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Critical Review of Organization-Technology Sensemaking: Towards Technology Materiality, Discovery and Action

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Critical Review of Organization-Technology Sensemaking: Towards Technology Materiality, Discovery and Action

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Abstract

More than two decades of sensemaking research has brought thorough knowledge of how people understand organizational phenomena and attach meaning to them. This stream of research explores varied social and cognitive aspects of the process in the context of organizations and information technology (IT). However, such a large body of literature exhibits some significant shortcomings: there is a lack of IT materiality; a neglect of the discovery aspect of perception; and a lack of action orientation. So, there is limited understanding of the role that the material artifact plays in shaping users' sensemaking of new IT, as well as how users' actions affect their sensemaking. Moreover, while the literature mostly focuses on sensemaking as the creation of new meanings to rationalize user experiences, it neglects the discovery aspect of sensemaking that refers to perception of the meaning already available. To address these issues, this article provides a thorough review of the literature on organization-technology sensemaking and synthesizes our current understanding of the phenomenon. It then analyzes the major shortcomings in our knowledge and highlights the need to address those shortcomings. It subsequently discusses an ecological approach consistent with the tenets of critical realism that can address the existing shortcomings.

Keywords: Organization-Technology Sensemaking, Literature review, Critical review, Socio-cognitive approach, IT artifact, Ecological approach

Introduction

> The first project assistant, Jean, basically views ProjectWeb as a *broadcast* medium and this notion pervades her thinking about how to design, manage and use the project web sites, which she is responsible for. For Maria, the other project assistant, ProjectWeb is rather a kind of *groupware* system, which may support cooperation and interaction in her projects. (Bansler and Havn 2004, p. 71)

Information technology (IT) is equivocal by nature and can be understood in various ways and used accordingly (Weick 1990). For instance, ProjectWeb is a web-based groupware system that supports file and document sharing, information publication and group messaging. While Jean in the epigraph understood the ProjectWeb technology as a broadcasting medium and used it accordingly, Maria understood it as a collaboration support medium and used it thus. Studies abound that have investigated instances of IT that have been understood and enacted in different ways by different organizational members: First Class (Henfridsson 2000), Lotus Notes (Karsten 1995; Orlikowski and Gash 1994), group decision support (Gopal and Prasad 2000), e-mail (Barley et al. 2010; Fulk 1993; Markus 1994), enterprise accounting (Svejvig and Jensen 2013), healthcare computer systems (Prasad 1993; Savoli and Barki 2013; Siino and Hinds 2005), and business-to-business (B2B) technologies (Barrett 1999; Mishra and Agarwal 2009).

Such equivocality brings about significant consequences for individuals and organizations, whether intended or not (DeSanctis and Poole 1994; Mishra and Agarwal 2009). For instance, taxi drivers in Singapore provided with GPS dispatching units used the technology in very different ways, resulting in varied organizational consequences (Hsiao et al. 2008). Drivers who understood the GPS as a "detector" of customers who had called the dispatch center to request a taxi could enhance the quality of service given to the existing customers. However, those who understood the GPS as an "explorer" of new routes and hot-spots could attract new customers found in their explorations. In this case, varied understandings of GPS among taxi drivers could result in either retention or expansion of the company's customer base. In other examples, varied sensemaking of account management systems (Beaudry and Pinsonneault 2005) and electronic medical record systems (Lapointe and Rivard 2005; Savoli and Barki 2013) led users to use systems differently and to have different definitions of success or failure of information system projects. Managers could greatly benefit if they could better understand user sensemaking of technology[1] and how to manage it.

Sensemaking is the process of attributing appropriate meaning to new experiences (Louis 1980; Weick 1995). Organization-technology[2] scholars have studied sensemaking processes for more than two decades and developed a coherent body of knowledge about how individuals and groups interpret and make sense of organizational phenomena, including technologies (Faraj et al. 2004; Griffith 1999; Maitlis 2005; Orlikowski and Gash 1994; Weick 1990). This body of

[1] In this article, we use the terms "information technology" and "technology" interchangeably.

[2] We use the term "organization-technology" to refer to the body of research that spans organization studies and information systems research.

research informs the cognitive processes through which people develop the mental models, called representations or frames, that attach meaning to the flux of individual experience. It also examines various aspects of the social context that influences user sensemaking of technology. Despite the insights that the extant literature provides on the cognitive and social aspects of sensemaking processes, it provides limited understanding about the technological artifact plays in these processes. The technology artifact is of key importance, particularly at the early stage of technology introduction and sensemaking, because it is typically the only element which new users can draw upon to make sense about the technology before the rules and conventions of use are shaped (Hallerbach et al. 2013). For instance, we know that taxi drivers may understand GPS technology as either "detector" or "explorer," and these understandings influence their technology use and work practices in certain ways (Hsiao et al. 2008). However, we know very little about how these understandings are related to the GPS features and design characteristics. Filling this gap could be quite consequential for both organizations and technology developers. Having such knowledge, the taxi service company could promote using the features that foster understanding technology as "detector," if its core strategy is to retain existing customers rather than attracting new ones. Moreover, technology developers could customize the GPS system to facilitate its use as "detector" if they knew how such understanding is related to the design characteristics of the technology; they could reinforce the appropriate understanding of the technology by highlighting the related design features.

To take stock of decades of sensemaking research and push it beyond the current limitations, this article takes the first step by studying how people ascribe meaning to organizational and technological phenomena; the shortcomings in our current knowledge of these phenomena; and how we can address these shortcomings. The scope of this review includes sensemaking in both organizational studies and information systems (IS) literature because sensemaking is a social process in nature and it cannot be examined and understood in isolation from its social/organizational context. While the IS literature focuses more on the technology-specific elements of sensemaking, the organizational studies focus more on power, structure, norms, culture and other organizational elements that play a role in sensemaking of any organizational phenomena, including technology. Thus, one cannot obtain a solid understanding of technology sensemaking without drawing on both literatures. In addition, this study clarifies how the design of the material artifact could play a role in technology adaptation processes in organizations. Drawing on ecological psychology, this study proposes the general foundation of an ecological approach to technology sensemaking. It suggests that what people understand about a new technology are affordances, that is, the functional relationships between themselves and the material artifact.

Figure 1 lays out the overall structure of the article, and the three main contributions it makes to the technology sensemaking research. First, the paper reviews and synthesizes current research on organization-technology sensemaking. It recognizes four major streams of organizational sensemaking that study sensemaking and sensegiving at the individual and collective levels. It also reviews the literature on sensemaking concerning technology.

Second, this study highlights three important shortcomings of the current sensemaking research: a) the socio-cognitive approaches do not address the role of the IT artifact in shaping user sensemaking of new technology; b) while the cognitive aspect of sensemaking is well examined, the non-cognitive discovery aspect (that is, discovering the meaning that already exists in the environment, rather than creating new meanings to rationalize experience) has been only marginally studied; and c) while we know much about how sensemaking affects users' actions, we know very little about how users' actions affect their sensemaking.
Third, this study discusses the basic foundations of an ecological approach to sensemaking that addresses the shortcomings of current socio-cognitive approaches. It examines individual sensemaking in relation to adaptation to the IT artifact. Moreover, it facilitates a shift from the traditional structurational perspective to a critical realist one. It recognizes the three-layer stratification of real-actual-empirical of the IT sensemaking phenomenon, and it identifies affordances as generative mechanisms that shape users' sensemaking of new technology.

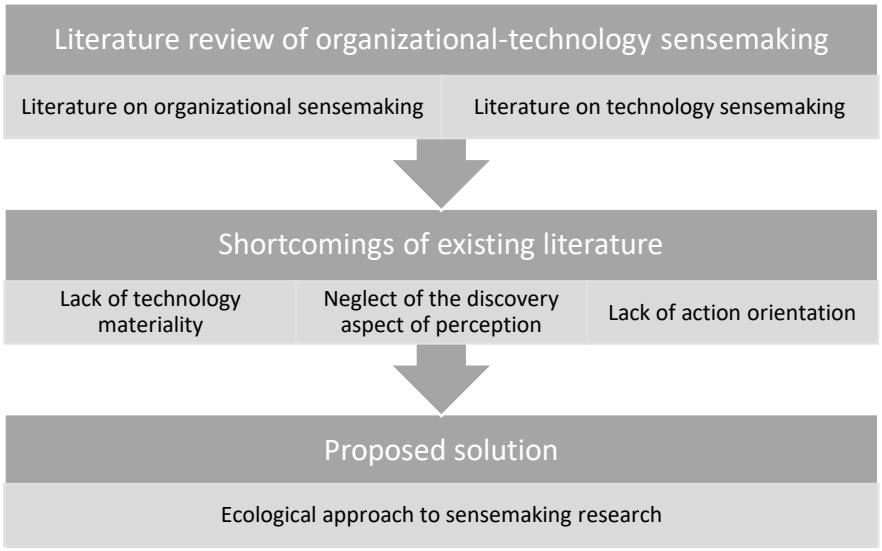

Figure 1. Structure and contributions of this article

Concerning our methodology, the goal of this standalone literature review article is to synthesize the organization-technology sensemaking literature, to critique the literature by identifying important shortcomings and to propose some remedies to these shortcomings. This is what Paré et al (2015) call a "critical review", whose goal is "to critically analyze the extant literature on a broad topic to reveal weaknesses, contradictions, controversies, or inconsistencies" (p. 189). We describe our methodological procedure in detail in the appendix. Next, we present the results of our review for organization and technology research.

Sensemaking in Organization Research

Sensemaking in general is the process of "attributing meaning to surprises" (Louis 1980, p. 241), or more precisely, "the ongoing retrospective development of plausible images that rationalize what people are doing" (Weick et al. 2005, p. 409). Organization research is focused on

organizing, that is, the processes, structures, and practices of managing social units of people to meet certain goals. Organizing is tied to the way people understand their environment; this is why "attentional processes" play a crucial role as a "determinant of human organizing" (Weick 1969, p. 38). The fact that "sense makes organizing possible, and organizing makes sense possible" highlights the sensemaking processes as a crucial component of doing and organizing, because it is the process through which people understand their environment and attach meaning to it (Weick 2000, p. 95). Moreover, sensemaking can have a major impact on organizations (Hahn et al. 2014). For example, Lapointe and Rivard (2005) provide evidence that what people perceive when they start interacting with an electronic medical records system can result in differing technology adoption behaviors, from adoption to passive or aggressive resistance. Such differing adoption behaviors resulted in failure of the implementation project in two hospitals compared to one hospital that successfully delivered the project. In fact, the same software package succeeded in one hospital while failing in another because of the very different perceptions and adaptive behaviors that arose.

We have identified four streams of organizational sensemaking research based on the two main dimensions of the sensemaking process. First, sensemaking is always tightly coupled with sensegiving towards others in the organization (Gioia and Chittipeddi 1991); managers and other organizational stakeholders not only make sense of the organizational issues (sensemaking), but they also communicate their crafted meaning to influence others' understanding of those issues (sensegiving) (Bartunek et al. 1999; Gioia and Chittipeddi 1991; Hill and Levenhagen 1995; Maitlis 2005; Rouleau 2005). While the two processes are closely related, they form two streams of research that deserve to be acknowledged on their own.

Table 1. The topics studied in four streams of organizational sensemaking research

	Individual	**Collective**
Sensemaking	The individual, organizational, and network resources on which members and managers draw for individual sensemaking	The processes and facilitators of collective sensemaking
Sensegiving	The practices that support sensegiving to individuals	The processes, triggers, enablers, and supporting mechanisms of sensegiving to collectives by managers and other stakeholders

Individual Sensemaking

Second, people make or give sense either individually or collectively in groups. Since organizations are collectives that accomplish shared goals, making and giving shared meaning is crucial to organizing activities. Indeed, collaborative work is always handled through a common

understanding of the process that emerges from and shapes individuals' sensemaking (Gasson 2005). Therefore, here we analytically distinguish the two streams that examine sensemaking at the individual and collective levels, though the two are interrelated. Table 1 demonstrates the four major streams of research that result from the interaction of the two identified aspects of organizational sensemaking, though some articles treat more than one of the streams. We now discuss each of the four streams in detail.

