

ADVANCED TECHNOLOGY AND ENDTIME IN ORGANIZATIONS: A DOOMSDAY FOR COLLABORATIVE CREATIVITY?

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Forthcoming in *Academy of Management Perspectives*, 2020

Published Online: 24 Apr 2020. <https://doi.org/10.5465/amp.2019.0040>

ABSTRACT

Our capacity to tackle grand challenges facing humanity depends on collaborative creativity. Increasingly, such collaborative creativity is affected by advanced technology such as mobile technology, virtual communications, and algorithmic computing. We use a temporal lens to study the potential of advanced technology to influence collaborative creativity. Prior studies have found that inner time and social time are critical for collaborative creativity. To creatively and purposefully contribute to collaboration, inner time – a temporal capacity to reflect on actions, meaning, and consequences over time - is required. Also necessary is social time—the time spent with others—to practice giving and taking of multivocal ideas and perspectives. What has not been well scrutinized in the organization and management literature is whether advanced technology might suppress both inner time and social time. In this paper, we advance future-oriented conjectures on the potential role of advanced technology on such temporal capacity. Included in our projections is a futuristic doomsday in which advanced technology has

extinguished inner time and social time and hence curtailed collaborative creativity. We advance policy considerations for avoiding such an “endtime” scenario in organizations and societies.

INTRODUCTION

How will advanced technology affect human capacity to collaboratively address grand challenges? Business, government, and academic leaders alike call for new, creative solutions for the world’s pressing problems: food and water scarcity, climate change, poverty, and human trafficking, for example (Marti, 2018; Seidel et al., 2013). That no single individual or organization alone can do much to solve these grand challenges is well accepted, and the recognition has led to calls for collective creative processes (Dorado & Ventresca, 2013; Eisenhardt, Graebner, & Sonenshein, 2016) that bring together heterogeneous actors (Furnari, 2014; Jarvenpaa & Valikangas, 2016) and engage them “over prolonged timespans” (Ferraro, Etzion, & Gehman, 2015: 373).

Because grand challenges are by definition complex, advanced technology are called for to augment collaborative creativity (Becker, vom Brocke, Heddier, & Seidel, 2015). Following Huber (1990), we consider advanced technology to include various material artifacts that compute, automate, augment, digitize, and mobilize work in organizations. Advanced technology

is shaping the frontiers of what humans in organizations can accomplish both alone and together (Beane, 2018; Burton, Stein, & Jensen, 2019; Davenport, 2018; Faraj, Pachini, & Sayegh, 2018; Raisch & Krakowski, 2020). While some researchers suggest that advanced technology can augment human efforts (Raisch & Krakowski, 2020), others are concerned about the potential of advanced technology to impose a particular rationality (Lindebaum, Vesa, & den Hond, 2019). Still others envision technology not just as acting as a servant to human endeavor but also as shaping, or pre-empting, that very action (Kallinikos, 2004, 2009; Demetis & Lee, 2018)—and even as constructing humans as artifacts that the technology can manipulate (Kallinikos, 2004). With advanced technology, collaborative creativity might be weakened, thus closing the window on opportunities (Tyre & Orlikowski, 1994) to respond to grand challenges.

In this paper, we are concerned about the effects of advanced technology on temporal reflexivity, that is, questioning, articulating, and reconsidering temporal assumptions and exploring their alternatives in organizations and management (Reinecke & Ansari, 2015). Prior studies in organizational research and management literatures have made multiple calls for such a concern (Antonacopoulou & Tsoukas, 2002; Kaplan & Orlikowski, 2013; Orlikowski & Yates, 2002; Woolgar, 1988). Orlikowski & Yates (2002: 698) write that “[t]emporal reflexivity – being aware of the human potential for reinforcing and altering temporal structures” that is, coordinating organizational activities through timing and pacing – “is essential if we wish to act with effect in our world.” Human agency is, fundamentally, temporally grounded (Emirbayer & Mische, 1998) through its ability to reflect upon and assess actions over time and relate with others. We therefore choose to examine the effect of advanced technology on collaborative creativity from a

temporal perspective. How does advanced technology influence temporal capacity for collaborative creativity in organizations, and why?

Responding to calls for prescient or future-oriented thinking and theorizing (Corley & Gioia, 2011; Shepherd & Suddaby, 2017), we project literature-based conceptions into the future to examine anticipated developments in collaborative creativity and advanced technology through a temporal lens. Our aim is to assess what we need to know and what conversations academicians and practitioners should be having in relation to temporal aspects of collaborative creativity. We frame our conclusions regarding these conversations as policy recommendations that would enable collaborative creativity to be maintained at a broad scale.

