacts. The notion of performativity provides a useful perspective to consider digital technology power as a contemporary driving force that is shaping how tasks, information and decisions are made in organisations, we vision that the performative dimension of management information systems and analytics influence managers' information behaviour, hence this dimension is included in the conceptual model.

In summary, managerial information behavior research is rooted in general information seeking/retrieval behavior, but has evolved in two main stages - the early stage that focuses primarily on individual information processing behavior and the digital era stage that technology advances (performative force) are shaping managerial and organizational information behavior. Figure 1 maps out this evolutionary process.

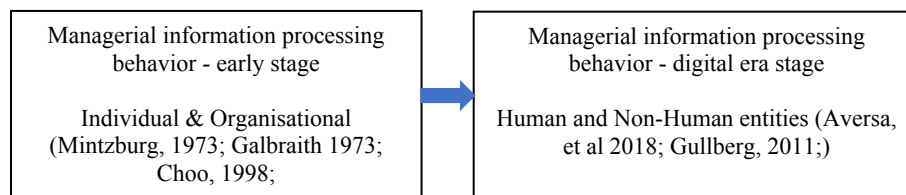


Figure 1. The evolution of managerial information behavior

The review supports Gullberg's (2011) assertion that managerial information patterns evolve slowly compared to the technological development. However, new technologies have influenced more routine exchange of information, thereby causing increased dispersion among users and creating new roles.

### 3. Discussion and The Framework

#### 3.1 The driving forces

The theoretical review suggests three key driving forces shaping managerial and organizational information processing.

***The situational dependencies*** - From Taylor, Mintzberg to Choo and Aversa, et al. it is clear that managerial information behavior is contingent on multiple factors including managerial role, task nature, decision situation, problem solving assumptions, organizational culture, sector differences etc. This is akin to the notion of “Situational nature of decision making” (Aversa, et al. 2018). Given the multiple dependencies and variations of these dependencies, we argue that it is unlikely to abstract managerial information processing in a homogeneous general pattern. This supports Gullberg’s (2011) assertion that managerial information patterns resemble a mosaic rather than a puzzle that can be solved by specific pieces.

***Human cognitive capability and affective response*** Managers use their experience, knowledge, vision and judgement to interpret new information leading to either positive or negative affective response. Despite the heterogeneity of individual information processing behaviors, this has been proved as a common cognitive process that drives managerial information processing. We envision that individual cognition is constant, it underlines organizational responses - specifically on collective team cognition and collaboration.

***The digital performativity*** - The non-human entities centred around digital performativity is a drive affecting managerial information processing in the digital era. This can be viewed as an emerging distinctive driving force shaping not only managers as information user, but organizational setting for information processing. The digital power refers to e.g. intelligent systems, AI and distributed network that formulate new (non-human) decision nodes in distributed decision networks. As such, performativity has associated processing-decision responsibilities and accountabilities that require organization reconfiguration.

To summarise, the variety and the dynamics of the driving forces can be considered as independent variables, which are hypothesized to be associated with managerial information processing represented by individual behavior and organizational responses as dependent variables. Figure 2 depicts the hypothetical relationship.

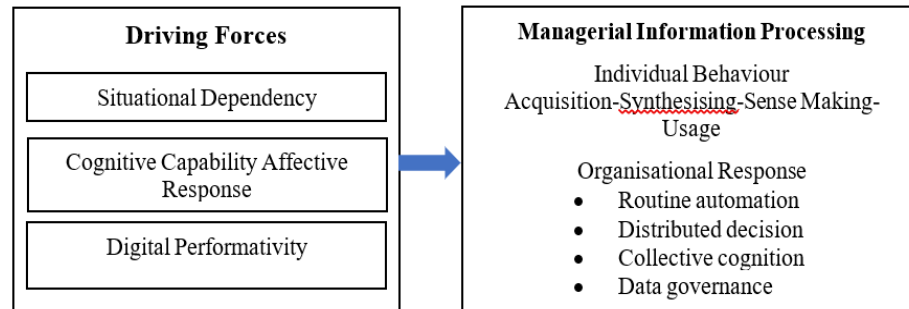


Fig. 2. A conceptual framework of managerial information processing

The two dependent variables contain sub-variables that are assumed different strength of relationships. It can be argued that managerial information processing behavior are changing when referring to the conventional process - acquisition, synthesizing, sense making and usage.