In any organizational context, individuals need to make sense of what is going on to be able to act accordingly. This is even more important for newcomers who have little information about the social context of an organization (Louis 1980). Managers also need to make sense of organizational challenges by formulating messy issues, facing dilemmas, and handling paradoxes to be able to shape more workable situations (Lüscher and Lewis 2008). There are various resources on which organizational members draw to individually make appropriate meaning: individual, organizational, network resources, and also resources specific to managers (Table 2). The individual resources consist mainly of the various selves composing the individual identity. Such selves include professional, social-psychological, physiological and financial selves directly affecting how people make individual sense of organizational phenomena (Gephart 1993; Grant et al. 2008). Furthermore, existing knowledge structures and mental maps are the cognitive resources that facilitate the process of sensemaking for organizational members as well as newcomers (Bartunek et al. 1999; Louis 1980). Individual past experiences are well reflected in the existing schemas and shape the individual expectations, thus could be consequential for individual sensemaking (Sonenshein 2007). However, the schemas are always under construction and reconstruction to reflect changes in the context. Additionally, individuals make sense of any organizational phenomenon by drawing on their predispositions and purposes (Louis 1980). Moreover, the emotions and affective status of individual sensemakers influence how they understand the situation (Bartunek et al. 1999; Gioia and Mehra 1996; Grant et al. 2008; Weick et al. 2005).

Table 2. Factors that contribute to individual sensemaking in organizations

Resource types	Contributing factors	References
Individual Resources	• Professional self • Social-psychological self • Physiological self • Financial self • Schema; Predispositions and purposes • Past experiences • Affective status	(Bartunek et al. 1999; Gephart 1993; Gioia and Mehra 1996; Grant et al. 2008; Louis 1980; Sonenshein 2007; Weick 1995; Weick et al. 2005)
Organizational Resources	• Functional integrity • Compliance • Style	(Dutton et al. 2002; Gephart 1993; Grant et al. 2008; Harris 1994)

	• Contextual cues • Qualities of organizational culture • Qualities of management	
Network Resources	• Network centrality • Proximity to power • Others' interpretations	(Ibarra and Andrews 1993; Lockett et al. 2013; Louis 1980; Sonenshein 2007)
Resources specific to managers	• Awareness of opportunities and threats • Organizational image and identity desired • Organizational strategies • Information processing structures	(Bartunek et al. 1999; Basu and Palazzo 2008; Gioia and Thomas 1996)

The organizational resources are the context-specific factors that contribute to individual sensemaking processes. Among them are functional integrity, compliance, and style (Gephart 1993). Functional integrity refers to the main purpose of the organization that needs to be met for the organization to survive. Compliance refers to the rules and standards that require conformity and compliance of the individual members; it includes policies, hierarchies, and job descriptions. The style resource of an organization refers to the informal norms that define the range of acceptable behaviors and activities in the organization. Moreover, an organizational strategy could affect how individuals make sense of new phenomena, especially in a crisis (Bundy and Pfarrer 2015). In addition, there are various contextual cues that are the raw ingredients of sensemaking processes. In an organizational context, such cues may include demographic patterns, qualities of organizational culture, and qualities of management (Dutton et al. 2002). For instance, whether to raise an issue related to gender equality in the workplace could be dependent on such cues in connection with demographics and management. Organizational culture influences the individual sensemaking by shaping the content of individual cognitive schema; that is, the common culture of the organization promotes the congruence of many individual sensemakings within an organization (Bean and Eisenberg 2006; Harris 1994). Although culture is a collective-level concept, it is carried by every individual within that culture and thus can affect the way the individual makes sense of many organizational phenomena. For instance, an organizational culture of voluntarily trying to help each other may influence individuals' sensemaking about the organization (Grant et al. 2008). The effect of culture is most salient in international and multicultural organizational environments where people of various cultures work together (Shoib and Nandhakumar 2003). In such a context, bridging cultural frames is needed to facilitate sensemaking (Su 2015).

The network resources refer to the aspects of the individual's social network that contribute to their sensemaking. Since sensemaking is a social process, particularly in organizations (Weick 1995), other people's schema and interpretations are as important as the individual's interpretive schema in the process of sensemaking (Louis 1980; Sonenshein 2007). Moreover, the individuals' positions within their social networks may influence sensemaking (Lockett et al. 2013). Individuals' sensemaking can also be affected by the stakeholders with whom they

interact in the organization (Songqi Liu et al. 2015). Network centrality and proximity to power positions are among such position-related features (Ibarra and Andrews 1993). The more central individuals are to the network (i.e. the more important they are to the network) and the less distant from the power position (i.e. the more they interact with people who give them access to resources), the more their sensemaking is affected by their social network.
Furthermore, there are resources specifically available to managers that make sense of organizational phenomena. Strategic awareness of opportunities and threats influences how managers understand and attach meaning to strategic change initiatives (Bartunek et al. 1999). To successfully accomplish strategic change in organizations, management has to modify the organizational image and identity to reflect the new strategic position. Therefore, managers' sensemaking of strategic issues during a strategic change is more affected by the desired image and identity than by the current ones (Basu and Palazzo 2008; Gioia and Thomas 1996). That is, whether a specific issue is labelled as threat or opportunity and as strategic or tactical depends on the desired identity and image of the organization. Moreover, the strategies and information processing structure seem to influence management's sensemaking of organizational issues. For example, the more offensive the organizational strategy, the more strategic will be management's interpretation of the issues (Gioia and Thomas 1996).

Sensegiving to Individuals

Managers and other organizational stakeholders consistently engage in sensegiving to other individuals, because sensegiving is tightly linked to managing change. For managers, initiating strategic change processes involves a sequence of sensemaking and sensegiving activities. It involves the four phases of envisioning, signaling, re-visioning, and energizing (Gioia and Chittipeddi 1991). While sensemaking is about understanding, sensegiving is about influencing. While sensemaking is mostly cognition-based, sensegiving is mostly action-based. Indeed, sensegiving is tied to sensemaking in such a way that it is sometimes hard to differentiate the two in organizational processes. However, the proportion of the two would vary across different phases of organizational change (Gioia et al. 1994). In the early stages, the change agent or management is mostly engaged in making sense of the organizational situation retrospectively and creating plans prospectively. Later, the change agent increasingly engages in sensegiving processes that influence how organizational stakeholders understand and conform to the changes. The meanings that managers try to communicate are not necessarily equivalent to the ones that people receive, thus the sensegiving activities are not always successful. Such failure may happen because the continuously changing sensemaking of the manager can result in inconsistent sensegiving (Bartunek et al. 1999). Middle-level managers are most of the time in the front line of changes, as they are the ones who are supposed to communicate the meaning of the changes to lower-level employees and external clients. They may employ various practices to communicate the appropriate sense to individual clients. Such practices include translation of the new orientation (that is, authoring new meaning and telling a new story using symbolic elements), overcoding the new strategy (making the story substantial by saturating it with socio-cultural

codes, norms and symbols), disciplining the client to support the story, and justifying the change (Rouleau 2005).

In summary, individuals in organizations are continuously engaged in sensemaking and sensegiving processes that unfold sequentially, simultaneously and interactively. Sensemaking is mostly cognition-oriented, while sensegiving is action-oriented. There are multiple resources that feed the cognitive sensemaking processes and multiple practices that support the active sensegiving activities. Figure 2 summarizes the resources and practices that support sensemaking and sensegiving processes at the individual level in organizations.

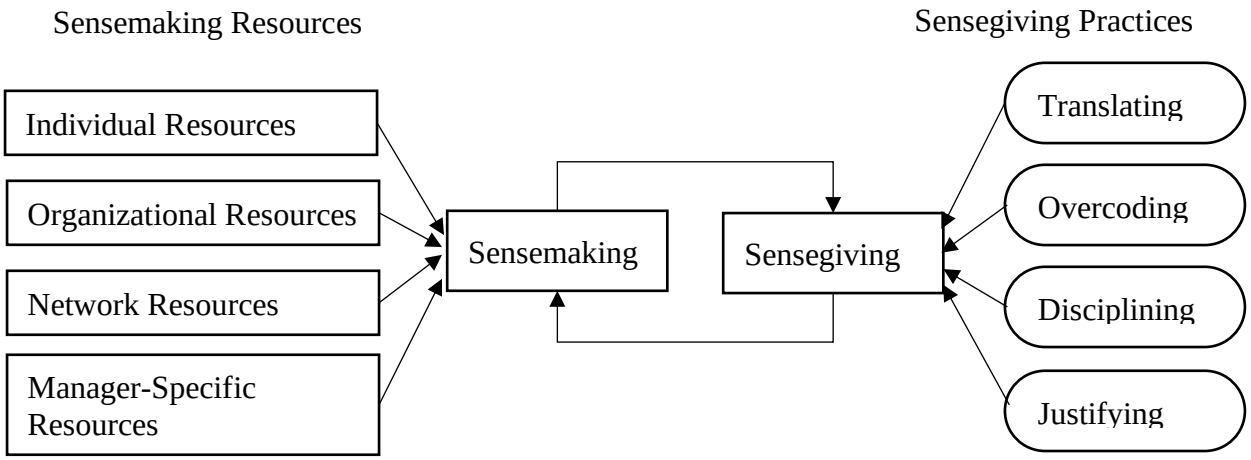

Figure 2. Individual sensemaking and sensegiving

Collective Sensemaking

Collective sensemaking is about how groups of people arrive at a shared understanding of a new experience in the organization. It arises from the need in an organization to have a "collective mind" and shared understanding about issues; it is even more important when the collective is dispersed across time and space (Campagnolo et al. 2015). Collective sensemaking affects how people create and execute organizational strategies in relation to environmental changes (Lewis et al. 2011). It refers to the process of collectively making sense of an interruption or surprise. Since collective sensemaking occurs through social interaction within the group, the social component is more important than the cognitive one. Past research sheds light on the social processes of collective sensemaking and the factors that facilitate the process, as we discuss in the following sections.

Processes of Collective Sensemaking

Organizational members normally form like-minded clusters within which they have similar understandings of phenomena. In this sense, organizational members may not generate, but rather choose one of the competing meanings available; and their choices would be affected by their contexts, including their roles in the organization (Henfridsson 2000; Rose and Kræmmergaard 2006; Vaast 2007). For instance, the cluster of technical employees and the cluster of managers most likely make different collective minds about project success factors. While technical employees assume experimentation and technical creativity are the core to project success, managers may envision administrative creativity and project management as the major success factors (Drazin et al. 1999). However, there is always a balance between the multiple understandings of these clusters, and the balance can change during team work through a process of negotiation (Kjærgaard et al. 2010). Negotiation of the balance unfolds through articulation and elaboration processes in which people use material practices, verbal articulation and interactive talks to translate the dispersed individual meanings to shared collective meaning (Ovaska and Stapleton 2010; Stigliani and Ravasi 2012). Moreover, the specific nature of an issue may influence the balance. When there is a functionality crisis, the balance of the collective sensemaking may change to favor the understanding of the technical staff who are capable of resolving the crisis. When there is a managerial crisis, like cost or schedule issues, the disruption may change the collective sensemaking to favor the understanding of project managers, who are capable of dealing with such issues (Drazin et al. 1999).

Even if there is a unique meaning shared across the whole organization for a specific issue, sudden changes may unsettle the situation such that the current schema and sensemaking can no longer handle the work. Then like-minded groups start to develop clusters of schema. These clusters of schema come closer together later, during the processes of coordination and negotiation between the groups at stake. Eventually, shared but differentiated schemas will form that are characterized by contractual intergroup working (Balogun and Johnson 2004). Moreover, the group identity and legitimacy among the stakeholders are two forces that shape the meaning made within the collectives. Groups tend to make meaning that is consistent with their shared identity and that looks legitimate to all stakeholders (Basu and Palazzo 2008).