The paper proceeds as follows: First, we review research in the organization and management field to see how the temporal capacity of social and inner time influence the literature on collaborative creativity and grand challenges. Second, by reinterpreting existing studies in organizations and management as well as information systems, we infer how advanced technology might influence collaborative creativity through their effects on social and inner time. Third, we construct examples of how these inferences can be extrapolated, as future projections, to imagine and illustrate future possible worlds. In examining the potential influences of advanced technology on temporal capacity, the purpose is to make the resulting policy consequences of our analysis explicit and urgent. Thus, with these futuristic examples, we aim to be provocative rather than to argue for certainty in our predictive accuracy. To avoid an endtime scenario, we conclude that attending to the temporal elements of collaborative creativity is

increasingly urgent in light of the automation and intermediation offered by advanced technology.

GRAND CHALLENGES, COLLABORATIVE CREATIVITY AND TEMPORAL RESOURCES

In the literature addressing grand challenges, collaborative creativity is deemed essential. Collaborative creativity is defined as the ability to contribute and combine ideas in interaction with others (Amabile, 1983, 1990; Carlsen, Clegg, & Gjersvik, 2012; Harvey, 2014). Ideas need to be useful but also novel (Grant & Berry, 2011). George, Howard-Grenville, Joshi, & Tihanyi (2016: 1869) call for bold and unconventional ideas “to tackle large, unresolved managerial or societal problems.” Ferraro et al. (2015) write that multivocality and its integration is critical for grand challenges, as is forestalling disengagement. Resolving grand challenges requires a give and take among diverse perspectives, so that participants are able to communicate their own ideas, are open to each other’s ideas, and can constructively challenge and critique their own and each other’s inputs (Elsbach & Flynn, 2013; Elsbach, 2019).

Grand challenges require participatory architectures, multivocality, and broad experimentation (Ferraro et al., 2015). The significance of this type of relationality is recognized by other scholars as well. Jarvenpaa and Välikangas (2016) note the importance of networks in collaborating on discovery-driven research, and Koschmann, Kuhn, and Pfarrer (2012) emphasize cross-sector partnerships in addressing social problems. Studies also recognize that solution-seeking happens over time. In their study of five companies’ organizational responses to

climate change, Slawinski and Bansal (2015: 1559) found that “what differentiated these companies was their approach to time.” That is, understanding time as linear or cyclical shaped the openness of companies’ responses to climate change: A linear time conception led to more immediate short-term fixes whereas a cyclical time conception was more long-term oriented, tolerant of uncertainties involved.

Collaboration, by definition, is about interacting with others. Meanwhile, collaborative creativity requires time as a resource (Adams, 1990). We combine these elements of interaction and the passage of time in the term, *social time*. However, creativity that leads to novel and useful ideas requires more than social time; it also involves *inner time*. In this conceptualization, we consider the qualitative nature of time (unlike clock or calendar time, for example) and we rely on Huy’s (2001) study of temporal capabilities. Huy (2001) argued that the combination of social and inner time is essential for managing planned organizational change. We next consider the relationship of inner time and social time to collaborative creativity.

Inner time. We define inner time as a temporal resource during which people can engender unique and useful ideas. Inner time itself does not produce these ideas; but without inner time, individual creativity tends to remain superficial and cannot feed or contribute to collaborative creativity.

For Huy (2001), inner time concerns a person's subjective experience at a particular moment and its simultaneous extension into the present, past, and future. This definition addresses two important perspectives. First, collaborative creativity requires an ability to imaginatively contribute ideas from one's subjective experience (Dawson, 2014; Weick, 1979; Bakken et al., 2013). Second, these ideas are situated in the flow of time (Ford, 2000; Fortwengel et al., 2017). Citing Whitehead (1920), Reddy, Dourish, & Pratt (2006:30) note that "[t]ime is experienced as a continual movement. What we experience as the present is the vivid fringe of memory, tinged with anticipation." Subjective experiences and reflections of their meaning over time—interacting as past, present, and future—catalyze human agency (Emirbayer & Mische, 1998).

Inner time gives people the opportunity to hone their ability to imagine and reflect; without it, they lose this ability. Imagination requires seeing what others cannot see; these visions then can be used to actively challenge what is or has been; to initiate paths that deviate from the current reality; and to evoke possible futures with alternative "what if" hypotheses (Patvardhan & Ramachandran, in press). Inner time brings emotional energy, as well as the determination to proceed down unfamiliar, untraveled paths. In Huy's view (2001:608), "[i]nner time allows us to relive the past and pre-live the future in the present"; it makes temporal reflection possible, including considerations related to causality and consequences of actions.

