The Role of Writing in Distributed Collaboration

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Distributed collaborations face significant dialogical challenges: sharing knowledge, questioning ideas, and developing new solutions. These challenges are often associated with collaborations' reliance on written communication such as emails and documents, which are not seen as conducive to the rich dialogues necessary for effective collaboration. However, numerous successful distributed collaborations exist despite their sometimes exclusive reliance on written communication. Based on a qualitative study of distributed collaboration in two contexts—an organization effectively coordinating work across two continents and a pair of scientists working together to develop a new theory—we examine how writing supports dialogue, and thus collaboration, among distant partners. Our analysis of the correspondences exchanged in these two historical distributed collaborations identifies four mechanisms of writing—objectifying, contextualizing, specifying, and reflecting—and shows how they support dialogue and so address the dialogical challenges involved in distributed collaboration. These findings are particularly relevant in our era of technology-mediated communication where even collaborations in colocated settings rely extensively on written communication. Our findings advance our understanding of fundamental aspects of distributed collaboration and propose to rethink the value of written communication in enacting dialogue and supporting collaboration at a distance.

Keywords: written communication; distributed collaboration; knowledge development; dialogical challenges; qualitative methods; historical perspective
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Introduction

Distributed collaboration is of increasing importance for individuals, teams, and organizations. Employees and managers are constantly seeking to understand how to better meet its challenges. Studies of distributed collaboration have emphasized the challenges experienced by distributed collaborators, especially in relation to knowledge sharing (Szulanski 1996, Cramton 2001, Orlikowski 2002, Faraj and Xiao 2006), critical inquiry of others (Levina 2005, Faraj and Xiao 2006), and development of synergistic solutions, i.e., solutions combining differences among collaborators (Hardy et al. 2005, Levina 2005, Faraj and Xiao 2006). These challenges—knowledge sharing, the questioning of ideas, and the synergistic development of solutions—are dialogical because they require collaborators to engage in a sequence of iterative and mutually influencing exchanges to fulfill a common goal (Tsoukas 2009). Such dialogues are central to addressing the challenges of collaboration and of supporting coordination and knowledge creation in colocated (Bechky 2003, Faraj and Xiao 2006, Tsoukas 2009) and distributed contexts (Kiesler and Cummings 2002, Kraut et al. 2002, Orlikowski 2002, Wilson et al. 2008). Hence, when dialogue is absent, distributed collaboration cannot take place. For example, Metiu (2006) showed how software developers distributed between the United States and India ignored the needs and documents of their faraway coworkers, failing to provide sufficient details about their work and context while communicating across sites. This lack of engagement in mutual exchanges led to difficulties in developing a successful product.

Dialogue can occur in oral, face-to-face, and written communication (e.g., letters, emails, memos) (Hardy et al. 2005). However, most studies of distributed collaboration implicitly or explicitly assume that only face-to-face communication—because it is synchronous and allows for quick iterations—can support the dialogic exchanges necessary for effective collaboration (Kiesler and Cummings 2002, Kraut et al. 2002, Olson et al. 2002). This assumption warrants close examination since an immense amount of distributed work relies on written communication. Thus, numerous successful distributed collaborations rely primarily on written communication: information sharing and know-how in online communities (Fayard and DeSanctis 2008, Faraj et al. 2011), the development of technical innovations (Malhotra et al. 2001, Orlikowski 2002), and open source software projects (Kogut and Metiu 2001, O'Mahony and Ferraro 2007). Many of the new communication technologies (e.g., email, chat) are based on writing, and many of us spend a lot of our time writing emails to distant colleagues, clients, and suppliers to solve problems and develop papers and theories (Byron 2008). Some scholars have acknowledged and examined the role of written communication in creating shared

understandings among faraway individuals and groups and in the management of complex distributed organizations (Weber 1968, Yates 1989a, King and Frost 2002, O'Leary et al. 2002). Subsequent studies, which tend to emphasize the recording function of writing, have not gleaned insights from these in-depth studies of complex distributed collaborations, ignoring the way writing meets the dialogical challenges in distributed work (Kiesler and Cummings 2002, Kraut et al. 2002, Olson et al. 2002). As a result, we do not know enough about *how* written communication supports distributed collaboration.

Inspired by the work of literacy scholars who emphasized the role of writing in knowledge creation in historical contexts (Havelock 1963, Ong 1982, Goody 1987), we provide here an explanation of how written communication addresses the dialogical challenges of distributed collaboration. We define writing as the act of expressing ideas and thoughts and representing them in a medium that can be shared—be it paper, computer screen, papyrus, or clay tablet (Martin 1995). We focus on how writing in the context of ongoing exchanges such as letters or emails allows dialogue and collaboration.

By examining two distributed collaborations relying almost exclusively on written communication—an organization that sought coordination among different sites and actors and a scientific collaboration seeking a new theory in physics—we show how written dialogues support distributed collaboration. More specifically, we identify the writing mechanisms that address the dialogical challenges (knowledge sharing, the questioning of ideas, and the synergistic development of solutions) faced by distant collaborators. Identifying four writing mechanisms—objectifying, contextualizing, specifying, and reflecting—and how they support distributed collaboration is the core contribution of this paper. Our findings advance our understanding of fundamental aspects of distributed collaboration and propose to rethink the value of written communication in enacting dialogue and supporting collaboration at a distance.

The rest of this paper is structured as follows: In the next section, we review the literature on the role of written and oral communication in distributed collaboration. We also present an overview of work that shows how writing can support dialogical processes, albeit not in an organizational context. Second, we describe our research settings, historical correspondences between distributed collaborators, and our qualitative approach. Third, we present findings about the role of the four writing mechanisms that emerged from our analysis of two distributed collaborations. Last, we discuss the implications of our findings.

Distributed Collaboration and Written Communication

Distributed collaborations are ubiquitous, especially with the increasingly dispersed nature of organizations (DeSanctis and Monge 1999, Gibson and Gibbs 2006) and the emergence of new forms of collaborations outside and across organizations (Lakhani and von Hippel 2003, von Hippel and von Krogh 2003). Empirical studies have highlighted key challenges faced by distributed collaborators: *knowledge sharing*, i.e., sharing best practices and contextual knowledge to build common ground and support coordination (Szulanski 1996, Cramton 2001, Orlikowski 2002, Faraj and Xiao 2006); *challenging ideas*, i.e., the ability to reflect on collaborators' knowledge and practices and to investigate or even contest their meaning or use (Levina 2005, Faraj and Xiao 2006); and *developing synergistic solutions*, i.e., the production, through joint sensemaking across the perspectives of different collaborators, of a new practice or solution to address a problem (Hardy et al. 2005, Levina 2005, Faraj and Xiao 2006).

These challenges are dialogical in nature; they require ongoing and mutually influencing exchanges among distributed collaborators. As research has shown, such dialogues are facilitated by factors such as trust (Jarvenpaa and Leidner 1999, O'Leary et al. 2002), shared identity (Wiesenfeld et al. 1999, Hinds and Mortensen 2005), managing status and power differentials (Metiu 2006, Levina and Vaast 2008), structured management (Moon and Sproull 2002), and the basic geographic configuration of distributed teams (O'Leary and Mortensen 2010). Research also tends to assume that such dialogues require face-to-face communication (Orlikowski 2002, Faraj and Xiao 2006, Tsoukas 2009). As Tsoukas (2009) stated, "Dialogue is a joint activity between at least two speech partners, in which a turn-taking sequence of verbal messages is exchanged between them, aiming to fulfill a collective goal" (p. 943). This view that face-to-face communication facilitates the clarification of misunderstandings, the creation of common language(s), and the production of new understandings (Tsoukas 2009) is echoed throughout the literature on distributed collaboration (Kiesler and Cummings 2002, Kraut et al. 2002, Olson et al. 2002).

In contrast, writing (in the form of writing-based media) has been seen as less conducive to the deep exchanges and dialogues that support collaboration because it is fixed (it records and appears to "freeze" ideas) and asynchronous (Daft and Lengel 1984, 1986; Olson et al. 2002; Gibson and Gibbs 2006). Rarer still are studies that hold that written communication, such as email, can be effective in distributed collaboration (Orlikowski and Yates 1994; Walther 1995, 1996; Cummings et al. 1996). The consensus seems to be that writing is particularly suited for the recording of information but less likely to enable nuanced, meaningful exchanges among distant partners (Kiesler and Cummings 2002, Olson et al. 2002).

However, given the nature of distributed work, such dialogues often (and sometimes exclusively) happen in writing as opposed to face-to-face encounters. Historically,

most distributed collaborations took place through writing, especially correspondences. For instance, writing was critical to the collaboration of members of the Roman Catholic Church because it allowed meaning to be fixed and transferred across different parts of what may be described as the first global service enterprise (King and Frost 2002). Also, important scientific knowledge was developed through intense exchanges of letters among members of distributed scientific communities, such as the Republic of Letters (Collins 1998). Thus, members of the Republic of Letters rarely met in person; instead, they exchanged ideas and developed theories via correspondences that revolutionized the epoch's worldview and shaped our current world (Crane 1972, Bazerman 1988, Collins 1998).

Also, studies have documented that complex and creative knowledge is developed in contemporary distributed, computer-mediated settings (Cummings et al. 1996, Malhotra et al. 2001); that knowledge sharing can be nurtured through computer-based information systems (Finholt et al. 2002); and that rich information can be shared via email (Markus 1994, Ngwenyama and Lee 1997). The open source software and cognitive science communities are great examples of how computer-mediated communication can support idea production and collaboration, as well as the complex social process of choosing leaders (Kogut and Metiu 2001, Schunn et al. 2002, O'Mahony and Ferraro 2007). These instances show that writing can support the type of meaningful and intimate exchanges usually ascribed to face-to-face dialogue as well as enable complex distributed collaboration even when collaborators rely heavily on written communication.

Yet despite examples of past and contemporary distributed collaborations that were enacted mostly through writing, our understanding of the role of writing in enabling such collaborations is still limited. Organizational scholarship, when examining the role of writing in distributed collaboration, tends to refer to writing as a recording tool and to prioritize face-to-face communication. Thus, scholars have shown that genres of written communication such as the report, letter, and memo play a focal role in the evolution of organizations because each is traceable and supportive of knowledge sharing in complex, often distributed operations (Yates 1989a, b). Furthermore, writing's traceability allows meaning to be fixed across space, enabling members of an organization or a community to share information and ideas and to refer to them without having to endlessly frame the messages (King and Frost 2002, O'Leary et al. 2002).

At the same time, writing's traceability or fixedness, together with its asynchronicity, has been viewed as antithetical to dialogue and collaboration. The meaning captured in written traces are considered pale versions of the rich and complex nuances of utterance (Short

et al. 1976; Daft and Lengel 1984, 1986), whereas asynchronicity has become synonymous with sluggish input, a problematic association because feedback is seen as essential to collaboration (Daft and Lengel 1984, 1986; Kraut et al. 1988; Olson et al. 2002). Even scholars willing to entertain the notion that writing can support dialogue note that the medium in which writing is instantiated (e.g., documents, emails, chat) is less conducive than face-to-face communication for solving problems, creating common ground, or maintaining awareness of long-distance coworkers (Kiesler and Cummings 2002, Kraut et al. 2002, Olson et al. 2002).