The social process of collective sensemaking concerns how organizational members interact to collectively make meaning about their environment and facilitate collective action. More sensegiving by managers leads to more controlled sensemaking processes while more sensegiving by other stakeholders leads to more animated processes (Maitlis 2005). The combination of these two aspects creates four forms of sensemaking processes: unitary/multiple accounts, narrow/rich accounts, one-time/emergent series of action, and consistent/inconsistent action.

Facilitators of Collective Sensemaking

Agreement and congruence of individual minds and schema is key to successful collective sensemaking. This occurs through heedful interrelating, responsibility assignment, formal organizational schema and social norms (Maitlis 2005; Weick and Roberts 1993). Common goals and shared tacit knowledge, expertise and practices also facilitate creating a collective mind (Gasson 2005; Hartnett et al. 2012). Moreover, the history of past organizational changes influences how people and managers make sense of the change being undergone (Bartunek et al. 1999). Thus, collective sensemaking would be facilitated by having shared experience and background about the issue, as well as by the organizational culture (Harris 1994).
The collective mind is affected by and manifested in the actions of individuals. "Heedful interrelating" refers to the members of the collective interacting with each other with awareness about how their actions are related (Weick and Roberts 1993). It facilitates the creation of the collective mind and would be disrupted if the collective mind were dissolved. Investigating collective sensemaking in control rooms, Wahlström et al. (2011) identified three types of practices that facilitate the sensemaking process: practices for using redundant representations, updating inter-subjective understanding by verbal coordination, and gradually correcting hypotheses to match actions.

Sensegiving to Collectives

Sensegiving to collectives is about managers (or sometimes other organizational stakeholders) giving a shared sense to a group of people as a collective. The meaning people make is fundamental to the process of organizing, so one major day-to-day activity of managers is to communicate the appropriate meaning to the organizational members and stakeholders (Gioia and Chittipeddi 1991). Managers usually communicate plans and changes to a collective audience rather than just individuals. Therefore, the sensegiving process in organizations is examined mostly in its collective form. In this section, we examine the factors that trigger and enable sensegiving activities by managers and other stakeholders, and the practices employed to communicate the collective meaning, as depicted in Table 3. We differentiate sensegiving by managers from sensegiving by other stakeholders, because the literature provides evidence that managers benefit from certain managerial resources that are not available to other stakeholders in order to communicate the intended meaning. For instance, they may manage information flows (Bartunek et al. 1999) or use sanctions and rewards (Maitlis 2004) to promote and communicate their intended meaning. While the managerial practices for sensegiving to collectives are specific to managers, the other practices are used by all organizational stakeholders, including managers.
There are various factors that trigger and enable sensegiving activities, and these seem to be different for managers than for other stakeholders (Maitlis and Lawrence 2007). *Trigger* factors are those that initiate the process of sensegiving. Managers are triggered to undertake sensegiving by the ambiguity of an issue. However, the other stakeholders would be motivated to engage in sensegiving activities when they perceive an issue to be significantly consequential to

them or to the entire organization, and also perceive the manager as being incompetent to handle the issue.

Table 3. Mechanisms for sensegiving to collectives

Aspects of collective sensegiving	Managers as sensegivers	Other stakeholders as sensegivers	References
Triggers	• Ambiguity of an issue	• Issue is significantly consequential to them or to the organization	(Maitlis and Lawrence 2007)
Enablers	• Issue-domain expertise • Organization performing strongly in that issue domain	• Issue-domain expertise • Issue-domain legitimacy • Organizational routines that support them	(Maitlis and Lawrence 2007; Petkova et al. 2013)

Practices	• Storytelling practices
	  ○ Making issue appear logical and reasonable
	  ○ Providing a credible story
	  ○ Making issue consistent with values of the receivers
	  ○ Demonstrating the credibility of the sensegiver
	  ○ Managing impressions
	  ○ Using metaphors
			(Bartunek et al. 1999; Brown et al. 2008; Fiss and Zajac 2006; Hill and Levenhagen 1995; Maitlis 2004)

	• Managerial practices
	  ○ Developing and exploiting key relationships
	  ○ Managing information
	  ○ Protecting and exerting formal authority
	  ○ Using sanctions and rewards
		Managerial practices apply only to managers	

The *enablers* of collective sensegiving are the factors that empower the managers or other stakeholders to perform effective sensegiving activities. Organizational management can be effective in sensegiving when they have expertise in the specific issue and the organization performs strongly in that domain (Maitlis and Lawrence 2007). Moreover, the human capital of the executives boosts the intensity and effectiveness of their sensegiving (Petkova et al. 2013). Other organizational stakeholders are effective in sensegiving activities when they have expertise and legitimacy in the issue and are supported by the organizational routines and processes (Maitlis and Lawrence 2007).

There are several *practices* employed by stakeholders to give appropriate sense to collective others. Among these are storytelling practices that could be used by any stakeholder, whereas managerial practices are specific to managers.

To facilitate the communication of appropriate meaning to collectives, one must first draft and tell the story in an effective way that appears logical and reasonable to all stakeholders to be able to obtain their support. The sensegiver should frame the change in a way that makes sense to the varied stakeholders of the organization (Bartunek et al. 1999; Fiss and Zajac 2006), considering the dependence and power of each stakeholder while also being consistent with the norms and values of the receivers. To demonstrate credibility, the storyteller should display an image of legitimacy and competence (Brown et al. 2008; Maitlis 2004). Moreover, metaphors can be useful in the process of effective communication of meaning and stories, especially for radical change and entrepreneurial organizations. A metaphor is more abstract than a mental model; it is incomplete and somewhat emotional (Hill and Levenhagen 1995). Its incompleteness gives it the needed flexibility in situations of radical change, and its emotion can motivate the collective towards action.

Managerial practices normally draw on a number of organizational features such as organizational structures, rules, events, formal statements, physical designs and discourses to communicate and give the appropriate meaning (Bartunek et al. 1999). Such practices include developing and exploiting key relationships with influential board members. Managers may also communicate intended meaning by gathering, holding, concealing and disseminating appropriate information to certain key people at the right time. Moreover, protecting and exerting formal authority given by their position while behaving humbly could facilitate communication of meaning to collectives, which could include using formal sanctions and rewards (Maitlis 2004).

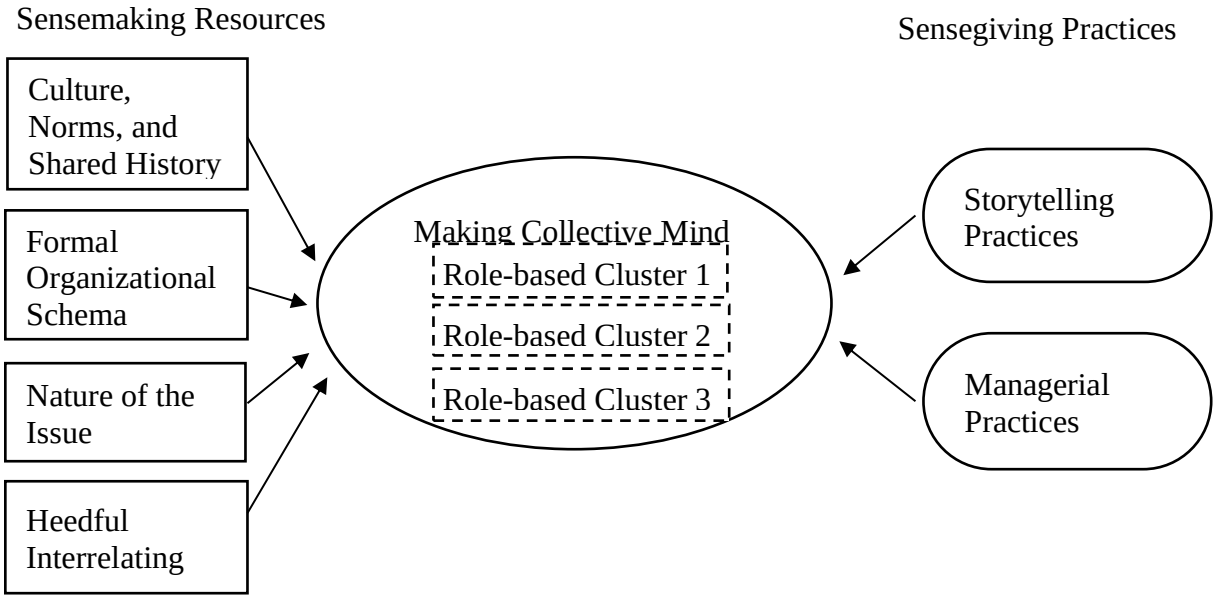

Figure 3: Collective sensemaking and sensegiving

Figure 3 summarizes the sources and practices used to shape and influence the collective mind. Both sensemaking and sensegiving at the collective level are about shaping a collective mind. While there are always numerous like-minded clusters in an organization, the balance between the existing clusters, which are mostly role-based, could define the creation of the collective mind. Collectives draw on varied sources to make sense of organizational changes. The sources for collective sensemaking appear to be different from those at play in individual sensemaking. They reflect the need to arrive at consensus with others in order to make collective sense, because the collective sources are shared across people and are helpful in arriving at that consensus among them. Moreover, managers employ various storytelling and managerial practices to communicate the intended meaning to collectives of organizational members and stakeholders.

The stream of research synthesized thus far provides an extended picture of how people make sense of organizational phenomenon at individual and collective levels (see Figure 2 and Figure 3). It provides rich and valuable insights about how technology, among other organizational phenomena, is understood and made sense of. It highlights the individual, organizational, and network resources that people use to make sense of organizational phenomena, including technology. Moreover, the sensegiving practices discussed lend themselves to sensegiving about new technology. However, this stream is general to all organizational sensemaking and it provides no insights on the specifics of sensemaking about technological phenomena in organizations, if there is any. The following section reviews the studies that shed light specifically on technology sensemaking.

Sensemaking in Technology Research

In addition to general sensemaking research in organizational contexts, we are particularly interested in this study in how people make sense of information technology. Information systems and their combination with organizational features and practices are changing the way organizing unfolds by providing new capabilities and affordances that support new forms of coordinating work (Zammuto et al. 2007). This has evolved technology into an essential part of every organizational phenomenon and has led organizational scholars to study technology sensemaking in order to understand how technology is enacted and woven into the organizational fabric. Technology research, as we discuss here, refers to the field focused on the processes and practices of developing, implementing and using information technologies in organizations. In this section, we review research that investigates how people understand and make sense of new technologies in organizations.

Technology is a substantial organizational phenomenon, so it is always subject to sensemaking. It is recognized as being equivocal, admitting “several possible or plausible interpretations” (Weick 1990, p. 2). It is understood in very different ways by various people in diverse contexts, and this makes it necessary for individuals and collectives to make sense of technology before acting on it. Information technology sensemaking is the process through which individuals and

collectives come to an understanding of new technology and attach appropriate meaning to it (Gephart 2004). Technology sensemaking begins when people encounter a new technology or updated versions of an old one and it ends where the process of structuration of technology within the social system begins. That is, it is through the very initial phase of IT introduction and implementation in organizations that people get to know the technology, develop beliefs and attitudes towards it, and make up their minds about how it can be appropriated to do the task; this process feeds the adaptation and structuration processes that shape the technology-in-use crafted for a certain situation (Griffith 1999).