Inner time gives a temporal orientation to a subjective self and the production of ideas, and their meaning, through time. Such inter-temporal experience is an intrinsic property of consciousness (George & Jones, 2000). The connection between temporality and a subjective self is also made by Bakken, Holt, and Zundel (2013: 18), who state that "[t]his ground [of temporality, or world

time] permits humans to find themselves, the surrounding world, and others along with them as they project themselves in action.”

Studies on grand challenges point to the relevance of inner time (George et al., 2016). Inner time is connected to operative choices involving short-term versus long-term orientations, plans, and goals. For example, in their study of business sustainability, Slawinsky and Bansal (2015: 1558) find that organizations connecting “the past, present, and future exhibit a greater willingness to make long-term investments.” Inner time is the space in which temporality and a subjective self become integrated, and this integration, as inner time, is at the core of people’s and their organization’s ability to act creatively (Amabile, 1988), purposefully (Cardinale, 2018), and reflectively (Seo and Creed, 2002). As such, inner time constitutes a temporal resource for collaborative creativity, through which grand challenges can be addressed.

Social time. As already noted, collaborative creativity relies on not just inner time but also on social time. We define social time as a necessary temporal resource for the ability to give and take or, in other words, to share and integrate ideas by engaging with others. Social time does not produce collaborative creativity, just as inner time cannot. However, without social time, no collaborative creativity can take place.

Social time, according to Huy (2001), is characterized by bonding and shared meaning-making. Social time is the time spent with others – being available in “the embedded process of social

engagement” (Emirbayer & Mische (1998: 963) and combining one’s ideas with those of others (Amabile, 1990). Different and divergent knowledge and perspectives are pursued in a shared understanding, novel to the problem at hand (Harvey, 2014). Inconsistencies between competing, sometimes conflicting perspectives can give rise to disagreement, but more significantly, they also engender an opportunity for integrating differences and varying perspectives (Harvey, 2014). Such a creative synthesis increases the chances for breakthrough ideas, as well as for a shift in the understanding of what a good idea or a better question is (Brown, 1978; Hardagon & Bechky, 2006). Harvey (2014: 330) states that “[t]he ‘better question’ might open up new possibilities that were unlikely to be considered within the previous interpretation.”

The integration of ideas and their broader assimilation (Elsbach & Flynn 2013; Elsbach, 2019) among diverse or even interstitial members requires social time. Furnari (2014: 441) finds that social time, as spatially and temporally bounded social interactions, “produce high levels of mutual attention and emotional energy.” Social time hence goes beyond chronological or event-based temporal markers for activity coordination (Orlikowski & Yates, 2002). Social time is not just clock or event time, it is engagement with others. Nevertheless, conflict can arise if pacing norms are not shared, and if normative temporal markers are transgressed (Aeon & Aguinis, 2017; Gersick, 1988, 1994).

Social time is recognized as a necessary concept in social change (Sorokin & Merton, 1937: 615). However, change in organizations or institutions cannot be guaranteed by social time. Instead, social time might add to an illusion of the irreversibility of change just accomplished (Granqvist & Gustafsson, 2016) or social time might contribute to structural stability (Huy, 2001). Although outcomes depend on the quality and character of social time, studies on grand

challenges speak to social time as essential. It has been found to promote “industry-wide collaborative initiatives” (Slawinsky & Bansal, 2015: 1560). Slawinsky and Bansal conclude that in its capacity to encourage information-sharing and dialogue, social time may motivate firms to respond to climate change and hence promote sustainability.

Collaborative Creativity and Inner and Social Time. We conclude that inner time and social time are both required for the production of collaborative creativity. Inner time leads to multivocality in social time through the differentiated, subjective experiences of each person’s autonomous imagination and reflection; inner time does not demand an explicit consensus (Furnari, 2014; Garud, Dunbar, & Bartel, 2011). Social time then provides the temporal opportunity to voice and negotiate among these different and multivocal perspectives, as social time participants give and take ideas and integrate them into new understandings. Hargadon and Bechky (2006) coined such collaborative creativity as “reflective reframing,” in which individuals “respectfully attend to and build upon the comments and actions of others” (Hargadon and Bechky, 2006: 489).