Insisting on face-to-face communication for dialogue and distributed collaboration stems partly from the importance of tacit, noncodified knowledge in organizations (Kogut and Zander 1992, Nonaka 1994, Tsoukas 1996). For instance, studies of the Hudson's Bay Company, while acknowledging the importance of written correspondence for knowledge sharing within the organization, stress how employees' visits via canoe on the Hudson River were germane for controlling operations and developing trust among a vastly dispersed organization (O'Leary et al. 2002). Also, studies of modern distributed work point out the importance of informal face-to-face interactions in sharing best practices, establishing common ground, and building trust (Allen 1977, Olson et al. 2002, Fayard and Weeks 2007).

Yet interactions around the watercooler take up just a tiny fraction of daily work life. People increasingly work alone, communicate in writing, and meet rarely, if ever. Email and constant written exchanges are the norm even in colocated collaborations and brainstorming sessions, where taking notes and producing documents to capture and further refine ideas is essential (Sutton and Hargadon 1996, Baron 2008, Byron 2008). In short, the increased reliance on writing in distributed collaboration, along with the lack of specific attention to the ways in which writing supports dialogue among distributed collaborators, prompts questions: How does writing address the dialogical challenges posed by distributed work? How does written communication support distributed collaboration?

To address these queries, we examine the mechanisms in written communication that generate productive dialogue among distant collaborators. Our approach is informed by literature beyond the management and organization theory fields, which recognize the role of writing in knowledge creation and the development of literate societies. Literacy scholars, historians of science, sociologists of knowledge, and psychologists have shown that written language is important for the development of new knowledge (often among distributed correspondents; see Havelock 1963, Olson 1977, Goody 1987, Bazerman 1988, Collins 1998, Wolf 2008) and suggest that writing has specific characteristics that support productive dialogue (Ong 1982). These scholars argue that writing's fixedness and its asynchronicity are liberating: without the burden of memorization

that an oral tradition required, people could engage more freely in analysis and so further develop knowledge. More specifically, psychologists such as Vygotsky (1962) and, more recently Wolf (2008), claimed that written language has a "dialogic capacity" (Wolf 2008, p. 73) because it forces us to articulate our thoughts for ourselves and others. Such scholars emphasized the importance and value of written communication in knowledge creation, essentially as a result of the dialogic capacity of writing. However, they focused on human cognitive capabilities and the impact of writing at the societal level. We build on their work to look at writing as a communicative process between various individuals and small groups of people working to achieve a common goal.

Thus, in this paper, we focus on the mechanisms through which writing enables a dialogue among distant collaborators working toward a shared goal. Our findings bring to light the objectifying mechanism through which we articulate ideas for ourselves and others, the result being a written document. This articulation is an ongoing process in which documents are never "finished," and knowledge is shared and developed. Also, we examine contextualizing (adapting to the needs of the reader), specifying (providing details and nuances), and reflecting (engaging in deep understanding), the three other mechanisms to emerge from our analyses of two correspondences. Before presenting our findings in detail, we describe our methods.

Research Setting and Methods

Our interest in writing's role in supporting distributed collaboration led us to study organizational letters exchanged by employees of Hudson's Bay Company (HBC), a distributed organization where coordination and accountability were the main goals. We also looked at personal letters between Swiss physicist Albert Einstein and French mathematician Élie Cartan whereby the scientists laid the groundwork for a new theory. Our analysis suggested four specific mechanisms that explain how writing enabled collaboration. In the following section, we explain why we chose to take an extreme case approach and analyzed historical letters from two canonical cases. We then summarize the context of the two distributed collaborations and discuss our methodological approach.

Why Letters?

Letters seemed appropriate, given our goal of detecting the mechanisms that underlie writing's capabilities to support dialogue and collaboration. First, letters' dialogical and semiprivate nature allowed us to focus on the process of writing. It would not have been the same if we had studied reports or articles, which tend to present a "finished" output. Indeed, since the invention of writing, letters have provided the primary means by which dispersed people enact a dialogue whereby ideas are shared and

developed, and relationships are maintained and shaped (Bazerman 1988, Yates 1989a, Collins 1998). Furthermore, letters are the ancestors of emails,[1] which play a key role in today's organizations (Byron 2008). Although there are important differences between the two, both are malleable genres spanning short, spur-of-the-moment notes to more complicated and sometimes quite well-considered, elaborate texts (Orlikowski and Yates 1994). Additionally, focusing on letter writing allowed us to better grasp the underlying mechanisms of writing regardless of the medium in which it has been enacted over time. That is, although we live in an era of media and channel proliferation, focusing on a time in which face-to-face interaction and letters were the only communication options allows us to better understand the full potential of writing. This extreme case approach is appropriate: when building a theory, extreme or polar cases are preferred because they uncover rich insights and information about the phenomenon (Ragin and Becker 1992, Flyvbjerg 2011). For these reasons, we chose two settings in which dialogical, exchange-type writing in the form of letters was the norm.

It is worth noting that the differences between these well-known, canonical cases make our findings stronger because our analysis showed similar mechanisms at work in two very different distributed collaborations. The first took place at a formal organization, HBC, between post managers who wrote yearly letters to a committee based at its London headquarters. The letters were sparse (one annually from each party), were sent from one to many (managers' letters to staff), and sought to support the coordination of vast and complex operations. In contrast, the second distributed collaboration took place between two individuals, Einstein and Cartan, who exchanged letters frequently (sometimes several in a week) as they sought to develop a new scientific theory. Each setting is described below.

Distributed Collaboration at the Hudson's Bay Company

HBC, a large, successful organization and the oldest company in North America, has epitomized distributed organizing for centuries. It was incorporated on May 2, 1670, with a royal charter from Charles II of England. Headquartered in London, England, most of its operations took place in North America. The company established remote posts in a vast territory situated largely in today's Canada, where small groups of men traded with locals in the hopes of sending furs to London. The London governor, deputy governor, and committee members made decisions about the pursuit of trade. The post managers had almost no face-to-face contact with headquarters and virtually no London manager visited the posts; the vacuum was filled with extensive record keeping and correspondence (Brown 1980, O'Leary et al. 2002). Therefore, collaboration between headquarters and the post managers took place

almost exclusively in writing. Each May, letters and journals were exchanged via ships that arrived from the river Thames and that set off from Albany or York Fort in August (Glover 1965). They were the primary means by which headquarters and managers of the different posts communicated, shared knowledge, coordinated, and solved problems at a distance.

The annual letter sent from the forts was generally four to six pages long (some reached 10 pages) with an inventory often attached. The letter contained answers to the instructions or questions the ships brought from London yearly, as well as stories of the problems each post faced. The letter was accompanied by a fort journal similar to a ship captain's log; the journal provided more details—analogous to today's email attachments.

The HBC correspondence supported the coordination of vast distributed operations and collaboration among organization members in several ways. The post managers' letters provided headquarters with contextual knowledge and gave post managers a means to explain and justify their actions and decisions during the year. Headquarters was suspicious of the managers' actions, as indicated by their frequent requests for clarification and justification (O'Leary et al. 2002), and always assumed the managers to be potentially deceitful. In particular, smuggling, a private trade the HBC forbade, was a matter of concern, and managers tried hard to demonstrate their honesty. Letters also enacted a dialogue through which post managers and headquarters shared knowledge and solved problems in a collaborative fashion. Despite the clear status difference between headquarters' members and post managers, both questioned each other's ideas and then succeeded in integrating their different perspectives. Thus, dialogue through letters was imperative for effective collaboration in an environment where writing was the only method of communication.

Distributed Collaboration Between Einstein and Cartan

Albert Einstein (1879–1955) was a Swiss theoretical physicist widely considered to be one of the greatest physicists of all time. Best known for the theory of relativity, Einstein was awarded the Nobel Prize for physics in 1921. He was an active and prominent member of the scientific communities of his time and developed some of his major ideas through voluminous correspondence with various scientists. The intensity of his correspondence with members of his network of scientists—he sent more than 14,500 letters and received more than 16,200 (Oliveira and Barabási 2005)—provides an interesting parallel with the online communities that promote scientific collaboration and idea sharing today.

Einstein's correspondence with French mathematician Élie Cartan (1869–1951) offers a particularly powerful example of distributed collaboration and knowledge creation. Exchanged while Einstein was in Berlin and Cartan in Paris, the correspondence was especially dense: 39 letters between 1929 and 1932, out of which 26 letters and long mathematical notes were exchanged in a 12-week span (from December 1929 to February 1930). The letters allowed the two scientists to set the foundation for the Cartan–Einstein unification theory finalized by physicists José Vargas and Doug Torr (Vargas and Torr 1999).

The theory originated with Einstein's attempt to transcend general relativity through the postulate of Finslerian teleparallelism. He elaborated his ideas in a series of papers that began appearing in 1929. In May of that year, he received a letter from Cartan, who wrote that mathematical issues could be solved by some of his published work. Einstein then tried to elicit Cartan's answers to a series of mathematical questions about the singularity of the field equations he was proposing. Were the equations sufficient to determine the field fully? Cartan gave Einstein mathematical advice on how to implement Finsler's postulate, but Einstein chose not to follow the recommendations and so did not develop the theory completely (Forman 1980, Vargas and Torr 1999). Later, Vargas and Torr (1999) picked up Cartan's suggestions and fully developed the theory.

Method

To gain a better understanding of how writing supports dialogic communication and distributed collaboration, we took a qualitative and inductive approach consisting of four phases. We analyzed the 79 letters sent from the forts to headquarters between 1703 and 1740 (Davies and Johnson 1965),[2] as well as the correspondence that Einstein and Cartan exchanged from 1929 to 1932 (Devever 1979).[3]

We started the first phase hoping to learn whether dialogic exchanges occurred in extreme cases of distributed collaboration (e.g., the HBC and Einstein–Cartan correspondences) where writing was the main way to communicate. The phase was an iterative discourse analysis of the correspondences that involved multiple readings of the letters by the two authors. We read each correspondence separately before discussing and comparing our notes. We realized that these letters were dialogic exchanges between writers offering context to distant correspondents in the hopes of being better understood. They built on previous letters and so sustained a conversation involving several letters. The first important insight occurred when we uncovered the significance of what we define as the objectifying and contextualizing mechanisms that support the dialogic process. We noticed that the writers gave readers detailed accounts of their activities, as well as highly intricate and nuanced thoughts that recipients occasionally developed further. This is what we call *objectifying*, or the process of writing down, by which writers express ideas and make them into objects to share with correspondents. We also noticed that the writers adapted their letters to the perceived needs, level of knowledge, and interests of the reader, which resulted in persuasive letters. That act

corresponds to the *contextualizing* process; i.e., a writer always writes "to someone," providing her with contextual information but also anticipating and answering questions she might have. Thus, in this first stage, we realized that writing seemed to possess specific mechanisms central to the dialogue and collaboration between distant correspondents.