Users' sensemaking of new technology affects their practices and how they adapt it to their work routines (Ellway and Walsham 2015; Yu Tong et al. 2015). There are several studies that report evidence of the significant consequences that user understanding of technology can bring about. Employees of two North American banks reportedly understood the new account management system as either a controllable opportunity or an uncontrollable threat for their job; while the former maximized their use and benefit of the system, the latter limited their use of the new system to decrease the disruption it caused (Beaudry and Pinsonneault 2005). In another example, Lapointe and Rivard (2005) provide evidence of differing user adoption behaviors, from adoption to passive and aggressive resistance, based on what people perceived when they started interacting with an electronic medical record (EMR) system. Such differing adoption behaviors resulted in the failure of the EMR implementation projects in two hospitals compared to another hospital that successfully delivered its project. In fact, the same software package succeeded in one hospital while failing in others because of the very different perceptions and adaptive behaviors raised. The differing perceptions towards the EMR system are attributed to the "interplay between its features and individual and/or organizational-level initial conditions" (p. 461). Savoli and Barki (2013) provided evidence that users who understood a healthcare system as facilitator, inhibitor, guardian angel, or imposer used the system in various ways, then came up with very different results in how successfully they could control their asthma. Based on these studies, we draw the conclusion that managers would greatly benefit if they could better understand user sensemaking of technology and how to manage it.

Strictly speaking, technology sensemaking is a subset of organizational sensemaking, in the sense that it focuses on sensemaking of the technological phenomenon in organizations (Davidson 2006; Weick 1990). In our review, the two domains are not exclusive and the articles that we identify as focused on technology sensemaking can also be considered as organizational sensemaking studies. Technology sensemaking research delves into three aspects of the phenomenon in organizations: cognitive processes, social context and sensegiving activities by technology-use mediators, which are examined below. Table 4 represents the topics involved in each of the three streams, though some articles treat more than one of the streams. Next, we will discuss the current status of research on cognitive and social aspects of technology sensemaking and sensegiving practices in organizations.

Table 4. Topics studied in three streams of technology sensemaking research

Research Streams	Topics Involved
Cognitive processes	Domain categories, patterns, processes, and triggers of cognitive frames about technology
Social context	Structure, interaction intensity, occupational roles and other aspects of the social context
Sensegiving by technology-use mediators	Practices used to promote technology and realize the value of IT during implementation

Cognitive Processes

Technology should be understood as "*équivoque*" (Weick 1990, p. 2); that is, multiple interpretations of the technology highlight the role that individual cognitive processes may play. Scripts (Weick 1990), technological frames (Orlikowski and Gash 1994), and social representations (Vaast and Walsham 2005) are the mental models constructed and maintained by individuals to guide their behavior towards technologies. Whereas a script is the general mental model that refers to the sequence of actions that make up an event (Weick 1990); a technological frame is the cognitive structure concerning the assumptions, expectations, and knowledge that people use to understand and interpret technology in organizations (Orlikowski and Gash 1994); and a social representation is a collective-level general mental model shared among members of the community, rather than made and maintained at the individual level (Vaast and Walsham 2005).

Whereas congruence of the individual mental models facilitates technology implementation in organizations, their incongruence may potentially raise either conflict and difficulty (Azad and Faraj 2008; Olesen 2014) or productively improve the system if treated wisely (Karsten and Laine 2007). Executives create and carry dominant frames that may be influential over and above others over time (Olesen 2014). They can play a major role in making consensus among frames by promoting IT, engaging users with IT, and facilitating communication between IT and business people (Tallon 2014). Mental models can play both facilitating and constraining roles. They facilitate action by providing the cognitive structure and assumptions for understanding the world, and they constrain creative action by compelling people to distort information to comply with existing frames (Orlikowski and Gash 1994). Various aspects of the cognitive processes have been examined, including frame domain categories, frame patterns, framing processes, and triggers. These aspects are depicted in Table 5 and further presented in the following.

Domain categories: Technology-related mental models can represent individual understanding about IT features and attributes, IT organizational applications, incorporating IT into work practices, and developing IT applications in organizations (Davidson 2006). Executives make their own frames about the application and impact of IT in their organizations (Tallon and Kraemer 2007). Although the contents of frames are highly varied and context dependent, they

mostly refer to one of the categories of frame domains. There are also technology-specific categories of frame content. For instance, frames related to GPS technology for taxi drivers may consider GPS technology as detector, navigator, explorer, or guardian; each refers to one aspect of the technology's application (Hou 2008; Hsiao et al. 2008). The structure of a frame is of equal, if not greater, importance than its content. Various aspects of frame structure include construction of arguments, the breadth of issues considered, and the rigidity of frames. Both the content and the structure of frames need to be taken into account when identifying and examining technology frames (Davidson 2006).

Patterns: Three patterns of technology sensemaking are variously important during different phases of technology use in organizations from training to technology routinization: pragmatic, romantic, and pessimistic symbolism (Prasad 1993). Pragmatic sensemaking understands technology as efficient, inevitable, and linked to organizational survival. Whereas pessimistic sensemaking of technology understands it as related to negative consequences like errors, physical hazards, and misuses, romantic sensemaking interprets technology in positive ways related to playfulness, fun, and intelligence.

Table 5. The cognitive aspect of technology sensemaking

Framing aspects	Findings	References
Domain categories of frames	• IT features and attributes • IT organizational applications • Incorporating IT into work practices • Developing IT applications	(Davidson 2006; Orlikowski and Gash 1994)
Patterns of frames	• Pragmatic • Romantic • Pessimistic symbolism	(Prasad 1993)

Processes of framing	• Individual level processes
	  ○ Initial adoption
	  ○ Transitional adoption
	  ○ Senselessness in post-adoption
	• Collective level processes
	  ○ Frame differentiation
	  ○ Frame adaptation
	  ○ Frame stabilization
		(Azad and Faraj 2008; Hsiao et al. 2008; Jensen and Kjærgaard 2010)

Triggers	• Situational factors
	  ○ Novelty of the technology
	  ○ Discrepancy between observation and expectation
	  ○ Deliberative initiatives
	• Technological factors
	  ○ Core vs. tangential
	  ○ Concrete vs. abstract
		(Griffith 1999; Hsiao et al. 2008)

Framing processes: Focusing on the framing processes rather than on the frames themselves enriches the understanding of the dynamics of technology sensemaking processes (Davidson 2006). While individual technology sensemaking is about making and maintaining frames, collective sensemaking is about making the diverse frames of individuals more congruent and less disparate. To make sense of technology, individual sensemakers go through the three phases of initial adoption, transitional adoption, and senselessness in post-adoption, that is, when the individual automatically follows the meanings and mental models already made (Hsiao et al. 2008). Studying the transitional phase, Zamani et al. (2013) explained how iPad users elaborate their initial frames, question the frames, compare, preserve, and reframe them. Consequently, users may change either their frames or the technology at hand by developing workarounds; otherwise, they may abandon the technology. During the transitional phase, professional identity plays a key role in shaping the meaning people attach to technology. People tend to construct meaning that is more consistent with their professional identity and practices (Jensen and Kjærgaard 2010; Svejvig and Jensen 2013). To collectively make sense of technology, groups of organizational stakeholders go through frame evolution processes in the three general phases of frame differentiation, frame adaptation, and frame stabilization that reconcile the competing frames into a truce frame, a stable frame on which the competing parties agree (Azad and Faraj 2008).

Triggers: The technology sensemaking process may be triggered by either situational or technological factors, especially the core and concrete features of the technology (Griffith 1999). The novelty of the technology or of any new feature may trigger the need for developing new related frames to understand and use the technology. Moreover, any discrepancy between observation and expectation leaves the individual unable to explain the situation and activates the sensemaking processes. In addition, deliberative initiatives would require sensemaking activities; this could happen when the individual is asked to decide about or use the technology (Hsiao et al. 2008).

Social Context

Besides the cognitive processes that construct and maintain individual frames, there are some characteristics of the social context that influence how people make sense of the technology in organizations. While the cognitive aspect of technology sensemaking focuses on the cognitive structures and patterns as the basis through which people make and ascribe meaning to technology, the social aspect focuses on the social factors that facilitate technology sensemaking (Gephart 2004).

The structure of the social context affects how people make sense of the technology. For instance, sex segregation influences the cognitive frames that people adopt to understand technology in organizations. The workers in male- or female-dominated occupational positions are prone to develop quite different understandings about a robot deployed in a hospital (Siino and Hinds 2005). The intensity of the social interactions between group members facilitates the congruence of the meaning they make about technology. For instance, technology frames of

different user groups towards an electronic patient record (EPR) system were mostly similar because of the high interaction between groups (Karsten and Laine 2007).
The social and occupational roles that people play influences how they ascribe meaning to IT phenomena (Siino and Hinds 2005). For instance, various occupational groups in a hospital make sense of information system security in different ways and develop representations indicative of their work context (Vaast 2007). Group belonging, social norms, power and influence are other social factors that affect technology sensemaking (Sneddon et al. 2009). People make sense of technology in such a way that their understanding does not conflict with the social norms and the meanings other members of the same group make. In addition, people tend to make the meanings that enhance their power position. Moreover, technology sensemaking of individuals is affected by the sensegiving activities of peers and powerful others. Such sensegiving activities are elaborated in the following section.

Sensegiving by Technology-use Mediators

After examining the cognitive and social aspects of sensemaking about technology, this section reviews the other side of sensemaking: sensegiving about technology. This is distinct from organizational sensegiving in that it focuses on concrete and objective technological features and functions that may further limit the sense being communicated by the sensegiver. Sensegiving activities are normally used by technology-use mediators, the individuals responsible for facilitating the adoption and adaptation of the new technology by users in the organization (Okamura et al. 1995). They use sensegiving to make sure the business value of IT is understood and realized by others in the organization (Gäre and Melin 2013).
Technology-use mediators employ various practices to influence user sensemaking by changing either the users' perceptions or the technology. While user-oriented practices focus on communicating the IT system and promoting use, the technology-oriented practices focus on adapting the system to fit the users and to easily communicate action possibilities to the users (Bansler and Havn 2006). The frames that technology mediators develop and the practices they employ could be different during various phases of the technological change (McDaniel Albritton 2010). While the main concern of mediators, in the initial phases, is to install the system and get people to use it, later they are more focused on guiding people to make the best use of the system. In other words, the mediators' practices change from technology-oriented ones to user-oriented ones during the later phases.
The stream of research reviewed in this section extends our understanding of organizational sensemaking to the sensemaking of technology. It delves into social and cognitive processes involved in making sense of technology and giving sense to their users. Synthesizing the two sections provides comprehensive understanding of the current state of literature on organization-technology sensemaking; it tells the story of what we know about how people make sense of organization-technology phenomena. However, in our reading of the literature, we have uncovered some important shortcomings in this body of research. In our extended discussion of

the literature that follows, we highlight these and briefly suggest an alternative approach to address them in the future.

Discussion

Organization-technology sensemaking research has employed social and cognitive perspectives to examine the question of why and how people understand organizational phenomena, including technology. From a cognitive point of view, people start sensemaking when they face something new or ambiguous; then they extract the salient cues, draw on related mental models, categorize the cues, and label them with the appropriate meaning. The meanings are stored in the form of mental models that are continuously revisited to reflect people's new experiences. The social perspective examines how people's sensemaking is influenced by their social resources, including their social interactions, culture, norms, and power relations. The notions of the collective mind, shared meaning, and consensus are central to the social aspect of the sensemaking processes.

In light of the current socio-cognitive understanding of the sensemaking phenomena, here we highlight three major shortcomings of the existing research. Next, we present the basics of an ecological approach that can potentially address some of these shortcomings. Finally, we discuss the potential implications of the ecological approach provided for research and for practice.

The Need for a Fresh Approach to Technology Sensemaking

Whereas past research has looked into cognitive and social aspects of the technology sensemaking phenomenon, it has paid less attention to some other important aspects. Here, we highlight the lack of technology materiality, the neglect of the discovery aspect of perception, and the lack of action orientation across technology sensemaking research.