Table 1 provides a matrix of our conclusions on inner time and social time in relation to collaborative creativity. When social time and/or inner time is lacking as temporal resources, their absence constrains collaborative creativity – either in terms of the ability to contribute novel

ideas based on one's subjective, intertemporal experience (inner time) or the ability to give and take ideas and integrate them with the ideas of others (social time). In the context of grand challenges, inner time sustains "different interpretations among various audiences with different evaluative criteria, in a manner that promotes coordination without requiring explicit consensus" (Ferraro et al., 2015: 373). This inner time-enabled multivocality is acknowledged as essential in tackling challenges that require multi-party collaboration (Jarvenpaa & Välikangas, 2016). Social time constructs the participatory architectures that "facilitate the engagement of diverse stakeholders in a series of temporally and spatially interconnected events, thereby setting in motion an ongoing process" (Ferraro et al., 2015: 37). Silicon Valley's Homebrew Computer Club is a documented example of people from varying backgrounds—hippies and engineers alike - coming together to share ideas about the future of computing (Markoff, 2004) and how those club gatherings became influential for how a personal computer developed. Furnari (2014: 32) also underscored the importance of simultaneously integrating such social time and inner time: Designing innovations requires "[an] appeal to the diverse individuals interacting in interstitial spaces" such as computer clubs (social time as a temporal resource) and open-mindedness that is not constrained by "the potential evolution of understanding and action that follows use" as in the potential development of personal computers and their use that differed from the dominant industry norms (inner time as a temporal resource). Thus, both social time and inner time appear to be critical in enabling collaborative creativity.

Table 1. Inner Time and Social Time as Temporal Resources for Collaborative Creativity

<i>Inner Time</i>	Present	Constrained collaborative creativity: loss of ability to give and take, and integrate ideas	Enabled collaborative creativity: ability to balance inner and social time
	Absent	No collaborative creativity	Constrained collaborative creativity: loss of ability to contribute novel ideas based on subjective experience
		Absent	Present
		<i>Social Time</i>	

In the organizational and management literatures, both inner time and social time reflect strong, endogenous views of time, such as “time is in us” and “time for us” (Holt & Johnsen, 2019). Holt and Johnsen (2019) call for more exogenous views to access “beyond time-for-us or time-without-us” (Holt & Johnsen, 2019: 10). Both inner time and social time are vulnerable, or open, to exogenous influences, including societal structures, external norms, and technological intermediation or automation. For example, Bluedorn and Waller (2006) argue that social time is affected by private/public ownership and societal norms and values. Their writings imply that temporal capacity might be susceptible to both endogenous and exogenous factors, including technology, that change priorities, relationships, and modes of engagement. Advanced technology has become ubiquitous; it is transforming work environments in organizations along trajectories shaped by social relations and actions (Adler, 2006). Such technology can have significant effects on inner time and social time, thus also affecting collaborative creativity in ways that potentially go unnoticed by organizational participants.

ADVANCED TECHNOLOGY AND COLLABORATIVE CREATIVITY

In this section, we consider the role of advanced technology in collaborative creativity. We do so by raising the questions: How and why does advanced technology influence inner time and social time (if at all)? Advanced technology has become ubiquitous in nearly all facets of organizational life, so that its influence on temporal capacity of collaborative creativity deserves further study. Advanced technology increasingly automates routines and practices through autonomous algorithms in ways that might not be transparent to organizational members (Davenport, 2018; Faraj, Pachini, & Sayegh, 2018; Burton et al., 2019). This potential lack of transparency increases the importance of forward-looking and prescient analysis.

Organization and management literatures suggest that technology structures inner and social time, and this structure coordinates organizational action and directs individual reflection. A seminal study by Thompson (1967: 59–60) examined the effects of the mechanical clock and found that the clock changed the workflow from “natural rhythms” to “labor timed by clock.” The change transformed “work” – both its conceptualization and its practice – with respect to the notions of speed, punctuality, and calendaring.

In the past few decades, temporal structuring of organizations (Orlikowski & Yates, 2002; McGrath & Rotchford, 1983; Yakura, 2002; Yli-Kauhaluoma, 2009) has been the dominant theoretical lens in organization and management literature, focusing on temporal coordination of work activities. In an early study, Barley (1988) described how computer-based radiology equipment changed the way users experience time –specifically, the “temporal order” of work.

The technology allowed users to alter temporal constraints by aligning the flow of work between radiologists and technicians. In some cases, this alteration of flows involved one group of technicians – sonographers – who were able to decouple their work from the availability of radiologists and to engage in independent meaning making (inner time) that formerly had to involve counseling with radiologists (social time).