In the second phase, after reviewing the literature on organizational communication and distributed collaboration, we realized that we did not have the theoretical tools to explain the dialogic exchanges we observed in the letters. Thus, we turned to various fields—literacy theories, history of science, sociology of knowledge, and psychology—that suggested that written language is important for the development of new knowledge, often among distributed correspondents. Prominent among the fields are literacy theories because of their focus on the role of writing in the history of society, particularly in the creation of knowledge. Armed with our knowledge of these literatures, as well as with insights from the first round of analyses, in a third phase we reread the correspondences and stayed open to new patterns in the data. This process led us to consider how some of writing's dimensions (fixedness and asynchronicity) could support mechanisms central to dialogical communication and thus distributed collaboration. We realized that, rather than focusing on the dimensions of writing, as literacy theorists do, it was more productive to analyze writing in terms of its mechanisms. For example, all scholars highlight the importance of fixedness and the ability to track or record ideas exchanged as one of writing's main dimensions. Our analysis showed that the power of writing did not reside solely in the output (the recording of ideas) but also in the objectifying process that allows writers to articulate and develop ideas further for themselves and others. Our findings about the actions taken by people in the writing process made us adopt a mechanism-based approach to writing (Hedström and Swedberg 1998) rather than a description of its dimensions. A social mechanism is a precise, abstract, and action-based explanation that shows how the occurrence of a triggering event regularly generates the type of outcome to be explained (Hedström and Swedberg 1998). This third stage of analysis culminated with the identification of writing's four mechanisms: objectifying, addressing, specifying, and reflecting.

We identified the mechanisms via theoretical categories that emerged from a comparative analysis of the ways distant collaborators in the two cases used letters to work together (Glaser and Strauss 1967). Table 1 provides an exhaustive list of mechanisms and categories as well as representative examples from the two sets of correspondences. For instance, we identified categories such as (1) referring to a previous letter or document that was read, shared, or discussed (e.g., "for the particulars of which misfortune, refer to Mr. Beaven's letter," "I have

received your letter and I have read and thought about it") and (2) referring explicitly to the act of writing (e.g., "for reasons that I outline in my note," "The reason why I sent no particular indent the last time I wrote"). We then grouped these categories into themes we call *mechanisms* because they help explain how dialogical communication could be enacted in writing. The two categories mentioned above make up the objectifying mechanism.

In the fourth and last phase, we reviewed the literature on distributed collaboration, focusing on challenges central to effective distributed collaboration: the sharing of knowledge and organizing practices (Szulanski 1996, Cramton 2001, Orlikowski 2002, Faraj and Xiao 2006), the ability to question one another's ideas (Levina 2005, Faraj and Xiao 2006), and the development of synergistic solutions (Hardy et al. 2005, Levina 2005, Faraj and Xiao 2006). We used axial coding (Strauss and Corbin 1998) to link each of the mechanisms with practices (e.g., common ground, providing a rationale) that allowed distant collaborators to address the dialogic challenges— knowledge sharing, questioning ideas, and synergistically developing ideas—they faced when working together. In this final stage, we noticed that, although analytically distinct, in practice the mechanisms often worked together to support the enactment of dialogical communication and thus collaboration in the two settings. Next we further elucidate each of the mechanisms and show the role they play in supporting effective distributed. collaboration.

How the Mechanisms of Writing Support Distributed Collaboration

Our analysis shows that writing has four mechanisms central to dialogic communication: objectifying, contextualizing, specifying, and reflecting. In the following sections, we define each mechanism that emerged from our data analysis and show how it was enacted at HBC and in the Einstein and Cartan correspondence. (See Table 1 for representative examples not discussed in the text.) We present evidence that shows how, through the mechanisms' enactment, distant collaborators could address the dialogical challenges involved in distributed collaboration, i.e., knowledge sharing, questioning ideas, and developing synergistic solutions. Table 2 provides representative examples of how the mechanisms were enacted in both correspondences to address dialogic challenges and thus support collaboration. The mechanisms should be seen as neither exhaustive nor exclusive. They are discussed independently for analytic convenience only. In practice, they do not operate independently; on the contrary, they overlap and interact in supporting the dialogue (and thus the collaborative process) among distributed collaborators. For example, objectifying supports specifying because it allows writers to be more detailed in the development of their arguments; it also supports reflecting because it gives readers the opportunity to deepen their understanding. Therefore, many of the examples in the text and the

Table 1 The Mechanisms of Writing: Definition and Representative Examples from the Two Sets of Correspondences

Mechanisms	Categories	Representative examples from the HBC correspondence	Representative examples from the Einstein–Cartan correspondence
Objectifying	—Referring to a previous letter or document (that one has written or has received), e.g., mentioning that the letter has been read, shared, or discussed —Referring explicitly to the act of writing down, e.g., "It took me time to reply in order to present my ideas clearly…" or "As I'm finishing writing"	"I received your Honours' letters and herein return you my humble and grateful acknowledgements for this so singular a favour, in my being appointed Chief Factor at Moose River." (Letter 44, August 23, 1732, p. 171) "And concerning the servants' characters staying in the country, also those staying in the country, we have sent in the list, as ordered." (Letter 33, August 8, 1728, p. 140) "I now acquaint your honours that Richard White will not agree to sign a contract for four years by reason his salary is so small. He will write the full intentions of his minds to your honours in relation to that affair." (Letter 42, August 14, 1732, p. 165)	"After having written my little note, I realized that it is quite long: may it at least be clear!" (Cartan to Einstein, December 3, 1929, p. 31) "I have just now read your very thorough letter and—without grasping all the details—I am *completely convinced* of the reliability of the results." (Einstein to Cartan, January 30, 1930, p. 159, emphasis in original) "Dear colleague, immediately after I sent off my letter, it became clear to me that, from the standpoint of the degree of determination, your system, $R_{ik} = 0$, etc., is fully equivalent to mine." (Einstein to Cartan, December 27–28, 1929, p. 89)
Contextualizing	—Providing contextual information, e.g., on when the letter was written or received, or elements in the life of the writer that might explain better the decisions he took —Referring explicitly to the reaction of the reader, e.g., "You might disagree…" or to the readers' intentions —Providing extra information to clarify an idea that might be misunderstood, e.g., "In case you thought, here is what really happened or what I really meant"	"And as to the biscuits and prunes mentioned in the same paragraph, am surprised that your honours should be unacquainted with a thing that has been so long standing in the accounts from all your factories in the country, and therefore to satisfy your honours thereof I do humbly assure you that there is not an Indian comes to the factory but what expects some biscuit, prunes, a pipe and a pipe of tobacco, etc., at their first coming trade, which is a compliment of so long standing as cannot without danger to your honours' interest be recalled, and on this occasion is the biscuit and prunes your honours make mention of expended." (Letter 67, August 17, 1738, p. 252) "My reason for saying this is by experience, for at York Fort in the year sixteen hundred and ninety-four, we had two gunners in the fort at 50 pounds and 60 pounds per annum… ." (Letter 75, August 17, 1739, p. 300) "The powder that came last over was but very indifferent and a great deal of it damaged though I suppose you bought it for the best by reason you praised it much in your letter, but for the before mentioned reasons 'tis impossible to raise the standard." (Letter 2, July 23, 1706, pp. 15–16) "Whereas your honours charge me with sending memorandums and papers by the captain relating to your affairs and have omitted giving your honours an account of it in the general letter, I know not that I ever acted any such thing. I shall send you a full account of our transactions, with particular directions about what we want or would have and shall enclose in the indent etc. in the packet." (Letter 42, August 14, 1732, pp. 165–166)	"What you say about the number of *real* identities of your system can be reduced, perhaps, to a question of convention. When I say that there are 12 identities, I mean that I use the equations just as they are, without modifying them by the introduction of an auxiliary function." (Cartan to Einstein, December 13, 1929, p. 71) "I am sending you the second note, in which you will find the complete theory of systems in involution, with proofs. It is written from the point of view of systems of partial differential equations, and not, as in my papers, from the point of view of systems of total differentials." (Cartan to Einstein, December 25, 1929, p. 89) "I would like to tell you briefly the reasons why, on formal grounds, the new equations please me more. First, the field interpretation is not unified in that g and $\varnothing$ have logically nothing to do with each other. Second, the left and right hand sides of the gravitational field equations have no logical connection. Third, this theory can never express charged masses otherwise than as singularities… . All these drawbacks are overcome in the new theory." (Einstein to Cartan, January 10, 1930, p. 119)

tables illustrate more than one mechanism. For clarity of exposition, we present each mechanism separately but end the findings with an empirical example from each correspondence of how writing supported collaboration through the conjoined enactment of the four mechanisms.

Objectifying

Our analysis showed that writing's fixedness—which allows meaning to be set, discussed, and shared—is crucial for enabling knowledge sharing among distributed collaborators. The letters' existence and the frequent

Table 1 (cont'd)

Mechanisms	Categories	Representative examples from the HBC correspondence	Representative examples from the Einstein–Cartan correspondence
Specifying	—Developing long lists of events, objects, or people —Using long and complex sentences —Providing a lot of details and/or nuances	"According to your orders I have discharged the following persons for to come home, assuring your honours that it was not in my power for to it before, vizt. (the undermentioned servants discharged and come home in the *Hudson's Bay*) [*followed by 3 columns of 9 names each*] Thomas Macklish junior, Thomas Kendall, Alexander Groundwater ... ." (Letter 5, August 2, 1714, p. 252) "Honourable Sirs, the reason of our large indent last year for blankets was because Governor Macklish has sent for some to York Fort which we spared after the arrival of the ship, which you will find charged to that place in the account book that's come home now, and this year he has sent again for more trading goods which we shall send by the sloop what we can spare vizt. 5 pieces of red cloth, 200 hawks bells, and 3 cask brandy." (Letter 32, August 8, 1728, p. 133) "Last fall I continued the masons at work on the interior casing of the north-west square of the building till the 29th August by which time they raised it to the level of the exterior casing parallel to which was seven foot from the ground. Then I was obliged to employ ten men the remainder part of that fall in rafting home our ensuing winter's firing, four men at our goose tents and a mason with a labourer or tow in repairing and rebuilding our stoves, chimneys, ovens, etc., and securing them from the danger of fire." (Letter 67, August 17, 1738, p. 250) "The kettles that was mentioned in my letter last year, No. 43 to weigh 385 lbs. which your honours found to be 44 weight 379 lbs. We have cut off the accounts this year, without deducting five kettles from any other number ... ." (Letter 77, July 27, 1740, p. 316)	The system of 16 equations that I mentioned to you, and of which I write only a few equations, $X_{12} \equiv S_{1,2} - S_{2,1} + a(\phi_{1,2} - \phi_{2,1}) + b(\phi_{3,4} - \phi_{4,3}) - A_{12} = 0$, $Z \equiv \phi_{\alpha,\alpha} - C = 0$, $Y^{12} \equiv \Lambda^2_{1\alpha;\alpha} + \Lambda^1_{2\alpha;\alpha} + c(\phi_{1,2} - \phi_{2,1}) + d(S_{1,2} + S_{2,1}) - g^{12}[\Lambda^\mu_{\mu\alpha;\alpha} + \cdots] = 0$, falls under the second case; these are 4 linear combinations of the derivatives of the left hand sides in which the second order derivatives cancel." (Cartan to Einstein, December 13, 1929, p. 71) "By means of considerations which I indicated to you in my letter, a simple ordering of the equations leads to the following three results:

	$\mathfrak{I}_4$	$\mathfrak{I}_3$	$\mathfrak{I}_2$	$\mathfrak{I}_1$
$R_k j_{lm} = 0$	4	12	24	40
$R_{ik} = 0$	4	16	30	40
My system	4	24	46	64