Lack of Technology Materiality

Latour (1992, 2005) noted that the artifact is absent in most sociological explanations of everyday life. Whiteman and Cooper (2011, p. 892) affirmed that the organizational sensemaking research does not address the role of the "materiality of the natural world" in its explanations of the phenomenon. The same concern has been raised by many organization-technology scholars about the absence of the IT artifact in explanations of IT phenomena in organizations (Benbasat and Zmud 2003; Leonardi 2011; Orlikowski and Iacono 2001). This is a valid concern as well for technology sensemaking research, because there is barely any notion of technology materiality within the dominant socio-cognitive explanations of sensemaking processes.

Acknowledging this limitation, Griffith (1999) took the first steps to address the issue by examining how some characteristics of technology features would trigger the sensemaking processes. Her view recognizes the material artifact as a trigger of the sensemaking process; the

more concrete and core the IT artifact is, the more probable it is to trigger sensemaking processes by the individual. However, she neglects the role that the material artifact may play in shaping the meaning people attach to the technology.

Crystalizing the role of the material artifact in sensemaking processes will contribute to both research and practice in a number of ways. First, it extends the current understanding of the sensemaking process by going over the social and cognitive processes of sensemaking and highlighting how "the matter" about which people make sense can influence their understanding of new technology. Second, it brings traditionally socio-cognitive IS sensemaking research closer to the HCI and usability research so that these two disciplines can fruitfully exchange and contribute ideas. While usability research focuses on how design features are perceived and used, the sensemaking research can contribute to HCI research by explaining the role of the artifact in users' sensemaking of new technology. Third, it provides technology design teams with insights on how design features influence users' understanding and then adaptation to technology. It links the material artifact, its form and its features to how users make sense of the artifact.

Neglect of the Discovery Aspect of Perception

The current social psychological approach to technology sensemaking has dominantly assumed that meaning is fully made rather than discovered. In other words, the meanings that people ascribe to their environment are invented within the human mind using individual cognitive structures through their social interaction with others. However, Weick argued that "perception *creates* as well as reacts to an environment" (1969, p. 39) and clarified the fact that "sensemaking is about authoring as well as interpretation, creation as well as discovery" (1995, p. 8).

Despite Weick's acknowledgement, the discovery aspect of perception has been mostly neglected. While we know much about how perception creates meaning, we know very little about how perception discovers the meaning already existing in the environment. This may be partly responsible for the lack of materiality in sensemaking inquiries that we mentioned in the previous point, because when the meaning is fully made within the individual's mind without anything out there to be discovered, there is no place for technology materiality to interfere with the process of meaning-making. For instance, the current perspective reveals that taxi drivers may perceive the GPS technology as either explorer or detector (Hou 2008; Hsiao et al. 2008). However, such a perspective neglects the fact that individual perception may refer to the specific material artifact discovered by an individual perceiver. The perception of the GPS system as explorer/detector may refer to the manual/automatic dispatching capabilities discovered by the taxi drivers.

Investigating the discovery aspect of user perception might have major implications for IS research and practice. First, it extends the dominant constructionist approach to user perception of technology to incorporate how some meaning is grasped as it already exists in the environment; it highlights the non-interpretive and more direct aspect of user perception. For instance, it highlights the fact that perceiving GPS technology as explorer of new customers

partly reflects the capability of the manual dispatching feature to choose where to go and which customer to serve. This is part of the meaning already embedded in the GPS system and it takes the cab drivers some experimenting with the tool to discover such meaning. Second, investigating the discovery aspect of user perception facilitates the IS implementation processes by providing insights into which part of user perception could be constructed by technology mediators and which part is directly perceived from the technology itself. For the first part, mediators may focus on sensegiving and training activities, while for the second part they may focus on redesigning the technology features.

Lack of Action Orientation

Individuals' actions have a prominent position in Weick's account of the social psychology of organizing. To him, actions "provide the content for cognitions, and in the absence of action, cognitions are vacuous" (Weick 1969, p. 30). Action is the medium through which users grasp the discovery aspect of meaning, the meaning which is available in the environment. He believed that "too little attention has been paid to actions and too much to cognitions, plans, and beliefs" (Weick 1969, p. 30). Although he attested that action is an essential component of the sensemaking process (Weick 2000), its prominent role has been only marginally appreciated across sensemaking studies, as well as in other areas like IS use research (Barki et al. 2007). Actions are commonly examined in terms of activities and practices. Most technology sensemaking inquiries study how different understandings of technology enact specific practices (Hou 2008; Hsiao et al. 2008). Actions are seen as the product of sensemaking rather than as an antecedent. Although some sensegiving studies do study how the practices of a few sensegivers in an organization influence others' understanding of phenomena (Bansler and Havn 2006; McDaniel Albritton 2010), the question of how the actions of an individual or a group feed and influence the meaning they make has been mostly neglected.

Focusing on the role of users' actions in their sensemaking process will have various implications for IS research and practice. First, it extends the previous point regarding the focus on the discovery aspect of perception by explaining how the more direct part of meaning is actually discovered through user actions. Our understanding of the discovery aspect of user perception will never be complete unless we understand how it is discovered in action. Second, focusing on users' actions facilitates technology sensegiving practices of mediators by providing insights into what type of user actions should be encouraged to ease users' sensemaking of new technology. Moreover, it enlightens system design teams on what type of action should be supported by their design, so it facilitates users' sensemaking and meaning-discovery processes.

An Ecological Approach to Organization-Technology Sensemaking Research

To address the shortcomings of the current research, we propose an ecological approach that goes beyond the socio-cognitive understanding of sensemaking by linking the individual understanding of technology to the technological setting to which the individual adapts. It takes

the meaning out of the black-box of the individual mind and links it to the unique relationship between the individual and the specific technological setting to which he or she adapts.

An Ecological Approach: What and Why?

Ecological psychology augments traditional cognitive psychology with an alternative explanation of human behavior more consistent with Darwin's theory of evolution. The founders of the ecological school believed that the evolutionary theory provided a better understanding of how species adapt themselves to their environment and compete for survival. This adaptive understanding of human behavior required revision of dominant cognitive psychology, which seemed limited in its ability to explain the role that the environment plays in shaping human behavior (Heft 1996).

Gibson (1986) re-examined human perception from an evolutionary theory perspective and came up with the ecological approach to perception that focuses on *interrelatedness* of natural entities as its defining idea. Consistent with evolutionary theory, this approach is mainly concerned with the *adaptive fit* between an individual and the environment. To be ecological, a theory should not only take *adaptation* as its central theme, but also keep its focus on the *environmental conditions* to which the species has adapted; such an environmental focus is both *relational* and *reciprocal* (Heft 1996). An individual's ecological niche comprises those features of the environment that bear a functional relationship to the individual. The ecological approach considers human behavior as purposive goal-directed actions carried out in relation to an individual's niche. Individuals perceive their niche through detection of perceptual information that specifies the functional properties of the environmental features relative to the individual (Heft 1996).

From the ecological point of view, perception is always linked to action, and the intertwinement of the two facilitates the selection and adaptation processes of species in the environment. To explain this intertwinement and provide the link between perception and action, Gibson (1977) coined the notion of "affordance" to refer to the action-related perception of the environment and to establish the foundation for the theory of affordances. For Gibson (1986), an affordance is a possibility for action provided to the individual by its niche, and it is the building block of human perception. From this perspective, what people perceive when looking at their environment is not its substantive qualities and properties, but the action possibilities the environment provides in relation to the individual perceiver. For instance, when taxi drivers look at the extended screen of the GPS system, what they perceive is not the glassy window but the capability to provide the navigation information and obtain the touch input. However, such action possibilities are relational to individuals in the sense that the GPS screen may not mean the same thing to drivers as to passengers.

It is very important to differentiate ecological direct perception from cognitive indirect perception. From the ecological point of view, affordances are not perceived indirectly through cognitive processes, but directly through the information that exists within the environment. In other words, meaning is not invented in the individual's mind, but it is there within the environment and explored directly by the perceiver (Costall 1995; Gibson 1982; Greeno 1994;

Heft 1996; Turvey 1992). Therefore, perception of affordances, in the ecological sense, is different from the cognitive perception that dominates the sensemaking research. However, highlighting the direct aspect of perception does not diminish the role that cognition plays in human perception; rather, it complements it. The direct and indirect ways are two aspects of perception, and cognition starts right after direct perception ends (Michaels et al. 2001). That is, people make inferences and build mental categories and models based on what they initially discover directly about the affordances of their niche. In this article, to lay the groundwork for the ecological approach to sensemaking, we use the terms "perception", "exploration", "discovery", and "learning" of affordances interchangeably to refer to the direct perception of affordances. This is conceptually different from the normal, traditional use of the term "perception" in the cognitive sensemaking and IS literature.

From an ecological point of view, when individuals make sense about a new technology, they perceive the affordances provided to them by the IT artifact and its features. That is, they discover the action possibilities available to them rather than make new meaning cognitively to rationalize the new technology. Individuals' affordance perception is related to the technological niche to which they adapt. Technological niche is the specific combination of the technological resources to which the individuals adapt; it refers to the combination of technology features that the individuals use to accomplish their tasks. Individuals with the same technological niche are considered to be members of the same user species. User species adapt to similar technological resources and perceive the technology affordances in similar ways. Moreover, over time, members of the same species develop some common characteristics and conventions that enable them to optimize their use of the resources available in their niche.

For example, consider the ProjectWeb system used by Jean and Maria as described in the introduction. From an ecological perspective, Jean and Maria could be representatives of two user species that understand and adapt to ProjectWeb in different ways. Members of the user species represented by Jean understand the system as a broadcast medium for one-way communication of information. They probably adapt to those features of the system that allow them to post notes, announcements, and such. Moreover, they may develop and share the know-how for creating shortcuts to such features. In contrast, Maria would represent the user species whose members understand ProjectWeb as a groupware medium that lets them communicate and collaborate on various topics. Accordingly, they would adapt to certain features for two-way communication, file sharing, commenting, and such. In addition, they would develop and share the know-how for setting the notification capability so they would be notified when new messages come in or new files are shared with them; they may even develop higher teamwork skills compared to the other species represented by Jean. Such an ecological understanding of user adaptation to ProjectWeb links the user sensemaking of ProjectWeb (broadcast vs. groupware medium) to their adaptation to certain features of the technology and the characteristics they develop to optimize their use of certain features of the system.

We believe that an ecological approach to human perception has the potential to address the less developed aspects of technology sensemaking and further our understanding of the phenomenon

in multiple ways. First, the ecological view depicts an affordance-based relational human perception, rather than a frame-based cognitive one. Affordance-based human perception accounts for the materiality of technology, but not in terms of its absolute features. Materiality of technology is captured by the technological niche that provides relational affordances. The ecological approach explains various sensemakings and adaptations of the same technology not through cognitive models and different interpretations of technology, but through using multiple affordances provided by their niche (Mansour et al. 2013). In other words, people make different meanings about the same technology partly because they adapt to various niches that provide them with multiple and different affordances. This could offer one answer to the many calls for reviving the role of technology materiality in technology and sensemaking research (Leonardi et al. 2012; Orlikowski 2010; Robey et al. 2013).

Second, the central notion of direct perception appreciates the discovery aspect of perception. While the cognitive approach focuses on the meaning made in an individual mind through developing and maintaining mental models, the proposed ecological approach focuses on the less subjective aspect of the meaning discovered from the existing relationship between the individual and their ecological niche. Such an approach highlights the less examined discovery aspect of sensemaking.

Last, the ecological approach provides an adaptive view of human behavior in which perception and action are always tied to each other. Action and perception feed each other: people perceive while they are acting, and they act on the basis of what they perceive. Perception and action are intertwined in a way that one cannot be studied without considering the other (Michaels 2000). Conceptualizing human perception in terms of affordances, the ecological approach provides an action-oriented view of perception and facilitates examination of the link between action and perception.

Beyond being simply a new approach to considering IT sensemaking, the ecological approach we present here involves a fundamental epistemological shift. In particular, we proceed to explain how the ecological approach is consistent with a critical realist epistemology, in contrast to the structurationalist mindset of most existing sensemaking research.