Orlikowski and Yates (2002) studied temporal coordination among a group of geographically and organizationally dispersed researchers working to finalize a computer language. The collaborative technology was an email distribution list. The researchers adjusted their prior draft-based work structure to conference events (e.g., a meeting of the American Association for Artificial Intelligence) and to cutoff dates and manual deadlines imposed by the coordinator. Social time provided a rhythm for inner time as the group worked to finalize a shared dialect of the LISP language while using a temporal structure that was different from prior, occasionally contested, collaboration in the group. Other research has focused on how time is accessed and experienced (e.g., Ancona, Goodman, Lawrence, & Tushman, 2001) and on the presence of and responses to temporal pluralities and their reconciliation (e.g., Kunish. Bartunek, Mueller, & Huy, 2017; Reinecke & Ansari, 2015; Slawinski & Bansal, 2015). This rich stream of literature, focusing on temporal structuring, views time as an external coordinator more than as endogenous resources for collaborative creativity.

Various authors have addressed collaboration mediated by technology and have reflected on its effects on experienced time. Technology can redefine temporal boundaries in enlarging or transforming both social time and inner time (e.g., Barley et al., 2011). In virtual collaborative work, for example, temporal boundaries become reshaped by constant (or instant) accessibility

and by virtual presence (e.g., Sarker & Sahay, 2004; Rutkowski et al., 2007). In a study of virtual teams that relied largely on asynchronous email communication, O’Leary and Mortensen (2010) found that isolates (i.e., individual team members at a particular company site) not only increased their other-focus (social time) but also engaged in more reflection (inner time) to refine their distinctive contribution to the team, compared to their team members working at sites with multiple members.

Other studies paint a less positive picture of technology’s influence on social time and inner time. For example, technology might be reducing human agency when giving and taking of ideas and inner reflection are absent. In their study of Internet search engines, Kallinikos et al. (2013: 365) found “an ongoing disembedding of content production from local settings” and instead, a move toward a “generic context, marked by the interplay between global search engines and search engine optimization efforts.” Available information is... “dominated by the search engines and the findability practices and techniques they disseminate.” Recent research in the information systems literature has found that technology can have debilitating effects on human agency and collaborative creativity (Demetis & Lee, 2018). Although the research does not explicitly examine social time and inner time, we argue that the fading of these temporal resources can have similar negative effects. We consider three conjectures that relate to the effects of advanced technology on inner and social time, and we ground these conjectures in extant management and organization literature and on information systems literature.

Table 2 summarizes some of the reviewed literature through the lens of social and inner time. Many of these studies did not explicitly distinguish between social time and inner time. Hence, the interpretation of inner time and social time is ours, not that of the original authors. In

addition, collaborative creativity was often implicit because studies focused on processes rather than outcomes.

--insert Table 2 about here ---

Advanced Technology and Inner Time

As organizations become saturated with advanced technology, inner time can become reduced. Advanced technology offers flexibility at work, making virtual work possible (Barley et al., 2011). Yet such flexibility might require a capacity to postpone action or responses to requests in the interest of temporal reflexivity – that is, in the interest of inner time (Ryden & El Sawy, 2019). Others report that enforcing temporal boundaries and “segregating activities” between work and life might be easier in more senior than junior positions (Prasopoulou, Pouloudi, & Panteli, 2006). Mazmanian, Orlikowski, and Yates (2013) recognize the benefits of individual autonomy enabled by mobile and Internet technology but they also imply that advanced technology can result in a decline in inner time. Mazmanian et al. (2013: 1337) writes that knowledge professionals using mobile technology “restrict their autonomy as they choose to be technologically connected to work at all hours of the day and night.” Research finds an “implicit understanding among... close collaborators regarding their ‘anytime’ availability” (Prasopoulou et al, 2006: 281). Barley et al. (2011) found that some of their interviewees took pride in their accessibility yet complained about stress related to email.

Reduced inner time is a potential constraint on collaborative creativity. The constant attention online or instant responses – either because of social pressures or because of the fear of falling behind or losing out (Barley et al., 2011) can crowd out collective creativity. Gerlach and Cenfetelli (in press) discuss what they call technology-mediated state-tracking, whereby people continually attend to technology to close the information gap between what they know about the world and its actual state. These studies are indicative of the potential for inner time to become reduced and even extinguished as a result of continuous time demands, social and performance pressures, and the difficulty of maintaining boundaries that would allow disconnecting. In sum, the experience of inner time is lost as a temporal resource of reflexivity (Berends & Antonacopoulou, 2014). Our first conjecture focuses on inner time becoming reduced and its constraining of collaborative creativity.

Conjecture 1. Advanced technology can lead to reduced inner time and reduced inner time results in less collaborative creativity.