(The number of identities is always $r_3 + 2r_2 + 3r_1$.) One can see from the first row that, in a Euclidean space, 12 of the $g_{\mu\nu}$ and $g_{\mu\nu\alpha}$ can be freely chosen in a space of 3 dimensions by a suitable choice of coordinate system." (Einstein to Cartan, February 2, 1930, p. 173) "After reading your detailed definition, it seems to me that I have the same understanding as you with regards to identities. When I asserted for example that $F_{\alpha\beta,\gamma} + F_{\beta\gamma,\alpha} + F_{\gamma\alpha,\beta} \equiv 0 \equiv (F_{\alpha\beta\gamma})$ Are only 3 independent identities, I meant the identity $0 = F_{\alpha\beta\gamma,\sigma}\delta^{\alpha\beta\gamma\sigma}$ ($\delta^{\alpha\beta\gamma\sigma} = 1$ or -1 according to the character of the permutation $\alpha\beta\gamma\sigma$) is always satisfied, what one takes for $F_{\alpha\beta}$." (Einstein to Cartan, December 18, 1929, p. 75)

references to letters received made that point strongly. At the same time, our analysis showed how writing's fixedness (i.e., the document produced) is only one facet of the central mechanism we call *objectifying*. Writing does more than solely provide a trace that can be stored and retrieved as a memory in a distributed organization, a community, or between two individuals. It also brings knowledge and ideas to life, turning them into objects that correspondents can analyze, question, reflect on, and potentially integrate as a solution. Thus, objectifying is also the process by which dispersed collaborators, through inscription, clarify and further articulate their ideas. The two facets of objectifying, product and process, work together: by inscribing a concept, the writer refines it for herself and can share it with others who are also empowered to ask for clarification or to question the idea. In the correspondences we analyzed, objectifying—the

central mechanism of writing—supported distributed collaborations between post commanders at HBC and headquarters, as well as between Einstein and Cartan.

Objectifying Enacted in the HBC Correspondence. In the extreme context of HBC when only one letter was exchanged between headquarters and the different forts each year, the written records of events, actions, and decisions provided by the letters were obviously central to *knowledge sharing*. The objectifying mechanism supported the externalization of knowledge, which then could be shared with headquarters as well as other posts. In several letters, managers mentioned correspondence received from another post manager,[4] comparing its content with their own situation (e.g., Letter 9, pp. 40–46; Letter 60, pp. 222–225).[5] Managers *shared practices* by informing other forts of their activities and the rationale for their decisions and actions. In cases such as the one below,

Table 1 (cont'd)

Mechanisms	Categories	Representative examples from the HBC correspondence	Representative examples from the Einstein–Cartan correspondence
Reflecting	—Referring to the time taken to write or read a letter and to the interpretative process (e.g., "I received your letter a few days ago but I wanted to think before replying…", "If I understand your question well…") —Referring to the reading of the letter and questioning it (e.g., "As I was reading your letter, I came to wonder…") —Referring to multiple readings of the letter	"In relation to the punt which was sent for the last year, your honours are of the opinion that such maybe built in the country. It certainly may be done, but I judge it almost labour by reason the wood is of a soft nature and not able to resist the ice, for I had a small boat built at the East Main, but in the fall of the year were obliged to haul her up, the ice cut her almost through." (Letter 44, August 23, 1732, p. 172) "As to the condition of your fortification here, we account it to be in a better posture of defence than has been known for this twenty years past, and we don't know anything we have to dread from an enemy, if they don't take us on a surprise which we shall always be very careful to prevent." (Letter 35, August 2, 1729, p. 147) "As to our powder we judge the reason of it being bad was occasioned by the dampness of the powder room which we amended last fall…. But for opening all our powder whilst this ship is here it is very dangerous and having but a little time when they are here and not willing to detain them." (Letter 32, August 1728, p. 140)	"Your wonderful explanations leave me only the following new questions:…." [*followed by 2½ pages of questions*] (Einstein to Cartan, December 29–30, 1929, p. 95) [*After reviewing various interpretations of a system of equations they are working on*] "I incline to the opinion that the second approach is to be preferred because of its completeness. What do you think?" (Einstein to Cartan, January 30, 1930, p. 159) "Every such letter is truly a joy for me. But I am still not content with the $\Im$'s. Your argument, can in fact, be turned against yourself. For you consider $\Im 3$ in a four dimensional space to be a measure of *généralité* (and not $\Im 4$)." (Cartan to Einstein, February 13, 1930, p. 195, emphasis in original)

post managers referred to these letters and even included them in their correspondence to headquarters:

> Your honours will find by a letter which we received from Mr. Bevan dated by the 5th March 1728/9, of a bad accident that happened to the *Beaver* sloop the 9th of November last, but thanks to the Divine Providence, she received no damage. We shall waive giving you a particular account of it here, it being too tedious for to relate, but refer you to a copy of the aforesaid letter.
> (Letter 35, p. 146)

This reference to other letters highlights the dialogic nature of the communication at HBC, which involved multiple voices (i.e., headquarters and various posts in Canada); collaboration involves multiple actors who can develop a shared understanding of the different contexts and practices via objectified records. Beyond the obvious repository role of letters, they also had a performative role (i.e., they shape the activities of the posts, as well as headquarters' decisions), especially when it came to headquarters' authority. Indeed, although our analysis focused on the letters to headquarters, the latter's voice came through because of the letter writers' constant references to headquarters' own correspondence and directives. In the absence of the written word, headquarters did not have a voice. This is well illustrated in the following example; here, Joseph Myatt, at the time Albany post manager, decided to disregard an order from headquarters because it was not written in their letter:

> Whereas Mr. Thoyts informs me that your honours have been pleased to appoint him to be an assistant to me, I find no such orders in your instructions, therefore shall

continue Mr. Adams in that station till such times you are pleased to order it otherwise.   (Letter 31, p. 131)

Myatt, in the absence of a letter from headquarters, chose to disregard Thoyts' verbal statements and, to a certain degree, *question* the decision reported by Thoyts by keeping as his assistant Adams "who is a man that I very well approve" (p. 131). By explaining his decision and the grounds for it—his perception that the letter is "weightier" than the words—the fort manager explains to his superiors how he solves problems.

Our analysis of HBC correspondences unveiled the central role of objectifying in enabling distributed collaboration: the objectifying mechanism supports the sharing of knowledge among distributed managers, as well as problem solving, such as Myatt's decision to reconcile conflicting orders from headquarters. Objectifying permits the post manager to engage in a dialogical process with his superiors: he explains the rationale for his decision not to follow orders and tries to build common ground with headquarters despite making a choice that could be read as insubordination.

Objectifying Enacted in the Cartan and Einstein Correspondence. In Einstein and Cartan's correspondence, we found that objectifying was important in several ways. First, in many of their letters, the scientists used long, complex equations that could not be said orally and that needed time to be interpreted and understood. Second, the objectifying mechanism provided an object that helped clarify positions that could be discussed and *questioned*, thus supporting knowledge sharing, as well as *the development of a synergistic theory*. Objectifying was enacted

Table 2   How the Mechanisms of Writing Support Distributed Collaboration by Addressing Dialogical Challenges

How the mechanisms address dialogical challenges	Representative examples from the HBC correspondence	Representative examples from the Einstein–Cartan correspondence
Objectifying —Allows writers to share and refer to an idea on which they can build or that they can challenge —Facilitates discussions and debates, as well as combining ideas synergistically	*Knowledge sharing* "And to let your honours see the manner that I have proceeded therein I have sent enclosed in the packet a copy of the instructions that I give from time to time to Mr. Napper and Mr. White to be observed by them in my absence at the building." (Letter 67, August 17, 1738, p. 258) *Challenging ideas* "And perhaps you may think the indent here enclosed somewhat large; there is nothing of superfluity in it, for that which you reckoned two years of trade which came over in *Perry*." (Letter 1, August 2, 1703, p. 12) *Developing synergistic solutions* "Whereas your honours is pleased to leave the choice of the surgeons to us, we therefore choose Doctor Dale to continue surgeon at this factory at the same salary he had before, he having behaved himself very well in his station." (Letter 45, 1732, p. 177)	*Knowledge sharing* "Dear M. Cartan, I have read your manuscript—*enthusiastically*. Now everything is clear to me. You should publish this theory in detail; I believe it is of fundamental importance. Previously, my assistant Professor Muntz and I had sought something similar—but we were unsuccessful." (Einstein to Cartan, December 29 or 30, 1929, p. 95, emphasis in original) *Challenging ideas* "Dear M. Cartan, I believe I ought to communicate two points to you where—it seems to me—we are of different mind." [*followed by two pages explaining the equations and the reasons why he disagrees with Cartan*] (Einstein to Cartan, January 10, 1930, p. 119) *Developing synergistic solutions* "…Yesterday I sent off a review article on the subject to the *Zeitschrift fur Physik*…, I could add a postcript to this article which would discuss the mathematical antecedents of the theory…. Therefore I make the following suggestion to you: write a short analysis of the mathematical background which we will append to my new review, under your name of course, but integrally joined to my article. You should be doing me a great favour…." (Einstein to Cartan, May 10, 1929, p. 11)
Contextualizing —The text is always directed toward another who is clearly referred to and taken into account by the provision of contextual information and by style adaptations —Facilitates building of a common ground as the recipient is provided with contextual information and the writer articulates the argument with the potential questions the reader might ask	*Knowledge sharing* "As to what charges I've been at in presenting leading Indians and others to keep them firm to your interests you will see by your accounts that I have been no ways profuse." (Letter 1, August 2, 1703, p. 6) *Challenging ideas* "We not having a bricklayer come over shall be at a great disappointment for our chimneys and stoves are so very bad that the factory is in danger thereby, and I shall take care to follow your orders as much as in me lies but our summer is short and all our business comes together, nevertheless when opportunities serves we shall do what we can." (Letter 38, 1730, p. 156) *Developing synergistic solutions* "I hope this misfortune of the *Mary* frigate will be a warning to all your commanders never to engage with ice of Cap Farewell, for I assert that a ship may with as much safety run against a rock as against such, being all of a hard blue ice." (Letter 30, August 16, 1727, p. 127)	*Knowledge sharing* "Just a word to tell that I am almost sure of the result I have been searching for such a long time. There are no deterministic systems in involution other than the two known ones with 22 *equations* (and those with 15 and 16 equations that you reject as not deterministic enough). And the proof can be presented without any calculations which are too horrendous." (Cartan to Einstein, January 12, 1930, p. 131, emphasis in original) *Challenging ideas* "But this doesn't matter. For that formulation will be right in which the $\mathfrak{I}_4$, $\mathfrak{I}_3$, $\mathfrak{I}_2$, $\mathfrak{I}_1$ are as small as possible. Thus I am still of the opinion that *géneralité* can only be adequately described by all 4 numbers. (Do not be angry with me about my stubbornness; I can do no other.)" (Einstein to Cartan, February 13, 1930, p. 195, emphasis in original) *Developing synergistic solutions* "Actually, physics need never consider equations for which the difficulty raised by M. Hadamard occurs. But he still has raised an important question. M. Hadarmard's second remark is also very interesting. Let us consider a deterministic differential system [*followed by 1½ pages of equations and explanations*] All this goes to prove, that in the present state of Analysis, and in the discussion of systems as complicated as yours, one is obligated to stick to analytic solutions." (Cartan to Einstein, February 7, 1930, p. 189)