Shifting from Structuration to Critical Realism

The existing cognitive approach to sensemaking explains well how new technology brings consequences through structuration. It highlights the memory traces and technological practices that are stored and restored in the form of mental models and structures that not only construct future technology use and action, but also are constructed and reconstructed continuously throughout the sensemaking processes. However, the structurational approach is limited in explaining the role of the material artifact (Jones and Karsten 2008; Orlikowski 2005; Orlikowski and Iacono 2001; Rose et al. 2005). The Structurational Model of Technology (Orlikowski 1992) and Adaptive Structuration Theory (DeSanctis and Poole 1994) were among the early efforts to adapt Giddens' Structuration Theory (Giddens 1984) to the study of IT phenomena. However, they both faced many criticisms for deviating from the essence of their

origin because they assumed embedded structure into the IT artifact. From the structurational point of view, structures are emergent, and they are continuously reconstructed through individual practices; therefore, the user has the sole agency (i.e. denying any agency for the IT artifact), and the practices they employ construct emergent structures. As a result, technology is nothing but the product of user practices. Such an approach makes it difficult to capture the role that the material artifact plays in shaping technological consequences.

Due to the insufficient treatment of the material artifact in explaining IT phenomena, there have been numerous calls for alternative approaches to address this shortcoming in IS research. There is a growing literature on the critical realist approach to studying IT phenomena (Collier 1994; Khoo and Robey 2007; Markus and Silver 2008; Mingers 2004; Mingers et al. 2013; Smith 2006). Critical realism can offer a shift from the Giddens' emergent structures to embrace the real structures that are consequential to organizations (Dobson 2001). Markus and Silver (2008) suggested that Adaptive Structuration Theory is more aligned with critical realist thinking than with Giddens' structuration: "the premise of [Adaptive Structuration Theory] that technology can be *a contributing* cause (though rarely, if ever, the sole cause) of patterns of IT use and consequences is much closer to the critical realist position than to those of positivism, interpretivism, or postmodern theories such as Giddens' theory of structuration" (p. 613). Critical realism takes the ontological position that admits the existence of realities independent of human knowledge. Such realities comprise mechanisms and structures with enduring properties (real) that have the potential to produce events (actual), some of which may be observed (empirical), thus providing a three-level ontological stratification of real-actual-empirical (Anderson 2011; Mingers 2004).

The ecological approach supports a critical realistic understanding of the IT phenomenon in various ways. First, the ecological approach is consistent with the three-level stratification of real-actual-empirical provided by critical realism (Volkoff and Strong 2013). The meanings that people explore, that is, the affordances provided to people, are real and exist independently of the individual's perception—this corresponds to the real level. However, the affordances may or may not come to individual attention and perception. People adapt to their specific niche and actualize the related affordances. The individual goals, the range of availability and the amount of effort needed to actualize affordances could influence individual choices for actualizing affordances (Bernhard et al. 2013). The individual's niche is the domain of the actualities. This refers to what critical realism calls the actual level. The real affordances are potentials that may or may not come to the actual level. Moreover, even though many affordances may be unconsciously actualized, an individual may perhaps observe only a subset of the actualized affordances. The empirical level of critical realism refers to subset of actualized affordances that have been observed.

A second way that the ecological approach is consistent with critical realism is its support for the idea of generative mechanisms as the core structures that bring about technological consequences in organizations (Dobson et al. 2013). Generative mechanisms are the real "causal structures that generate observable events" (Henfridsson and Bygstad 2013, p. 911). While cognitively made

meanings from cognitive sensemaking processes do not provide an adequate understanding of these causal structures that produce consequences, the ecological approach provides the affordances that could serve as the building blocks of the generative mechanisms (Volkoff and Strong 2013). Examining various adaptations, niches, species, and configurations of the affordances actualized by each species could reveal the mechanisms that bring about specific results for each species. Next, we follow this discussion with some of the potential implications of the ecological approach.

Potential Implications of the Ecological Approach

The ecological approach provides fruitful insights about the non-cognitive aspect of the sensemaking processes that could feed critical realist inquiries of IT phenomena in organizations. It relates the various understandings of a technology to its technological setting and ecosystem, rather than to variations in interpretations; concepts like affordances, technological niches and user species facilitate this link between perception and the IT artifact. Exploring this relationship through an ecological lens has multiple potential implications for both research and practice, as is discussed in what follows.

Potential Implications for Research

For research, the most prominent contribution of this study is to synthesize the current knowledge about how people come to varied understandings of organization-technology phenomena and to identify the shortcomings in our knowledge. In addition, this study takes the first steps towards providing an alternative approach to address some of those shortcomings. While the current approaches answer the question through the different mental models and knowledge structures that users have in mind about technology and the world (Davidson 2006; Orlikowski and Gash 1994; Vaast 2007; Weick 1990), the ecological approach presented here complements the traditional approaches by highlighting the point that the varied understandings of technology are supported by different aspects of a technology and of an individual. In other words, people come to different understandings through the different relationships they hold with various aspects of the IT artifact. The ecological approach brings the user's understanding of technology out of the black-box of the individual mind and relates it to the IT artifact and to the relationship between the artifact and the user. This is in line with many calls for reviving the role of the IT artifact in organization-technology research (Benbasat and Zmud 2003; Leonardi et al. 2012; Leonardi and Barley 2010; Orlikowski and Iacono 2001).

Action has always been closely related to individual perception (Weick et al. 2005). The dominant cognitive approach for the most part examines one side of this relationship, that is, how perceptions and beliefs influence intention and action, and how individual sensemaking affects user practices. The ecological approach highlights the role that individual action plays in shaping individual understanding of technology. In other words, while the dominant approach focuses on the effects of perception on action, the ecological approach focuses on the effects of

action on the perception of new technology and how action facilitates sensemaking. It looks into the black-box of the "enactment" phase of sensemaking processes by examining the "exploratory behavior" people employ to extract the meaning that is specifically appropriate to them. Since users act upon the IT artifact and the actions need to be supported by the artifact, any insights about the role of action in shaping perceptions could inform the role of the artifact in perception as well.

For IS researchers, the ecological approach provides a framework to better explain IT adoption by depicting the relationship between user, IT artifact, and action. The concepts and theories developed in these fields enable scholars to explore and explain the relationship between these three elements. The technological niche captures the artifact in relation to the user group that is adapted to it. User species identify users in relation to the artifacts they use. Affordance presents the unique capabilities provided to each niche-species group; it shifts the focus from either artifact or user to the relationship between the two. For instance, {self-identifying citation} investigates the adoption of a learning management system by students by examining the relationship between users' sensemaking of the system and their use of system features in action. Such an approach could extend beyond the sensemaking research to explain how user species evolve and transform the technological niche to which they adapt, and provide the trends in adaptive behaviors over time.

Potential Implications for Practice

The suggested ecological approach has important potential implications for two groups of IS practitioners: business managers and technology developers. As described in the previous section, this approach identifies the various *understandings of the technology* in relation to some characteristics of the *users* and the *IT artifact*; it also identifies the *conventions* that users may develop to optimize their use of the available resources. This approach facilitates understanding of how varied sensemaking results in *organizational consequences* (see Table 6).

To explain the practical implications for managers and technology developers, we consider the case of the GPS dispatch system introduced to taxi drivers (Hsiao et al. 2008) discussed earlier. As represented in Table 6, the ecological approach could identify the two user species who adapt to different technological niches as those who understand the GPS system as either "explorer" or "detector". One differentiating aspect of their niche could be the manual/automatic modes of dispatching. While the explorers adapt to the manual mode, the detectors adapt to the automatic mode of dispatching. Moreover, the two species may be differentiated on some personal user characteristics. While explorers are risk-takers, the detectors are less prone to take risks. Furthermore, the members of each user species develop and share specific traits or conventions that could optimize the exploitation of their respective technological niches. In this case, the explorers develop the habit of identifying and sharing the hot-spots to be able to hunt for new customers using the manual mode. Moreover, the detectors could allocate and respect geographical territories for each driver to detect and serve the booked customers.

Table 6. The technology and individual aspects of drivers' understandings of GPS system

Understanding GPS as …	Technological aspect	Individual aspect	Practice conventions developed	Organizational consequence
Detector	Automatic dispatch mode	Risk-averse	Allocating and respecting territories	Retaining existing customers
Explorer	Manual dispatch mode	Risk-taker	Identifying and sharing hot-spots	Attracting new customers

For business managers, such insight about different understandings that drivers have about GPS technology and how they are related to the technology and to individual aspects would be very useful in their sensegiving practices if they need to promote specific understandings and demote others. If the company focuses on attracting new customers, then it prefers explorer drivers; thus, it would promote the manual mode, employ risk-taking drivers and facilitate sharing the explorer conventions. If the company prefers a portfolio of both explorers and detectors, it would promote the manual mode of the GPS system to risk-takers and the automatic mode to conservative drivers. However, the technological niche of the explorers and the detectors could include more than the single aspect of manual/automatic dispatch mode. Such an ecological understanding of user species and their technological and individual aspects helps managers in pursuing their strategic goals.

For technology developers, the ecological approach could provide insights for improving the design of current technologies. Realizing which aspects of the IT artifact support the specific understandings of a technology would enable technology developers to design the technology in a coherent way that better supports those understandings. For instance, the technological niche to which the explorer drivers adapt may include various dimensions including the manual dispatching mode and customer profile browser. Having such knowledge, the designers may decide to incorporate the profile browser feature as highly visible and accessible in the manual mode, while it might be less visible and hence less distracting in the automatic mode. In addition, since explorers need multi-tasking abilities, designers could ease multi-tasking by enlarging the text and the map on the screen, or adding text-to-speech capabilities or speech recognition to allow the drivers to talk with the GPS system. The availability of such capabilities would be more visible and accessible on the manual mode. Moreover, the designers could improve the GPS system by facilitating and supporting the conventions that the explorers have already developed; they could facilitate marking and sharing the hot-spots under the manual mode. These are examples of the kind of insights that the current cognitive approach to sensemaking has been ill-suited to provide.

Conclusion

This article presents a critical review that synthesizes the current research on organization-technology sensemaking. Although not a "systematic literature review", it did follow a systematic process as described in the appendix. It identifies three major shortcomings in the existing literature: lacking technology materiality, neglecting the discovery aspect of perception, and lacking action orientation. This article lays the groundwork for an alternative approach based on ecological tenets consistent with a critical realist perspective.

The suggested ecological approach is aimed at reviving the role of the IT artifact in explaining how people understand technologies in organizations. We review the literature on technology-organization sensemaking and identify four major streams in organizational sensemaking research that treat sensemaking and sensegiving at the individual and collective levels. Figure 2 and Figure 3 represent the resources and practices on which individuals and collectives draw for sensemaking and sensegiving. We also review the social and cognitive processes of sensemaking of technology (Table 5). While the dominant approach to sensemaking research sheds light on many social and cognitive aspects of the sensemaking phenomenon, it rarely pays attention to the role that the material artifact may play in shaping various understandings of the technology-organization phenomenon.

To account for the missing role of the IT artifact in technology sensemaking research, the ecological approach we present here draws on concepts and theories from ecology and ecological psychology. Ecology examines how living organisms interact with and adapt to their environments. Ecological psychology investigates the role of ecology in human perception and behavior. The theory of affordances and ecological niche theory provide insights and conceptual tools to examine how individual understanding of technology is related to individuals and to the IT artifact. According to the ecological approach, user understanding of technology is both functional and relational. It refers to action possibilities which are not necessarily equally provided to everyone; the availability of such action possibilities, called affordances, is dependent on certain characteristics of the individual. Moreover, these affordance understandings are explored through individual actions rather than made cognitively within the individual mind. It suggests that there are specific types of activities on which users draw to explore the affordances and understand the new technology. Furthermore, a user's understanding of a technology is related to the technological niche to which they adapt. The user species comprises the users who adapt to the same niche. The concepts of technological niche and user species lend themselves well to examining the relation between users and the IT artifact.