Advanced Technology and Social Time

As advanced technology penetrates nearly all facets of organizations, it reduces social time. This is evident despite the possibilities for collaborating online, asynchronously, and across distances of time and geography. This collaboration often is studied in terms of the ability of virtual teams to accommodate differences in viewpoints (e.g., Sarker & Sahay, 2004) and to still be productive (Rutkowski, Saunders, Vogel, and & Genuchten., 2007). Cramton (2001) highlighted how differences in organizational contexts and local situations, and in the absence of face-to-face interaction, created challenges for team members trying to maintain an other-focus and to

establish a shared understanding. Saunders, Van Slyke, & Vogel (2004) also reviewed global virtual team literature and noted that technology brings individuals together from different cultures but without the capabilities needed to negotiate the different time perceptions and norms. In a study of off-shore software development, Cummings, Espinosa, and Pickering (2009) found that little “social time” occurred when natural overlaps of regular working hours across time zones were lacking. Lee (2003) found that as communication within and between organizations became computer-mediated, people working together had fewer chances for face-to-face interactions. Organization members were found to review their colleagues’ calendar not primarily to set up meetings but rather to “locate them.” The separations of space and time for virtual teams might even result in suspicion (Sarker & Sahay, 2004). These studies suggest that, despite the virtual online connectivity, advanced technology may reduce social time or even render it nonexistent.

Reduced social time has negative ramifications for collaborative creativity. Advanced technology can standardize, colonize time zones, and create isolated spaces (Barrett & Scott, 2004), preempting multivocality across more open communication spaces. Such settings can deprive organizational actors from meaningful social time to join participatory architectures and engage with others. Further, as algorithmic decision-making may deny humans any opportunity to collectively consider their options before the (machine-rational) choice has been made by the computer (Lindebaum et al., 2019), collaborative creativity would become essentially nonexistent. We thus conjecture that collaborative creativity becomes constrained because of reduced social time, despite the possibility for virtual connections mediated by advanced technology.

Conjecture 2. Advanced technology can lead to reduced social time and reduced social time results in less collaborative creativity.

Advanced Technology and Both Inner Time and Social Time

We now turn our attention to the potential of advanced technology to impact inner and social time both at the same time. In some studies, for example Silva and Mousavidin (2015), there are suggestions that advanced technology, such as video gaming, may actually enhance the two. They found evidence of “articulated strategic thought and subsequent actions” (p. 9) by players familiar with the massively multiplayer online role-playing game (MMORPG) game. Players achieved benefit in their strategic thinking through their rehearsal of gaming strategies. They also suggested social time spent playing together was important: “A player who wants to succeed in this game must learn... how to associate and cooperate with others” (p. 172). Thus both inner and social time benefitted.

However, other studies have found that social and inner time may be at risk simultaneously and irreversibly. In a study of electronic trading systems, Barrett and Scott (2004) examined a global, never-ending trading workday, offering new profit-making frontiers. Their focus was on understanding how technology is coordinating, directing, suppressing, and changing work practices. The traders were concerned about being “structured away” by new electronic trading (p. 75) and the necessity to acquire new skills in virtual trading pits. They expressed a fear of becoming a work “dope,” having a limited life cycle as a trader, and working in global time

(including nights). These changes meant a likely loss of both inner and social time due to all-consuming work practices.

Social and inner time might be lost not only because of the possibility of 24/7 virtual collaboration but also because there is no need for social and inner time in automated operations. For example, the window of opportunity for influencing the characteristics of how work is performed might narrow or close altogether (Tyre & Orlikowski, 1994). Sawyer and Southwick (2002) similarly found that once a particular technology becomes embedded in the work environment, the human capacity to influence its further design or functioning goes away. In a study of an enterprise resource planning (ERP) system, human participation was invited “along highly-structured action patterns” (Kallinikos, 2004: 265). An ERP system specifically sought to capture resource flows and organizational structures and processes in an abstracted, machine-represented, way. No inner and social time was required for output production; no collaborative creativity was called for. These studies reveal ways in which advanced technology has taken control of work life, offering glimpses of a world without social and inner time.

Our third conjecture is about the advanced technology resulting into a loss of both inner and social time. There is no possibility to contribute nor benefit from distinctive, creative ideas in collaborative creativity nor experiment on their combination.

Conjecture 3. Advanced technology can bring about the absence of social time and inner time, which in turn can lead to the end of collaborative creativity.