Table 2   (cont'd)

How the mechanisms address dialogical challenges	Representative examples from the HBC correspondence	Representative examples from the Einstein–Cartan correspondence
Specifying —Allows collaborators to articulate better their ideas and thus make the dialogue more meaningful and more productive	*Knowledge sharing* "Sirs, as for the provisions that Captain Davis could spare when he went away, I gave Mr. Macklish an order for to take all that he could spare and for to give him a receipt. As for what beef, oatmeal he could spare I gave him a receipt for it as you will find upon perusal of the account of your provisions." (Letter 5, August 2, 1714, p. 30) *Challenging ideas* "…[S]o be pleased to send all the particular number of kettles indented for by their several weights, likewise the same quantity of blue cloth and red, but none of white, the natives here having an aversion to white. Likewise send us no small long knives, nor small roach knives, here being more upon remains than will be traded in two years…." (Letter 32, August 8, 1728, p. 134) *Developing synergistic solutions* "As to the 20 lbs. vermillion sent in 1726 and but 10 lbs. entered in the account book for 1727, I have rectified the same as far as can be done. We having found by an overhaul, when I arrived here last fall, but 4½ lbs. vermilion more than was upon Captain Beale's remains; and in brandy at least 12 gallons short of what was upon remains." (Letter 32, August 8, 1728, p. 137)	*Knowledge sharing* "I think I can assert, having written down all possible identities and viewed the different systems likely to fit, *that there is no system MORE determined than yours.*" (Cartan to Einstein, December 22, 1929, p. 83, emphasis in original) *Challenging ideas* "In any case, I was concerned with *algebraic* independence among the left hand sides of the identities, considered as linear combinations of the 24 partial derivatives of the quantities $F_{\alpha\beta}$ with respect to x^1, x^2, x^3, x^4. Our points of view were thus completely different." (Cartan to Einstein, December 22, 1929, p. 83, emphasis in original) *Developing synergistic solutions* I have now understood perfectly what you mean when you say that the 4 identities $F_{\alpha\beta\gamma} = 0$ are not independent. We do not give the same meaning to the word *independent*." (Cartan to Einstein, December 22, 1929, p. 83, emphasis in original)
Reflecting —Facilitates and enhances understanding between the people involved in the dialogue —Provides time for ideas to be developed and deepened between the dialogue participants	*Knowledge sharing* "It's certain we have had an enemy about us this summer, they having appeared about our works several times at unreasonable hours, but never offered to fire a gun at our men when they were on duty, neither do I believe there was a great body of them, only a few spies to see if they could take us on a surprise…." (Letter 35, August 2, 1729, p. 145) *Challenging ideas* *[In reply to a criticism by the headquarters regarding the decision by Norton in 1736 to repair the old factory instead of building the new fort]* "It is a great affliction to find your honours so adverse to our humble endeavours in carrying on the building at the Point which we have exerted at all times to the utmost of our power, and for answer to part of the said paragraph we humbly refer your Honours to Mr. Norton's letter per the *Hudson's Bay*." (Letter 66, August 1, 1738, p. 245) *Developing synergistic solutions* "I hope when opportunity offers your honours will build or otherwise provide a ship of a small draught of water, not to exceed 8½ foot water, which will carry as much goods as either the *Port Nelson* or old *Hudson's Bay*, and in a few voyages your honours will find the advantage by having a ship fit for this river." (Letter 9, July 16, 1716, p. 41)	*Knowledge sharing* "Francis Perrin, the son of Jean Perrin, made an interesting remark to me the other day. By modifying your system in the following way: $\Lambda^{\mu}_{\alpha\beta;\,\mu} = 0$, $G^{\beta}_{\alpha} = kg^{\alpha\beta}$, k being an arbitrary *constant*, one still has a system in involution with the same degree of generality." (Cartan to Einstein, January 19, 1930, p. 139, emphasis in original) *Challenging ideas* "I have not yet had time to reflect on your last letter of January 10. But I think your conclusion about the generality index of the system $R_{ik} = 0$ is not right; I calculated the index a long time ago, and I have just redone the calculations; I find $\Im = 4$ and not 8/Concerning your system which contains the tensor T_{ik}, I'll think it over at leisure and write you the results of my thoughts." (Cartan to Einstein, January 12, 1930, p. 131, emphasis in original) *Developing synergistic solutions* "…(But are we really sure that such solutions exist and that the coconut contains something inside?) We find ourselves in front of a wall and we mathematicians are quite at a loss as to how to make a hole in it. One can only hope for some miracle of divination, but then you already have had several." (Cartan to Einstein, February 17, 1930, p. 201)

in the letters themselves whereby Einstein and Cartan presented their ideas and background assumptions, as well as in attached notes or articles in which they articulated specific questions. For example, on December 3, 1929, Cartan sent a letter to Einstein in which he enclosed a note with a mathematical demonstration (objectifying) that sought to further explain his ideas:

> I enclose a brief account of the way in which I see the question; I apologize in advance for certain details that may seem a bit irrelevant, but this is because I want to help you understand my point of view; if I have taken the wrong road, I'd like you to tell me. (p. 23)

In this example, Cartan enacted the objectifying mechanism (1) as an output, by enclosing "a brief account of the way in which I see the question"; and (2) as a process, through writing, he could articulate the problem as he saw it, a first step toward knowledge sharing. Furthermore, Cartan invited Einstein to *question his views* and to engage in an exchange. He noted that the ideas expressed in the letter were not "fixed" but a first attempt to articulate his point of view ("certain details that may be a bit irrelevant") and a starting point for discussion ("if I have taken the wrong road, I'd like you to tell me"). Objectifying—as output and process—in this specific example, as well as all their letters, supported the dialogue between Einstein and Cartan and the evolution of their ideas into new theories.

Contextualizing

Along with objectification, contextualization was a major mechanism that emerged from our analyses. When writing to faraway collaborators, because of the distance and lack of shared context (which can limit understanding and hinder effective communication), people often imagine what might be their collaborators' questions and concerns and therefore *contextualize* their letters. First, they provide background and details about the data shared, the problem to solve, or the solution proposed so that the collaborator, steeped in a different context, can understand the situation. Second, they personalize the communication to address distant collaborators' level of knowledge, interests, and concerns. Contextualizing is critical to supporting distributed collaboration because it means adapting one's writing—in terms of style and content—to the perceived contexts, assumptions, and needs of the recipient(s), which leads to more effective communication.

Contextualizing Enacted in the HBC Correspondence. Contextualizing as enacted at HBC included providing a wealth of information about local operations, the all-important harsh weather, native populations, competitors (e.g., the French traders), the availability of animals with valuable furs (e.g., beavers), for example—all in an effort to create common ground and help headquarters understand the post managers' decisions and requests. Moreover, contextualizing often involved fictionalizing: managers

anticipated what headquarters might misinterpret and crafted their letters to answer as many of headquarters' potential questions. The time lag between each letter (which prevented any hope of rapid feedback from either side) made contextualizing key to supporting distributed collaboration between the managers and headquarters.

Contextualizing their daily operations helped managers articulate their actions (and the rationale for them) more clearly and invited headquarters to make sense of the actions and decisions. The managers knew that their superiors had, for the most part, never been to Canada and had very little idea of the living conditions and constraints there or the relationships between post managers, their employees, trappers, and Native Americans. Thus, the yearly letters sent by post managers to headquarters always started with an acknowledgment of the latter's last letter and a description of the current context (e.g., when discussing the weather, "we met with a long and tedious passage to Hudson's Bay which was occasioned by contrary winds and a ship that sailed and steered badly" in Letter 3, p. 20) to help managers in London imagine life in the faraway posts.

The following is representative of how all letters to London began:

> Honourable Sirs, Yours of the 28th of June by Captain Grimington I received in the winter the 17th of February from Gilpins' Island, although I had notice the 2nd of January of his arrival here, which was upon the 27th of September, by a letter that he sent overland by the young carpenter Thomas MackLeish and two Indians that came along with him; with whom I sent another hand[6] from this place back again with them in order to bring me your packet, that I might know the better to manage your affairs, knowing that it would be late and our trade over before that he could get here in the summer with his ship. He could not fulfill your orders in touching here in the fall for what by bad weather, contrary winds and withal so late in the season, it obliged him to put into Gilpin's Island. I'm heartily glad you received your cargo in good condition after so long and tedious a passage as I hear he had.... (Letter 1, pp. 5–6)

The excerpt exemplifies the contextualizing that took place in letters as the fort manager imagined how headquarters would wonder why he took so long to reply and thus explained the reason for the delay. This personalized explanation meant sharing a lot of contextual information about different locations in the territories, the harsh weather, the help HBC employees offered each other, and the information and letters they brought to one another. By providing such context, the fort commander attempted to establish common ground with headquarters so that his constraints and decisions could be understood. Both knowledge sharing and accountability building occurred when the fort commander tried to appear professional and trustworthy. In particular, he insisted on retrieving headquarters' letter (i.e., sending Tom MackLeish and

two Indians to get the packet instead of waiting until the summer) so he "might know the better to manage your affairs." Moreover, the manager used contextualizing to explain why some of headquarters' orders, such as those to Captain Grimington, went undone: "He could not fulfill your orders in touching here in the fall" because weather conditions forced him to stop on Gilpin's Island. Contextualizing played a crucial role in allowing managers to not only *share the knowledge* necessary to coordinate at a distance but also build a shared foundation, justify themselves, and shore up accountability—conditions critical for successful collaboration.

Contextualizing Enacted in the Cartan and Einstein Correspondence. Although contextualizing as enacted by Einstein and Cartan sometimes involved providing background information (e.g., "I received your two letters and your card one after the other. I was just intending to write you a word when the last one arrived" in a letter from Cartan to Einstein dated January 11, 1930; "I am deeply moved that you and your wife have experienced such a heavy and deep sorrow" in a letter from Einstein to Cartan dated April 26, 1932), it was usually enacted through the fictionalization of the other. Thus, contextualizing is reflected in each scientist's efforts to adapt his discourse to the other's knowledge, expertise, and status, thus enabling effective dialogue. For example, Einstein often expressed ignorance of deep mathematical knowledge, asking Cartan for further explanations and references. In Einstein's letters to Cartan, the contextualizing mechanism is enacted through frequent praise for Cartan's expertise and Einstein's expressed need to expand his knowledge of mathematics, as this representative letter from December 18, 1929, illustrates:

> I am very fortunate that I have acquired you as a coworker. For you have exactly that which I lack: an enviable facility in mathematics. Your explanation of the *indice de généralité* I have not yet fully understood, at least not the proof. I beg you to send me those of your papers from which I can properly study the theory. But I am very grateful to you for the identities $G^{\mu\alpha}_{:\mu} + \Lambda^{\alpha}_{\rho\alpha} G^{\rho\sigma} \equiv 0$, which, remarkably, had escaped me.
>
> (p. 73, emphasis in original)

Because Cartan is a mathematician, Einstein specifies his needs as a nonmathematician. He thus explicitly articulates them not only in terms of papers but also in terms of conceptual work he needs to do (e.g., "I have not yet fully understood, at least not the proof"). The above expression of ignorance on Einstein's part was not unique and corresponds to the collaboration's purpose: to use Cartan's expertise as a mathematician to advance a new physics theory.