With automatic information feeding, news alerts, regular information provision and exception reports, managers may shift their focus from information acquisition to synthesis and sense making. Wide information sources provide high accessibility but often low credibility, this require managers to perform specific targeted search to validate the data received. Structured data manipulation and analytics tools are widely available for data synthesising, it is envisaged that managers are actively using (or using the analytic results) computer-based systems for synthesising data, but not a shift of behaviour in using human cognition and effective response to make sense of information.

Comparing to changes in individual information behavior, more organizational responses that differ from the traditional mechanism will emerge. This includes reduction of information needs by automating routine tasks and repetitive data processing; more distributed data analytics and decision making performed by intelligent machines over interconnected networks and cloud platforms. Due to increased uncertainty and complex decision situations, it is expected there will be a shift from individual sensemaking towards more collective cognition and sense making via both vertical and lateral relations designed by specific organization. To minimise the risks caused by disinformation, misinformation and fake news, low trust on using AI and intelligent systems, a wide organisational digital governance framework is needed, particularly, the responsible AI to govern non-human decision risks and responsibilities. All these require organisational structure and culture transformation.

It is impossible to examine managerial information behavior without considering organizational dynamics. The managerial information focus shifts to uncertainties, which depends on the dynamic business and the environment situations. Low complexity and less dynamics suggest a tendency of more structured, repetitive and routine information processing, vice versa, high complexity and high dynamics demands mixed approaches and infrastructure to prevail.



Driven by performativity, there are two contrast directions in managerial information processing - to reduce managerial information needs and to increase performativity to simply complexity. The former is achieved by using advanced systems/technologies to perform routine information processing - including information acquisition and structured synthesising, and distributed decision making. The latter is realised by more intelligent systems including AI/ML to enhance complex information processing and sensemaking that usually performed less well by individual managers. The aim is not to substitute managerial role in making sense of the complexity, but to simply complexity by cues based on big data processing, algorithms and machine heuristics.

From organisation design perspective, two new elements for information processing should be considered in the era of big data and AI: the collective sensemaking and digital governance. This requires an overhaul or a new design of team working - the lateral relations and the hierarchy reporting structure on information processing in organisations. Digital governance is not merely for compliances of legislations, data security and privacy but more on risks and accountabilities when data processing and decisions are performed by advanced systems in distributed networks. Responsible AI is on the horizon (Mikalef, et al. 2022). Novel concepts such as Data Quality Board, Data steward, Responsibility Assignment Matrix and Accountability Network can be implemented as future digital governance framework in organisations.

#### **4. Conclusion**

This study reveals three driving forces shaping managerial information processing in the big data and AI era: Situational Dependency, Cognitive Capability Affective Response and Digital Performativity. The organizational / business dependencies are fundamental in determining the specific way of what and how information is processed by managers individual and by organisations. Attempt to generate a homogeneous pattern or model of managerial information processing is unlikely from this regard. Nonetheless, managerial cognition and effective responses are continuous playing important role in processing new information received, experience and judgements are indispensable knowledge used to establish initial cognition. The trend is on shifting focus from routine to complexity. Lateral relations and hierarchical escalation, as renewed organizational response, should be followed to form collective sensemaking for complex situation and incomplete information processing.

The performativity force impacts managerial information processing significantly by reducing managerial information needs through automation, distributed information processing and decision making, and by increased digital capability, e.g. powerful analytics, algorithms and computer heuristics to enhance managers' ability in handling complex situations. Performativity force in particular is changing the status quo of organizational design, i.e. call for corporate digital governance. This opens a spectrum of new organizational design and thinking as both an academic and a practical challenge.

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