LOOKING FORWARD: ENDTIME AND ADVANCED TECHNOLOGY

We now consider advanced technology's potential future effects on social and inner time in light of the literature-supported conjectures. How might technology eventually suppress collaborative creativity in ways that are detrimental to human capability to tackle its grand challenges through collaborative creativity? In Table 3, we present future-oriented illustrations of our three conjectures in terms of enabling or constraining collaborative creativity. We draw on existing research as well as on prescient science fiction, which has at times preceded and informed research. (For example, Lindebaum et al. (2019) builds on the research of E. M. Forster's novel, *The Machine Stops*, published in 1909.) Table 3 summarizes our illustrations in terms of social and inner time. Our illustrations go beyond organizations as traditionally understood. Advanced technology such as automation and augmentation of routines and decision making with algorithmic developments will affect organizations even when the advanced technology is not confined to any particular organizations. We are aiming to learn from unusual cases to better see the impact on social and inner time as they are difficult to study empirically in traditional settings (Siggelkow, 2007).

Table 3. Collaborative Creativity and Social and Inner Time: Futuristic Illustrations

<i>Inner Time</i>	Present	Constrained Collaborative Creativity: The Prison Scenario	Enabled Collaborative Creativity : The Temporally Balanced Scenario
	Absent	Loss of Collaborative Creativity: The Doomsday Scenario	Constrained Collaborative Creativity: The Gaming Scenario
		Absent	Present
		<i>Social Time</i>	

We start with the endtime *Doomsday Scenario*, in the bottom left quadrant, which illustrates advanced technology’s complete elimination of social and inner time (illustrating Conjecture 3) in a society. Steven Spielberg’s 2002 movie, *Minority Report*, examines this scenario. In the futuristic movie, the surveillance state uses face-retinal scans and location-based algorithms. Such predictive analytics have a potential for normalizing ways in which available information about people is used, including their identity and past behavior. In the extreme, extrapolation using machine-calculated probabilities based on available data might overly determine possible futures, even when the underlying data for prediction are scarce (See Perry et al.’s (2013) report on the state of predictive policing.) In the extreme case, machines are fully in charge of the “creativity” or outcomes of the analysis.

In this endtime Doomsday Scenario, technology is more than material to, or even controlling of, human behavior. Instead, technology has become constitutive of the collective behavior and its environment, as in Spielberg's *Minority Report*:

Imagine a world without murder. Six years ago, the homicide rates had reached epidemic proportions. It seemed that only a miracle could stop the bloodshed, but instead of one miracle, we were given [the ability to predict crime]. Within three months of the pre-crime program, the homicide rates in the District of Columbia had been reduced by 90 percent. (Hovarka & Peter, 2019: 6295)

The movie shows a time in which technology is rampantly autonomous at the expense of human sovereignty. A pre-crime program has created a virtually crime-free society. Data-intensive technology algorithmically creates past, present, and future (as if in inner time), as well as synthesizes them (as if in social time, or time spent with others, often online). These environments render reality in a computational format (Kallinikos, 2009). In machine calculations, time becomes concealed as “time-without-us” (Holt & Johnson, 2019). Kallinikos (2009: 190) writes about computational reality: “While humans may input data into the system, the link between data and the category is fully automated and beyond human discretion.” Studies by Lindebaum et al. (2019) and Zuboff (2019) have warned about the effects of a lack of transparency necessary to assess the grounds of decision making in algorithmic calculations. Machine–human interactions do not always work as intended or in morally acceptable ways (Suchman, 2018). In this Doomsday scenario, both inner time and social time essentially have been extinguished. Any capability for collaborative creativity has been lost. Humanity is left to machines identifying and addressing its lesser and grander challenges.

Our next futuristic illustration is focused on reduced social time (illustrating Conjecture 2). Such a situation has been studied in incarceration (Johnsen, Johansen, & Toyoki, 2019). In the top right quadrant, the *Prison Scenario*, inner time is available, even excessive, but social time is severely curtailed. One prison inmate reports the inability even to appreciate a moment of change as seasons pass. Another describes life as meaningless, “going to waste” (p.12). The incarceration results in emptiness, even depression, with no ideas to contribute nor share with others.

I remember during my last sentence, I spent a lot of time in my cell,... and I used to look out of the cell window and the trees were green, and then the ground was covered with snow, and there were colors again, some green and some orange.... I could, in a sense, have taken a photograph of each moment... but everything in between is totally meaningless, and... let's say that your life stops when you end up in here. (Johnsen et al., 2019: 12)

The Prison Scenario is characterized by isolation and a lack of social contact, or deprivation of social time. In some cases, this setting might be a chosen one. The Japanese government estimates that 1.5 million *hikikomori* people live in isolation from society, rarely if ever leaving home for various reasons.¹ Isolation might be an expression of psychological necessity, technological luddism (Jones, 2006), or based on a religious conviction about refusing the use of electricity – or it might be forced, as in a prison or as a result of existing on the far side of the digital divide.