Cartan also enacted the contextualizing mechanism in many of his letters by explaining the rationale for some of his questions and suggestions. In the following excerpt, for instance, he characteristically explained the seeming

naïveté of his queries: "If I asked you questions of a mathematical or physical nature that may have appeared a bit naïve, it is because I wanted to start from a secure base and to be able to formulate your mathematical problem in a precise way" (December 3, 1929). This example clearly demonstrates the scientists' desire to forge a shared understanding about their expertise, which was the basis of their collaboration. Contextualizing is crucial for sharing knowledge effectively in a cross-disciplinary collaboration, especially here at the start of the duo's collaboration, when the scientists stated their ideas and explained the reasoning behind them so that they could build a common foundation for synergistically developing a new theory.

Specifying

Our analysis uncovered that the specifying mechanism was prominent in letters exchanged both in distributed organizations and among scientists. Because they lacked shared context and opportunities for immediate feedback, distant collaborators needed to not only contextualize knowledge and ideas but *specify* their arguments as much as possible. Writing allowed distant collaborators to fully articulate their ideas by giving them room to insert specific examples and details or to add long lists (as in HBC's correspondence) or complex equations (as in Einstein and Cartan's correspondence) that supported their points. Moreover, when writing, one can eliminate inconsistencies because one can choose between words to make an argument as clear as possible. While specifying was enacted slightly differently because of the aims of the correspondences we studied—coordination in one case, knowledge creation in the other—it was still crucial for allowing distant collaborators to efficiently work together.

Specifying Enacted in the HBC Correspondence. It would be hard to picture a complex distributed organization functioning effectively without analytical precision in their communications, which specifying enabled. HBC's yearly letters provide many details of employees' actions: invoices, long lists of objects shipped to or from London and their values, tables listing the ships sent out at the end of a particular year. Yet these letters offer not only inventories but also explanations of how and why things were done or not done. Because the annual letter was nearly the only means of communication with headquarters, HBC commanders wrote long and detailed missives that carefully explained decisions made during the year:

> And I found the Governor when I came here for the same thing, and I told him my orders was to send them home . . . . I told them I could not nor would not take any charge of them, which at last we did agree and came to a price . . . . I bought all they had so you will be no losers by it . . . . All the guns as is bought, I have computed the charge with the locks and stocks and other mounter, will not stand me in above twelve shillings each, reckoning the armourer's wages to fix them . . . . (Letter 6, p. 35)

The excerpt shows how writing, by specifying the different elements and steps involved in decision making, establishes shared ground (key for effective knowledge sharing) for the post manager and headquarters. This example also shows how specifying facilitates collaboration in a company where headquarters wanted to know the details of distant branches. At the same time, by providing such a detailed account, the commander signaled that he could be trusted. Providing specific information on events, prices, and merchandise, as well as on the decision-making process, allowed post managers to *share their practices* with headquarters (and sometimes with other managers), occasionally developing synergistic solutions, as we show in the Moose Factory vignette later.

Specifying Enacted in the Einstein–Cartan Correspondence. It would be quite impossible to imagine any scientific collaboration without the specifying mechanism that writing offers.[7] Any scholar can recall extensive emails exchanged with coauthors when trying to clarify an argument being developed in a paper; the scientists' correspondence was no different. Sometimes they attached long explanations to their letters, stated equations, invited objections, and challenged the other's hypotheses. In a letter dated December 3, 1929, Cartan referred to his previous work (objectifying), suggesting that he might have some useful knowledge; he was trying to *share knowledge*: "I shall give you a few details of the theory of systems in involution which I discovered some thirty years ago that seems quite appropriate to your problem." He then developed calculations based on the theory of systems in involution (pp. 23–24):

> I have also made a few calculations without being able to decide if your solution is best of all others. Another possible solution, one which contains two cosmological constants, consists in taking the 10 old equations $R_{ij} = 0$ that still have here an invariant character and adding to them 12 equations of the form.

$$\Lambda^{\mu}_{\alpha\beta;\mu} = \phi_{\alpha,\beta} - \phi_{\beta,\alpha} = ChS^{\gamma\delta\mu}\phi_{\mu}, \qquad (1)$$

$$(hS^{\alpha\beta\mu})_{,\mu} = C'hS^{\alpha\beta\mu}\phi_{\mu}. \qquad (2)$$

Cartan continues sharing with Einstein various hypotheses and calculations triggered by a conversation they had in Paris at mathematician Paul Langevin's house. Although the colocated conversation prodded Cartan to further *reflect*, it would be difficult to imagine how an oral exchange could have achieved the level of detail and specificity attained in the letter. It was in writing that Cartan proposed several solutions to Einstein's problem, backing them up with complex details and mathematical expressions. The letter illustrates how this correspondence was an experimental space where both correspondents could express their ideas and expect the other (in this case, Einstein, who had a better grasp of the problem

from a physics perspective) to react to different options. Writing supported the collaborative process by which they explored in detail multiple options for *developing a solution* and furthering Einstein's theory based on their respective expertise.

Reflecting

Because writing is asynchronous, it goads people to reflect on their ideas. Reflecting, the fourth mechanism through which writing supports distributed collaboration, emerged in many of the letters we studied. First, collaborators mentioned how they reflected on a problem before and during their letter writing. They sometimes explained at length the underlying reasons for their decisions. When replying, they mentioned how they took the time to read (and often reread) the original letter and how doing so prompted a deeper understanding of its content and of their opinions about it. *Reflecting* thus allowed the responder to question key assumptions, suggest changes, or push an idea further. We found that reflecting was enacted while both writing and reading and played a key role in the collaborative process because it allowed collaborators to develop a deeper shared understanding and together elaborate complex and nuanced ideas.

Reflecting Enacted in the HBC Correspondence. HBC letters provide examples of the reflecting mechanism whereby post managers took the time to explain and justify their actions and decisions and to answer headquarters' questions. In many letters, fort managers such as Richard Staunton had to justify their decisions and/or explain the figures they provided. Staunton, replying to a letter in which headquarters questioned his figures and records, justified himself by referring to his perusal of several written documents that headquarters sent (objectifying) and by explicitly recalling his reflection on the problem:

> Gentlemen, as for explaining myself about the red and blue shirts or chequered, I cannot tell unless it be a mistake, for I have perused both the indents[8] that was sent home by the [Hudson's Bay ship] and I cannot perceive by their copies the mistake, unless it be where I write for 6 dozen red stocking, 6 dozen blue ditto, and 6 dozen for your servants.... (Letter 75, p. 305)

Despite his efforts, Staunton "cannot perceive by their copies the mistake" that has been made. The example shows how letters and "their copies" became an object of reference (objectifying) that could be shared and examined by both the writer and his superiors. Thus, the written text becomes a key reference that allows knowledge sharing and discussion (questioning ideas) when a different understanding or interpretation emerges. Moreover, Staunton suggests that he reflected on the situation and could not find an explanation: "I cannot perceive by their copies the mistake." With headquarters challenging the figures he reported, Staunton, by providing detailed accounts to his employers and objectifying those

accounts (thus providing traces that could be referenced), signals his trustworthiness, thus creating an important condition for effective collaboration.

In another case, a manager named Beale reflected on why he chose to *question* headquarters' orders to cease his predecessors' practices: he would be "maintaining the same correspondence with the leading Indians as my predecessors have done as well for the increase of the trade as to get of them information from time to time of the French's proceedings . . . ." (Letter 2, p. 17). Beale effectively states that continuing to correspond with local chiefs was a valuable practice he intended to maintain and, indeed, extend.

Writing allowed HBC managers to reflect on their practices and decisions, which headquarters often debated. Reflecting supported knowledge sharing and justified decisions that *questioned* headquarters' orders. In some instances, as shown in the Moose Factory example below and in Table 2, it also supported the collaborative development of a solution.

Reflecting Enacted in the Einstein–Cartan Correspondence. The reflecting mechanism is strongly enacted in Einstein and Cartan's letters. During their three-year correspondence, they shared ideas and theoretical assumptions and developed new knowledge by expressing their thoughts in writing, debating them until a common ground could be established. The power of the reflecting mechanism is illustrated by an exchange Einstein and Cartan had two years after trying to transcend general relativity through the postulate of Finslerian teleparallelism. On April 29, 1932, Einstein expressed his reflections on Cartan's newly published work:

> My coworker, the excellent Dr. Mayer, thanks you very much for your article which he and I have read with great pleasure . . . . I still cannot agree with you on the subject of the "*degré d'arbitraire.*" (p. 213)

Through reflecting and specifying, Einstein questions Cartan's ideas and lays the groundwork for further development. Cartan's answer is a strong enactment of the reflecting mechanism:

> Cher et illustre maître . . . .
> I haven't received the reprints you mentioned but I don't want to wait any longer before replying to your remark on the *degré d'arbitraire* of the general solution of a differential system.
> In order to clear up any misunderstanding, I first remark that . . . .
> After this too long letter, I venture to hope that if we do not yet completely agree, we will at least have shortened the distance between us. I was really touched that on a subject which, as you say, is rather unimportant, you will have had no rest until you came to an agreement with me.
> (April 29, 1932, pp. 217–225)

Cartan makes clear that the exchange has helped *share knowledge* so that they now have a joint understanding

("we will at least have shortened the distance between us"). The increased common ground between the two resulted from careful reflection on the correspondent's ideas and on the detailed expression of one's views. More generally, the act of writing (and the related act of reading) provides writers (and readers) time to reflect, i.e., to deepen their understanding, clarify their thoughts, and better articulate them. Reflecting was crucial in supporting Einstein and Cartan's collaboration because it allowed them to share knowledge, question each other's ideas, and develop the basis for a new theory.

Collaborating Through Writing: Examples of How the Joint Enactment of Writing Mechanisms Supports Distributed Collaboration

Although the above sections presented the four writing mechanisms as analytically independent for purposes of clarity, in practice they are always enacted together by distributed collaborators. Thus, in the sections below, we present two more complex examples that show how writing—through the mechanisms' enactment—supported collaboration at HBC and between the scientists. We then explain how all four work together to support dialogue and thus help distributed collaborators address the dialogical challenges of sharing knowledge, questioning ideas, and developing synergistic solutions.

Enacting the Writing Mechanisms Together in the HBC Correspondence. As the above analysis shows, the four writing mechanisms were crucial for supporting collaboration at HBC. Yet, although we distinguish between the four for analysis's sake, more often than not they work in tandem when supporting the practices that constitute distributed collaboration. Below we present an instance of collaboration between a fort manager, others in Canada, and headquarters that eventually led to the reconstruction of the Moose Factory, a fur-trading post. The example shows how the dialogical process supported by letters allowed the post manager and headquarters to *share knowledge, question each other's ideas*, and *develop a synergistic solution.*

In 1727, Joseph Myatt, the governor of Albany, proposed in a letter to headquarters to rebuild and reestablish the Moose Factory, which had fallen in the hands of the French in 1686, taken back in 1696, only to be then burnt and abandoned. The French had since built a small port on the Hudson River above the Moose establishment, where they were intercepting the Indians and so preventing trades with the fort at Albany. In the fall of 1726, Myatt had sent two men on a first visit to the Moose Factory, located north of Albany. He summarized that visit to headquarters in a letter dated August 12, 1727 (pp. 123–124). Headquarters wrote back on May 24, 1728: "We shall consider of that affair and send you our opinion concerning the same another year; in the meantime we shall expect a farther account from you upon Mr. Bevan return from thence to the Factory."