The present study has a few limitations. First, the ecological approach needs concrete conceptual and methodological tools before it can provide fruitful empirical insights. Further research is needed to elaborate and develop the ecological ideas to a full-featured theoretical framework with its related methodology. Second, no matter what the methodology is, any ecological inquiry would need diverse data that measure various aspects of users, technology and their interaction.

So, the researchers would need to evaluate the feasibility of an ecological study before choosing to do one.

Consistent with the core tenets of critical realism, the ecological approach contributes to organization-technology research by shifting the focus from the memory traces of emergent IT structures to the existing mechanisms within the user-technology ecosystem. It supports critical realist technology research because it identifies the affordances (realities) providing the mechanisms that have the potential to trigger and conduct actions and events (actual) that may be observed (empirical). Finally, the ecological approach has important potential implications for both research and practice that make it valuable for advancing current knowledge about technology sensemaking.

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Appendix: Literature Review Procedure

Here we explain the literature review process in detail. This article presents a "critical review" (Paré et al. 2015), whose goal is "to critically analyze the extant literature on a broad topic to reveal weaknesses, contradictions, controversies, or inconsistencies" (p. 189). Since there is no methodology guide that specifically describes how to conduct this kind of literature review, we followed the general approach of. As we indicate in Table A1, the main difference between our procedure and that which Okoli (2015) recommended is that, consistent with the observation of Paré et al (2015, p. 189) that "critical reviews … rarely assess the quality of the studies selected", we did not conduct any quality appraisal, which is not appropriate for a review like ours that critically assesses the body of literature, rather than trying to test the validity of results. Indeed, although our methodology is not a "systematic literature review" in the sense that Okoli (2015) describes, we are nonetheless "systematic" and "transparent" (Paré et al. 2016) in executing a "critical review" (Paré et al. 2015). We summarize our methodological procedure in Table A1 and explain it detail as follows.

Table A1. The steps followed in our literature review procedure

Step	Description by Okoli 2015	Our implementation
1. Identify the purpose	Clearly identify the review's purpose and intended goals.	We iteratively refined and eventually focused on clear purposes for the review.
2. Draft protocol and train the team	Prepare a written document that describes the review procedure and train reviewers accordingly.	We used evolutionary drafts of the literature review manuscript as a protocol. The two reviewers regularly met to discuss and refine the procedure.
3. Apply practical screen	Explicitly determine which kinds of studies to be considered for review and which should not.	We clearly identified the types of articles to search for, the databases in which to search, and the scope of topics to include.
4. Search for literature	Describe the details of the literature search and explain how a comprehensive search was assured.	We employed keyword searches of electronic databases until June 2016 and backward citation searches of identified articles.
5. Extract data	Systematically extract the applicable information from each study.	We extracted themes as part of our thematic content analysis synthesis approach. We also extracted literature domains and bibliographic details.
6. Appraise quality	Explain the criteria they use to judge which papers will be excluded for insufficient quality.	We did not carry out any quality appraisal.
7. Synthesize studies	Combine the facts extracted from the studies.	We employed thematic content analysis in conjunction with our data extraction.

8. Write the review	Write the research article and report the literature review process in detail.	We structured the written article mainly along the lines of the identified purpose of the review.

1. Identify the Purpose

We note that, as indicated by Okoli (2015), the process of determining and refining the purpose of the review was iterative, especially after the elaboration of the research protocol. Eventually, the clear and focused purpose that we settled on was to review the literature on IT sensemaking and on the larger context of organizational sensemaking; identify shortcomings in the existing literature; and propose resolutions that might potentially extend the literature.

2. Draft Protocol and Train the Team

Both authors developed the general protocol for the review. We used evolutionary drafts of the literature review manuscript as a protocol. The two reviewers regularly met to discuss and refine the procedure. In particular, we determined that the lead author would conduct the literature searches, read every article in the review, and classify the studies, with regular discussion and feedback from the second author and evaluation of a sample of the articles. We recognize that without the second author actually reviewing every article as well, there was the possibility of the lead author making some unverified errors; unfortunately, our resource constraints did not permit otherwise. However, both authors would work together on the synthesis of the articles and on writing the review report.

3. Apply Practical Screen and 4. Search for Literature

Since the practical screen and literature search are executed simultaneously, we describe them together in this section. We mainly looked for peer-reviewed journal publications that address any aspect of the sensemaking phenomenon in the context of organizations or IT; this search included studies that examine the antecedents, the processes, or the consequences of individual or group sensemaking of organizational or IT phenomena. We focused mainly on journal articles because in our relevant academic disciplines of information systems, management and sociology, journal articles are the standard terminal publication, that is, where the finalized and most refined version of articles are published. That said, we did include some conference articles and books that we identified by backward citation searches. Although a systematic review normally insists on being strict with the type of publication included, a critical review is more flexible in this regard (Paré et al. 2015). In short, our review focused on journal articles, but we did not hesitate to include other types of publications that we discovered were also relevant.

We excluded studies as irrelevant if a) sensemaking was only a peripheral topic to the study rather than a major one; or b) if sensemaking was studied in a context other than organizations or IT. To identify the relevant literature, we first searched in 2014, but we repeated our search to catch newly-published literature up until June 2016; we searched for all existing articles

published until that date. We searched for peer-reviewed journal publications in EBSCO Host and all its composite databases; this contains the vast majority of high-quality journals in information systems, management and sociology. We specifically searched for any of the words "sensemaking", "sense making", "sense-making", "sensegiving", "sense giving", or "sense-giving" plus the term "information technology" in the title, abstract, or keywords. Unfortunately, however, we did not search for synonyms of "information technology". This search resulted in 107 items, of which 75 were unique. To identify the relevant studies, we read the title and the abstract and skimmed the full text if needed. We thus identified 34 relevant articles (Table A2). In addition, to make sure that we did not exclude relevant articles that did not happen to mention "information technology", we searched for peer-reviewed journal publications in the repositories of the Academy of Management Publications and the Association for Information Systems Electronic Library plus the *Information Systems Research* journal from 2004, which included more than a decade of recent studies. Since these journals specifically focus on management or information systems, we used only the search term "sensemaking" and then manually screened out unsuitable articles when reading the abstracts. We thus identified another 20 relevant articles (Table A2).

Next, we did backward citation searches looking for the studies cited in the included publications. As we read the literature, studies cited in multiple articles or that were influential in shaping any of the emerging streams of research were also added, including some important conference articles and book chapters. These citation searches identified 47 more relevant studies (Table A2). In all, we identified and reviewed 101 unique peer-reviewed publications relevant to the sensemaking phenomenon in organizational and IT contexts. Table A2 lists the studies included from each electronic database with the number of studies incrementally added.

Table A2. Studies included through various searches

Search	Study included	Outlet	Domain IS or Organization studies (ORG)
EBSCO Libraries (34 studies)	Bean, C. J., & Eisenberg, E. M. (2006)	Journal of Organizational Change Management	ORG
	Bird, S. (2007)	Journal of Business Communication	ORG
	Campagnolo, G. M., Pollock, N., & Williams, R. (2015)	Information and Organization	IS
	Ellway, B. P. W., & Walsham, G. (2015)	Information Systems Journal	IS
	Gäre, K., & Melin, U. (2013)	Information Systems & E-Business Management	IS
	Gasson, S. (2005)	Journal of Computer-Mediated Communication	ORG

	Gersh, J., Lewis, B., Montemayor, J., Piatko, C., & Turner, R. (2006)	Communications of the ACM	IS
	Hartnett, E. J., Daniel, E. M., & Holti, R. (2012)	International Journal of Information Management	ORG
	Henfridsson, O. (2000)	Information Systems Journal	IS
	Im, G., & Rai, A. (2014)	Information Systems Research	IS
	Jacobs, C. D., Steyaert, C., & Überbacher, F. (2013)	Technology Analysis & Strategic Management	IS
	Jang, J., Dworkin, J., & Hessel, H. (2015)	Cyberpsychology, Behavior, and Social Networking	IS
	Karsten, H., & Laine, A. (2007)	International Journal of Medical Informatics	IS
	Landgren, J. (2005)	International Journal of Emergency Management	IS
	Lewis, M. O., Mathiassen, L., & Rai, A. (2011)	European Journal of Information Systems	ORG
	Olesen, K. (2014)	Information Systems Journal	IS
	Onook Oh, Chanyoung Eom, & Rao, H. R. (2015)	Information Systems Research	IS
	Ovaska, P., & Stapleton, L. (2010)	Journal of Information Technology Case & Application Research	ORG
	Pentland, B. T. (1999)	Academy of Management Review	ORG
	Petkova, A. P., Rindova, V. P., & Gupta, A. K. (2013)	Organization Science	ORG
	Pirolli, P., & Russell, D. M. (2011)	Human–Computer Interaction	IS
	Ravishankar, M. n., & Pan, S. L. (2013)	International Journal of Information Management	ORG
	Reyes, V. C. J., & Kheng, C. C. S. (2015)	International Journal of Information and Communication Technology Education	ORG
	Rose, J., & Kræmmergaard, P. (2006)	International Journal of Accounting Information Systems	IS
	Shoib, G., & Nandhakumar, J. (2003)	Information Technology for Development	IS
	Su, N. (2015)	MIS Quarterly	ORG
	Tallon, P. P. (2014)	European Journal of Information Systems	IS
	Tallon, P. P., & Kraemer, K. L. (2007)	Journal of Management Information Systems	IS
	van Oorschot, I. (2014)	Symbolic Interaction	IS
	Weaver, C. K., Zorn, T., & Richardson, M. (2010)	Communication and Society	ORG

	Wu, A., Convertino, G., Ganoe, C., Carroll, J. M., & Zhang, X. (Luke). (2013)	International Journal of Human-Computer Studies	IS
	Yu Tong, Swee-Lin Tan, S., & Hock-Hai Teo. (2015)	Information Systems Research	IS
	Mishra, A. N., & Agarwal, R. (2010)	Information Systems Research	IS
	Thomas, J. B., Sussman, S. W., & Henderson, J. C. (2001)	Organization Science	ORG
AIS Electronic Library (6 more studies)	Baker, J., Jones, D. R., & Burkman, J. (2009)	Journal of the Association for Information Systems	IS
	Berente, N., Hansen, S., Pike, J., & Bateman, P. (2011)	MIS Quarterly	IS
	Jensen, T. B., & Kjærgaard, A. (2010)	Scandinavian Journal of Information Systems	IS
	Kjærgaard, A., Nielsen, P. A., & Kautz, K. (2010)	Scandinavian Journal of Information Systems	ORG
	Seidel, S., Recker, J., & vom Brocke, J. (2013)	MIS Quarterly	IS
	Svejvig, P., & Jensen, T. B. (2013)	Scandinavian Journal of Information Systems	IS
Academy of Management Repository (14 more studies)	Balogun, J., & Johnson, G. (2004)	Academy of Management Journal	ORG
	Basu, K., & Palazzo, G. (2008)	Academy of Management Review	ORG
	Bundy, J., & Pfarrer, M. D. (2015)	Academy of Management Review	ORG
	Drazin, R., Glynn, M. A., & Kazanjian, R. K. (1999)	Academy of Management Review	ORG
	Fiss, P. C., & Zajac, E. J. (2006)	Academy of Management Journal	ORG
	Grant, A. M., Dutton, J. E., & Rosso, B. D. (2008)	Academy of Management Journal	ORG
	Hahn, T., Preuss, L., Pinkse, J., & Figge, F. (2014)	Academy of Management Review	ORG
	Lockett, A., Currie, G., Finn, R., Martin, G., & Waring, J. (2013)	Academy of Management Journal	ORG
	Lüscher, L. S., & Lewis, M. W. (2008)	Academy of Management Journal	ORG
	Maitlis, Sally. (2005)	Academy of Management Journal	ORG
	Maitlis, Sally, & Lawrence, T. B. (2007)	Academy of Management Journal	ORG
	Sonenshein, S. (2007)	Academy of Management Review	ORG
	Songqi Liu, Mo Wang, Bamberger, P., Junqi Shi, & Bacharach, S. B. (2015)	Academy of Management Journal	ORG
	Stigliani, I., & Ravasi, D. (2012)	Academy of Management Journal	ORG