In his letter on August 5, 1728, Myatt reported sending William Bevan and Joseph Adams to "go and survey Moose River" (Letter 31, p. 130). Myatt noted that the navigation on the river was easy and that they located the previous factory's site. In headquarters' 1729 letter in response to Myatt's suggestion about the Moose Factory, his superiors said they would reply in their next letter (i.e., a year later). In their May 15, 1730[9] annual letter, the committee agreed to build a fort on Moose River. Adams, who had replaced Myatt as the Albany fort manager, supervised the project. Myatt's proposal to reconstruct the Moose Factory proved successful. Indeed, in his original proposal, Myatt promised to take at least 3,000 beavers from the French trade; after one year of full operation, the factory far exceeded that figure: 5,499 beavers were counted (Davies and Johnson 1965, p. xviii).

The example illustrates how effective collaboration—a project proposal, sharing complementary research, a decision, and design guidelines—can take place through letters alone. The writing mechanisms were enacted often jointly throughout the entire exchange between Myatt and then Adams and headquarters. They supported collaboration by allowing distant collaborators to share knowledge, question others' suggestions or decisions in some cases, and eventually develop a synergistic solution. For example, in his annual letter of August 2, 1729, Myatt commented on the Moose River project:

> We observe what your honours have written concerning a factory at Moose River, but have not had any opportunity of making any farther observations of the place, but am still of opinion it would be of advantage to the Company, and all the ill properties that I am capable of judging that attends it, is its being in the mouth of the enemy.[10]
>
> (Letter 35, p. 146)

By referencing what was "written" and thus observed, Myatt shows the power of objectifying. He also reflected on the decision of opening a post on Moose River ("am still of opinion," "that I am capable of judging"), contextualizing some of the concerns (i.e., the close location of a French settlement) expressed by headquarters. By writing, Myatt could *question* his superiors' resistance.

Headquarters' response, which arrived with the *Moose River* sloop on May 15, 1730, explained in detail the different roles and who should take them on (specifying). The letter was offered as proof but was more a performative act of their decision (objectifying) than anything else. For example, headquarters explained that the person in charge of the *Moose River* would be Richard Griffess, but once the sloop reached its destination, he should return the vessel and all its provisions to Thomas Render, its appointed master. The level of detail is a great example of the specifying mechanism in action.

Headquarters' letter also *shared knowledge* from two experts in the form of two "attachments" (objectifying): a plan prepared by Captain Middleton for the proposed fort and a model of it made by Captain Spurrel. Headquarters

noted that although "the Exact Dimensions and Form thereof be strictly follow'd," the Albany council could choose the site. This presents a great example of a *synergistic solution*: the committee provided clear directions based on experts' work but acknowledged the expertise and contextual knowledge of the Albany governor, allowing them trust him to enact their plan for the fort.

As shown in the examples above, letters at HBC were more than just a useful database for accounting purposes; they were also a rich resource of practices developed by the manager. Letter writing and the writing mechanisms played a crucial role in collaborating effectively in a distributed context. In particular, through writing, the post managers and headquarters could share knowledge, question others' perspectives (and sometimes orders), and develop synergistic solutions, such as the reconstruction of the Moose Factory.

Enacting the Writing Mechanisms Together in the Einstein–Cartan Correspondence. The Cartan–Einstein unification theory relied on several postulates by Einstein, one of them being the logical homogeneity of geometry and theoretical physics, an idea to which he subscribed during the 1920s and 1930s; it reflected his ongoing and fundamental search for a unifying theory. In modern terms, this postulate would be that *the* " '*structural equations*' *of the postulated geometric structure must constitute the field equations of the physics*" (Vargas and Torr 2014, emphasis in original). However, Einstein did not have the mathematical apparatus (especially the concept of equations of structure) that would have enabled him to articulate his postulate. Cartan's work on differential forms and tensors, key concepts for the unified field theory (which itself was inspired by Einstein's general relativity[11]), was extremely relevant to Einstein's theoretical endeavor; Cartan had given a mathematical version of this postulate. The notion of generality index played an important role in Cartan's formulation and therefore was often mentioned in his correspondence with Einstein. Einstein tried to reformulate the notion and apply it to justify the system of 22 equations he had developed and did not want to abandon.[12] Cartan, on the other hand, tried to clarify the meaning behind the generality index and show how it leads to the definition of several possible systems of equations. Therefore, agreeing on a common definition of the generality index was imperative to Einstein and Cartan's goal of developing a new theory.

The following example shows how the writing mechanisms, when combined, supported the scientists' engagement in a deep dialogue about fundamental issues in physics and mathematics and how they worked together to elaborate these ideas across time and space. Thus, in a December 13, 1929 letter to which he adds a technical note, Cartan writes the following:

> Cher et illustre maitre,
> I have received your letter and I have read and thought about it. What you say about the degree of indetermination

interests me because I thought, for reasons that I outline in my note but which are a bit personal, that your system of 22 equations was perhaps *too* determined and that its solution did not have a sufficient degree of generality. But in this respect, you are infinitely more competent than I. Nevertheless, I think, that my concept of generality index, which has a precise meaning, may be of some help. If your system, for instance depended, in the sense I indicate in my note, only on 3 or 4 arbitrary functions of 3 variables, it would certainly not be general enough.

You raise objections to some of the systems I mention, objections that I am sure, are due only to the bad phrasing of my letter.   (p. 65)

Cartan explicitly refers to the reflecting process ("thought about it") supported by the objectifying process. Hence, because the ideas have been objectified, they can be discussed by the recipient but also developed and referenced by the writer later. Cartan's style and tone, his use of adverbs such as "perhaps" and "infinitely," and his use of italics demonstrate his respect for Einstein and his desire to preserve the other's feelings (contextualizing). While still questioning his collaborator's ideas, Cartan softens his queries about the degree of generality of Einstein's system by adding, "But in this respect, you are infinitely more competent than I am." He then reiterates his question and adds, "Nevertheless, I think, that my concept of generality index, which has a precise meaning, may be of some help." Cartan here uses specifying and contextualizing to build a common language with Einstein, a necessity for their work toward a unified theory. Cartan then illustrates his claim with a specific example ("If your system, for instance," an example of specifying) and refers to a previous note (objectifying) to ensure that he and Einstein are considering the same interpretation. Contextualizing is also present in Cartan's explanation of Einstein's questions: "Objections that I am sure, are due only to the bad phrasing of my letter." The careful choice of adjectives and adverbs and the balanced structure of the letter (shifting between questioning Einstein's system and praising his expertise) also demonstrate how writing supports the development of subtle arguments (specifying).

The enactment of the four mechanisms allows Cartan in the example above, as well as Einstein in his letters, to enact practices critical to the development of scientific knowledge in distributed collaborations. Thus, the two scientists *questioned each other's ideas* to ensure they were correct, as Cartan's reference to Einstein's objections suggests (objectifying, reflecting, specifying). They could *share knowledge* and so build common ground and link ideas together to *develop* (*in a synergistic way*) *novel understandings and theories*: Cartan explains (objectifying, specifying) how his work on the generality index may be helpful in advancing Einstein's ideas ("I think, that my concept of generality index, which has a precise meaning, maybe of some help"). Despite Cartan's clarifications in

his letters to Einstein, the latter stuck to his own epistemic beliefs and did not implement Cartan's correct advice. Thus, even though their collaboration did not produce a finalized theory, Einstein and Cartan worked effectively to exchange and develop complex ideas that proved the basis of a new theory.

How the Joint Enactment of Writing's Mechanisms Supports Dialogue in Distributed Collaborations

As the vignettes above illustrate, the four writing mechanisms are interdependent; they overlap and support each other. In this section, we briefly summarize how they relate to one another in written exchanges among collaborators.

Objectifying and contextualizing are the two mechanisms at the heart of the writing process; they are intrinsic to distant collaboration. First, the act of writing implies the *objectification* or articulation of an idea or a thought. It produces a written object that can then be shared with distant collaborators. More crucially, it supports dialogues at a distance because it allows not only the exchange of ideas but also the possibility that sender and recipient may reread the object several times and develop and nuance its content. In both the HBC and Einstein–Cartan correspondences, for example, collaborators could communicate because of the letters exchanged. But more than the material (physical) letter, they referred to content that they read several times or, in some cases, shared with others. Thus, objectifying supports the emergence of common ground, which enables dialogue in distant collaborations (Cramton 2001, Kraut et al. 2002). Common ground was also constructed through the contextualizing mechanism. As they objectified their ideas, distant collaborators provided supplementary information that might explain why or how a decision was made or the assumptions girding an argument; they also personalized the knowledge shared or the argument developed to make it easier to understand. When feedback is not immediate and opportunities for clarifying and explaining oneself rare, contextualization is a must for engaging in meaningful dialogue. As background information is objectified, it also becomes a resource to which the recipient can go back to or share with others. At HBC, contextualizing was compulsory for post managers because most members of headquarters had never been to Canada so had no inkling of its working and living conditions or of the relationships that had to be cultivated with Native Americans and other communities. Contextualizing was also important in the scientists' correspondence, as they came from different disciplines and thus needed to provide extra information about assumptions to avoid confusion and miscommunication while developing complex ideas.

Objectifying and contextualizing support the other mechanisms and are reinforced by them. In particular, objectifying and contextualizing entail specifying. As collaborators wrote their ideas down, the "line of the

sentence" forced them to be specific and analytical in the presentation of their ideas. Contextualizing also entails more specification: As writers aimed to provide background information to distant collaborators and to address all possible questions and concerns, the authors added more details: extensive lists, lengthy descriptions, and detailed justifications at HBC; complex equations, subtle distinctions, and detailed arguments between Einstein and Cartan. Reflecting, or taking the time to pause to consider an argument or idea, seems an obvious output of what might be called thoughtful writing, the type enacted in effective distributed collaboration. The asynchronous nature of writing, which makes it a solitary activity, also allows people to reflect while writing. Finally, recipients, who might read and reread the letters they receive, enact reflection, which we saw frequently in the correspondences we analyzed. The nature of reflecting varies in the two correspondences because of the nature of the collaboration: at HBC, coordination; with Einstein and Cartan, the development of a new theory. Yet in both cases reflection was often noted by the senders referring to past letters.

Discussion

Grounded by our analysis of two sets of correspondences, we showed how distant collaborators in different settings—a distributed organization deftly coordinating work across two continents and a pair of distributed scientists partnering to develop a new theory—were able to collaborate via written communication. Our findings indicate that the writing mechanisms we identified—objectifying, contextualizing, specifying, and reflecting—enable such work by supporting dialogical communication. Inspired by a literacy-oriented view of writing, which acknowledges writing's importance in knowledge creation as well as its dialogic nature, we illustrated how an examination of written communication can advance our understanding of collaboration in general and, in particular, distributed collaboration in the current era of technology-mediated communication where distributed work is now the norm (DeSanctis and Monge 1999, Gibson and Gibbs 2006) and where even collaborations among coworkers in collocated organizational settings rely extensively on written communication (Baron 2008, Byron 2008).

In the cases we studied—a formal organization where post managers communicated with the committee at headquarters and an informal collaboration between two scientists—distant collaborators could take part in productive written dialogue and thus in effective collaboration because they enacted four writing mechanisms. As they wrote, they objectified their ideas and shared them across distance and time, thus allowing joint activity. They contextualized the presentation of their ideas; i.e., they provided background information and shaped the message to compensate for the slower "turn-taking sequence" of

letters (as opposed to oral conversations, where the speakers exchange information more rapidly). Recognizing the need to provide as much information as possible in the absence of "live" turn taking, collaborators in the two cases articulated their ideas thoroughly and provided many details. Finally, they often explicitly reflected on their understanding of a previous letter and/or a decision or argument they presented to their distant collaborator. Although the four mechanisms are important in supporting distributed collaboration, they are not necessarily all enacted together or at the same level. The mechanisms and their level of enactment fluctuate depending on various factors, such as the nature of the work (coordination or creation of new knowledge) and the type of organizational context (e.g., formal or informal, one to many, a duo versus a small team). As they enacted the writing mechanisms and engaged in dialogue, the distant collaborators we studied shared knowledge (Cramton 2001, Kraut et al. 2002), coordinated actions and practices (Faraj and Xiao 2006), and, in some cases, developed new understandings (Tsoukas 2009)—all key to effective collaboration.

By unveiling the possibility of engagement in written dialogue, our findings extend dialogical perspectives on coordination (Faraj and Xiao 2006) and knowledge creation (Tsoukas 2009). Whereas these perspectives examined what happens in collocated settings and speech-based interactions (Faraj and Xiao 2006, Tsoukas 2009), we show how written exchanges supported coordination and knowledge creation among distributed collaborators. Although some scholars have called for further development "to accommodate the mediated environments in which knowledge creation takes place" (Tsoukas 2009, p. 954), research on coordination and knowledge creation has not until now examined directly the role of writing in these fundamental processes. When that view was incorporated, the studies tended to emphasize writing's ability to record and thus provide a set of shared understandings; the studies did not unpack how writing supported a nuanced and meaningful dialogue among distant collaborators (Yates 1989a, King and Frost 2002, O'Leary et al. 2002). In contrast, our findings identify the specific mechanisms through which writing enables complex, precise, and subtle exchanges among faraway collaborators. Our conclusions thus advance understanding of the major role played by the written word for (distributed) collaboration.

Furthermore, our study calls for a "balanced" view of communication processes in distributed collaboration where both oral and written communication play important and complementary roles. Scholars have long stressed the need for collocation and face-to-face communication for successful partnerships (Kraut et al. 1988, Olson et al. 2002). Although such research acknowledges the possibility of distributed collaboration relying primarily on writing, it tends to explain it via the rare, face-to-face encounters that took place (Kiesler and Cummings 2002, Kraut et al. 2002). However, multiple studies have described

successful contemporary distributed collaborations where collaborators were never (or only rarely) collocated and where their interactions were mainly written. Such distributed collaborations include the development of complex products in open-source software (Kogut and Metiu 2001, O'Mahony and Ferraro 2007), the formulation of novel solutions to problems in open innovation efforts (Lakhani and von Hippel 2003, von Hippel and von Krogh 2003), knowledge sharing among professionals (Fayard and DeSanctis 2005, 2008; Wasko and Faraj 2005), coordination between freelance technicians and their employers (Barley and Kunda 2006), and the successful collaborative design of a new airplane engine (Malhotra et al. 2001). Our findings can explain the success of such partnerships, which rely almost exclusively on writing, suggesting that distant collaborators in those cases were supported in their work by the enactment of the four mechanisms, which help support written dialogue. Our findings about how the writing mechanisms support deep and meaningful dialogues among distant colleagues also help explain how distant collaborators can develop as strong perceptions of proximity as those who are collocated (Wilson et al. 2008, O'Leary et al. 2014). Thus, our findings suggest that further examination of writing practices in distributed collaborations can illuminate its role in fundamental processes in distributed work.

Although our argument about writing's ability to support distributed collaboration is based on an examination of historical correspondences that represented extreme cases for their quasi-reliance on writing, our findings have implications for current collaborations that rely on a variety of communication media (both written- and oral-based). Indeed, the current proliferation of media and technology offers an important opportunity to reflect on how we collaborate at a distance via writing. Although "face-to-face" communication was not an option in cases like the ones we presented, today's technological developments raise questions, such as how important is collocation for dialogue? Can Skype-like tools solve the collaboration problem for those who are distributed across time and space? Our perspective on writing as dialogic communication suggests that dialogue does not need to be face-to-face or colocated.

More critically, our findings point to the need to rethink the role of both face-to-face and written communication in supporting collaboration in today's mediated contexts. In particular, we suggest that writing is not simply a replacement, something second-best to face-to-face communication. Indeed, writing is an important, often necessary, complement. This is why Skype-like tools, which engender easy, inexpensive oral communication, cannot replace written communication in successful collaborations. This is not to say that face-to-face encounters did not matter in our findings; at HBC, canoe visits occurred (O'Leary et al. 2002), and Einstein met with Cartan. For the latter, face-to-face interactions, rare as

they were, were important. In fact, more often than not, the process of collaboration involves numerous instances of both written and oral communication. Still, writing played an important role in supporting the dialogue by allowing collaborators to be specific and reflective.

In their study of a contemporary design organization, Sutton and Hargadon (1996) also show the importance of writing even in brainstorming, a situation that tends to epitomize face-to-face collaboration. They show that for all the emphasis on face-to-face brainstorming, "facilitators playfully enforce the rules and write or sketch suggestions on the board" and later "collect sketches and lists from participants, which they use to write a brainstorming report and to guide their subsequent work" (p. 694). Although we did not compare the enactment of dialogic communication in oral and written forms—instead focusing on written exchanges to show the role writing can play in distributed collaboration—we acknowledge the complex imbrications of written and oral communication and their role in collaboration. Careful studies are needed to show how both forms of dialogues (face-to-face and written) work together and enhance each other in collaboration. Another interesting avenue for future research would be to explore how the extent and nature of contextualizing varies not only with the existence (and rhythm) of face-to-face interactions but also with the frequency of written exchanges.

Our argument about the possibility of dialogue and distributed collaboration via writing does not overlook the fact that various kinds of writing vary in their ability to support a productive dialogue. Thus, short-text messages, chat, or even brief emails, although text-based, often do not enact the writing mechanisms and therefore do not support a truly productive dialogue. In some cases, without enacting the mechanisms, miscommunication can occur and collaboration can be hindered. For example, in the absence of contextualizing, problems can be misinterpreted, thus preventing the development of a solution and, on occasion, stoking an escalation in tone and then a conflict. Moreover, the increased connectivity and mobile nature of the communication technology make communication nearly synchronous, thus limiting reflection. In our world of fast-paced communication, people lose track of the message (which seems to be less and less objectified), failing to reflect upon it before replying (Fayard and Metiu 2013). This can also lead to miscommunication and potential conflicts. The nature of the medium (e.g., a small screen), the context of use (e.g., the street, train station, airport), and the expectation to be "always on" (Byron 2008) often impair the enactment of the writing mechanisms and the possibility of developing a dialogue and collaborating through writing. Although (as suggested above) we have many examples of successful distributed collaborations—past and present—that rely mainly on writing, it is important to be aware of the potential impact of new media on the enactment (or lack thereof) of the

writing mechanisms and the disastrous consequences it might entail for distributed collaboration. Interesting and relevant research questions regarding the possibility of truly engaging in written dialogues using new technologies arise: How do varying degrees of asynchronicity and other factors such as communication devices' features (e.g., size, wireless) and quasi-ubiquitous connection influence the ability to enact the writing mechanisms? How do emerging communicative practices and users' expectations about the possibility of enacting written dialogues evolve with changing media features?

Although we focus on asynchronous written interactions, collaboration also involves other forms of two-dimensional representations, such as drawing, sketches, and other forms of visual thinking as practiced by engineers, architects, and designers. Studies of knowledge creation and collaboration (Henderson 1991, Carlile 2002, Bechky 2003, Ewenstein and Whyte 2009) have highlighted the role of visual practices in supporting collaboration among various groups by allowing knowledge sharing, as well as debate and the development of synergistic solutions. These visual representations seem to support a role by enabling a dialogue across diverse groups (Carlile 2002, Bechky 2003), as well as by allowing collaborators to share knowledge, question ideas, and develop synergistic solutions (Henderson 1991, Ewenstein and Whyte 2009). We suggest that, as such, these representations enact the writing mechanisms and thus support dialogue. For example, drawings and sketches support the objectification and specification of ideas and therefore allow engineers, architects, and designers to share their work, as well as reflect upon it. Thus, our research perfectly aligns with the literature on visual practices and provides a deeper explanation of the mechanisms that enable visual collaborative practices. Future research could explore how the writing mechanisms provide an understanding of visual practices, especially in collaborative settings.

Conclusion

Organizational scholars have long recognized the possibility of complex collaborations across distance (King and Frost 2002, O'Leary et al. 2002). Less understood is writing's role in the dialogue necessary for collaboration (Orlikowski 2002, Hardy et al. 2005, Faraj and Xiao 2006) and the specific mechanisms through which written exchanges support work collaborations (Fayard and Metiu 2013). This study focused on the role written communication plays in enabling distributed collaboration, and it identified communication mechanisms that make distributed collaborations possible and successful. By explaining how written communication enables such collaborations, we expand our understanding of the dialogical processes involved in distributed, as well as colocated, collaboration because colocated efforts also rely in part on written communication. Future studies of collaboration

may benefit from a deeper exploration of the role of writing mechanisms and dialogue in coordination and knowledge creation.

Endnotes

[1] See Oliveira and Barabási (2005) for an analysis of the writing patterns of Einstein and Darwin's correspondence and the similarity between letters and emails.

[2] All quotes for HBC correspondence are excerpts from Davies and Johnson (1965); all quotes from Einstein and Cartan's correspondence are excerpts from Devever (1979).

[3] Whereas Einstein and Cartan's correspondence includes all letters received and sent, the HBC correspondence features just the letters of post managers to headquarters; however, the edition we used has a very detailed introduction and extensive notes that provide contextual information and many quotes from headquarters' letters—proof that they were part of a dialogue.

[4] The correspondence between posts was prepared in triplicate: one for the recipient, one for the originator, and one for London. This practice emerged after 1740 (Glover 1965) to support better knowledge sharing and coordination.

[5] We designate letters exchanged by the HBC by the letter's number and by the page number in which it appears in the volume.

[6] That is, a helper.

[7] As literacy scholars have shown, without writing, logic and mathematics would not have developed (Goody 1987).

[8] An indent is an official order for specified goods.

[9] Note 2, Letter 37, page 153 in Davies and Johnson (1965).

[10] Myatt refers here to the fact that "the French have a small settlement not far from" Moose River (Letter 35, p. 147).

[11] For a more detailed discussion of the conversation on relativity and differential geometry between mathematicians and theoretical physicists, see Goenner (2004).

[12] According to Devever (1979, pp. x–xi), this is symptomatic of Einstein's working methods: he had to rethink, in his own way (sometimes making mistakes), another's work. Moreover, Einstein found his own version of 22 equations and from there was only interested in proving his version, discarding any other possible solutions.

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