Backward Citations Search (47 more studies)	Azad, B., & Faraj, S. (2008)	Journal of Strategic Information Systems	IS
	Bansler, J. P., & Havn, E. (2006)	Computer Supported Cooperative Work	IS
	Bartunek, J., Krim, R., Necochea, R., & Humphries, M. (1999)	Book	ORG
	Boland, R. J. (1984)	Management Science	ORG
	Brown, A. D. (2000)	Journal of Management Studies	ORG
	Brown, A. D., Stacey, P., & Nandhakumar, J. (2008)	Human Relations	ORG
	Butcher, K. R., & Sumner, T. (2011)	Human–Computer Interaction	ORG
	Davidson, E. (2006)	The Journal of Applied Behavioral Science	IS
	Dunford, R., & Jones, D. (2000)	Human Relations	ORG
	Dutton, J. E., Ashford, S. J., Lawrence, K. A., & Miner-Rubino, K. (2002)	Organization Science	ORG
	Gephart, R. P. (1993)	Academy of Management Journal	ORG
	Gephart, R. P. (2004)	American Behavioral Scientist	IS
	Gioia, D. A., & Chittipeddi, K. (1991)	Strategic Management Journal	ORG
	Gioia, D. A., & Mehra, A. (1996)	Academy of Management Review	ORG
	Gioia, D. A., & Thomas, J. B. (1996)	Administrative Science Quarterly	ORG
	Gioia, D. A., Thomas, J. B., Clark, S. M., & Chittipeddi, K. (1994)	Organization Science	ORG
	Griffith, T. L. (1999)	Academy of Management Review	IS
	Harris, S. G. (1994)	Organization Science	ORG
	Helms-Mills, J. (2002)	Book	ORG
	Hill, R. C., & Levenhagen, M. (1995)	Journal of Management	ORG
	Hou, S.-T. (2008)	Conference Proceeding	IS
	Hsiao, R.-L., Wu, S.-H., & Hou, S.-T. (2008)	Information and Organization	IS
	Ibarra, H., & Andrews, S. B. (1993)	Administrative Science Quarterly	ORG
	Louis, M. R. (1980)	Administrative Science Quarterly	ORG
	Maitlis, S. (2004)	Organization Studies	ORG
	March, J. G. (1996)	Administrative Science Quarterly	ORG
	McDaniel Albritton, W. (2010)	Conference Proceeding	IS
	Mumby, D. K. (1987)	Communication Monographs	ORG
	Okamura, K., Fujimoto, M., Orlikowski, W. J., & Yates, J. (1995)	The Information Society	IS
	Orlikowski, W. J., & Gash, D. C. (1994)	ACM Transactions on Information Systems	IS
	Prasad, P. (1993)	Academy of Management Journal	IS

	Rouleau, L. (2005)	Journal of Management Studies	ORG
	Siino, R. M., & Hinds, P. J. (2005)	Conference Proceeding	IS
	Sneddon, J. N., Soutar, G. N., & Mazzarol, T. (2009)	Experimental Agriculture	IS
	Snell, R. S. (2002)	Organization Studies	ORG
	Vaast, E. (2007)	Journal of Strategic Information Systems	IS
	Vaast, E., & Walsham, G. (2005)	Information and Organization	IS
	Wahlström, M., Salovaara, A., Salo, L., & Oulasvirta, A. (2011)	Human–Computer Interaction	ORG
	Weick, K. E. (1969)	Book	ORG
	Weick, K. E. (1979)	Book	ORG
	Weick, K. E. (1988)	Journal of Management Studies	ORG
	Weick, K. E. (1990)	Book	IS
	Weick, K. E. (1995)	Book	ORG
	Weick, K. E. (2000)	Book	ORG
	Weick, K. E., & Roberts, K. H. (1993)	Administrative Science Quarterly	ORG
	Weick, K. E., Sutcliffe, K. M., & Obstfeld, D. (2005)	Organization Science	ORG
	Zamani, E., Giaglis, G., & Pouloudi, N. (2013)	Conference Proceeding	IS

5. Extract Data and 7. Synthesize Studies

We synthesized the identified research by employing a thematic content analysis, consistent with critical reviews (Paré et al. 2015). Since the content analysis determined the themes that we eventually extracted from the identified studies, the data extraction and synthesis steps of the review were interwoven iteratively and cannot be separated for this particular synthesis approach. We also note that we did not carry out any quality appraisal, since this step is "not essential" (Paré et al. 2015, p. 186).

Table A2 lists the domain area of each study, either organization (ORG) or information systems (IS). We identified the domain area based on the focus of the study; while IS studies focus on sensemaking about information systems in organizational settings, the ORG studies focus on sensemaking about any organizational phenomenon, such as changes in practices or strategies. Figure A1 displays the distribution of the publication years of the included studies. Figure A2 presents the distribution of the studies across IS and organization domains. Figure A3 depicts the distribution of the included studies across scholarly outlets.

Figure A1: Distribution of studies across years

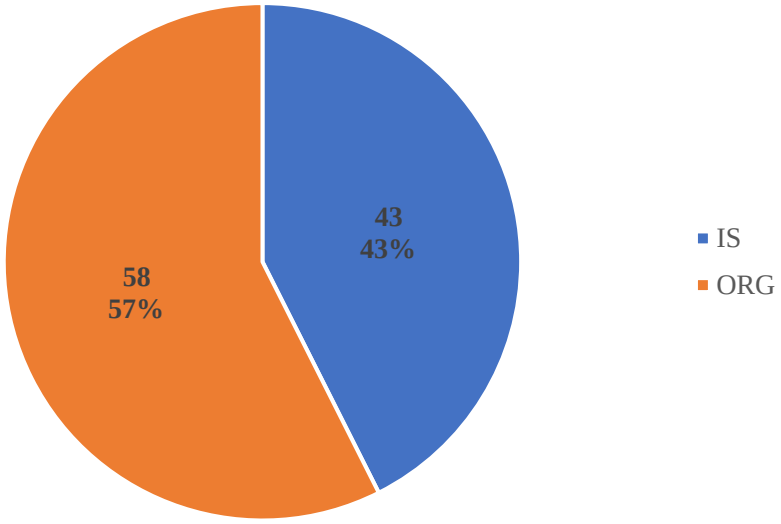

Figure A2: Distribution of studies across IS or Organization (ORG) domains

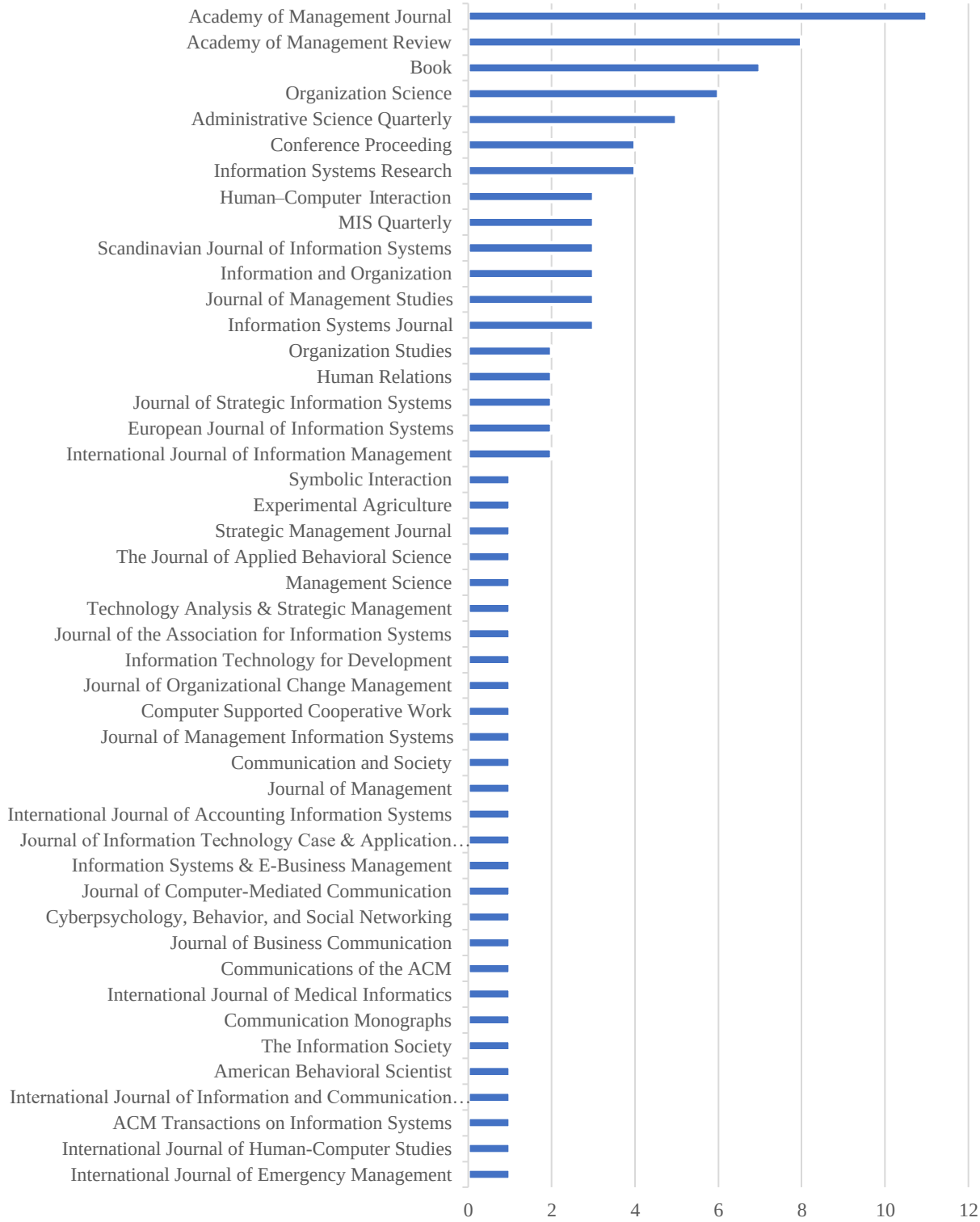

Figure A3. Distribution of studies across various outlets

To carry out our thematic content analysis, the lead author read each identified publication, took notes about the focus and contribution of each study, and identified common thematic categories across studies. In the first round of analysis, he initially categorized each article as treating sensemaking, sensegiving, or both. In the second round of reading, the lead author further categorized each article as related to the individual, collective, or both. In the third round, the second author reviewed and validated the categorizations, with some revisions and reclassifications. We iteratively read and refined the categories until some clear themes emerged (see Figure A4). We summarize our synthesized classification of articles in Table 1 and Table 4 of the main article.

Figure A4. The literature synthesis approach using thematic content analysis

In carrying out this synthesis iteratively with much discussion between the authors, based on our prior knowledge and our global view of literature that we reviewed, we were eventually able to crystallize the three major shortcomings of the literature that we present in the discussion. Furthermore, with our prior and concurrent knowledge, after much consideration and refinement, we were able to develop and elaborate the ecological approach that we present as a possible resolution to these shortcomings.

8. Write the Review

In writing the final review article, we generally followed the sequence of the purpose of our review to structure the article. The organizational and technology sensemaking sections of this review article are organized around the major streams that emerged during the in-depth study of the relevant research. In the discussion, we then present the shortcomings in the existing literature that we identified; and then we propose resolutions that might potentially extend the literature.