When such a scenario is technology-driven, digital tools are used to control human behavior, as with e-carceration, where GPS devices track location, or with cellular capabilities for mass

¹ <https://www.nippon.com/en/japan-topics/c05008/japan%E2%80%99s-hikikomori-population-could-top-10-million.html>

surveillance using facial recognition.² Such “big brother” surveillance was already the theme of George Orwell’s novel, *1984*, published in 1949. Monitoring technology and digital surveillance more broadly might have effects that deter social time as they violate privacy and pose threats to a person’s liberties for expression and for affiliating with others. Devoid of social time, inner time might become increasingly meaningless as creativity that comes from collaboration is lost.³ As the inmates in Johnsen et al., (2019: 12) report: “They might as well invent some pill that would just make you older; it’s the same thing basically.” Addressing individual or societal challenges has to wait: “When you get out, you can carry on with your life from where you left it.” (p.12).

In a third scenario inner time is reduced (Conjecture 1) and collaboration becomes a game, as shown in the bottom right quadrant of Table 3: the *Gaming Scenario*. The following describes a *Gaming Scenario*:

The setting is a virtual game environment, something similar to Fortnite, which is one of the best-selling battle royale games and played by 200 million people. We envision a situation where all work life becomes a game. To attract millennials, work needs to be explicitly game-like, become “gameful” (McGonigal, 2010). Tasks are thus organized in 30-minute battles or tournaments that have a challenge, set by the employer or the game host. Teams compete and gain points on solving the challenge. These battle pass points allow for faster progression in the game and give access to equipment. Getting 100 points in the “battle pass” is important for entering the next game with a proper set of looks (“skins”) and tools. Team members talk to each other while the game is ongoing, sharing observations and strategizing. Teammates share accomplishments and hence points. In addition, “you will see what someone is like as a person,” said one gamer; they might play selfishly, or they might come to an injured teammate’s aid. (Or team members might

² <https://www.thenation.com/article/archive/surveillance-prison-race-technology/>.

³ For some people, inner time allows for productivity. Martin Luther King wrote “Letter from a Birmingham Jail,” an important work for the social rights movement of the 1960s, while imprisoned. Other examples include Nelson Mandela’s diary and Dietrich Bonhoeffer’s *Letters and Papers from Prison*. In each of these cases, time in prison was already connected to a larger purpose infused with meaning.

have to come to mutual agreement that giving such aid is a trap, and the enemy is lurking and ready to kill again.)

In this illustration, work online has become entirely challenge-based; competitive tools extend to killing the other teams: The last team to survive and to complete the task wins. Occasionally, an organizational actor might play alone, but this model still requires engaging in the virtual game with others – if not as team members, then as enemies. But in this scenario, work only happens together with others to tackle the set challenges for which teams are rewarded. Some flickers of inner time may be manifested in gamers’ contributing to strategizing (Silva & Mousavidin, 2015), thinking about and discussing ways to win the battle-in-progress or drawing inferences from “what someone is like” – how they play the game. But there is little opportunity to creatively ‘think outside the game’ as rules of the game are an intrinsic part of the challenge and hence require submission to the game. Grand challenges that would present themselves outside the game worlds are not attended to or perhaps not even noticed (Boström, 2003).

While inner time is reduced, social time may become scaled in global game events, analogous to a recent Marshmello concert in Fortnite. The concert took place in Pleasant Park, an in-game location, at a particular time (i.e., at 2:00pm Eastern time, February 2, 2019). Tens of millions of people apparently participated, sharing a relatively calm and enjoyable event. The attendees were engaged in a dance together in a strictly social encounter, and dance moves had to be purchased or pirated, rather than self-choreographed (Crane, 2019). After the concert ended, the calm ended too. The Verge website (February 2, 2019) reported the chaos: “...the scene devolved into a killing contest between the two sides.” The concert was thus a forced calm because the use of

game guns was prevented during it (in so-called rumble modality). Any expressions of creativity were servient to the rules of the game (as suggested by Kallinikos, 2004).

The fourth scenario, in the top right quadrant of Table 3, is called *Temporally Balanced*. In this hopeful illustration, emphasizing how inner and social time - when balanced - contribute to collaborative creativity. A study by Leonardi (2011) suggests a possibility in which technology is narrowly focused to support human efforts. In a computer simulation technology for automotive design, Leonardi (2011) found that the standardization of simulation routines for car safety aided the engineers' use of CrashLab technology. The reason was that the standards allowed social time to be spent more creatively, asking more pertinent and better questions about how to improve car safety. This more creative and productive social time also enhanced the effectiveness of inner time, as reflection was directed toward the more pertinent research questions. Engineers then increased the frequency with which they consulted each other (Leonardi, 2011:160–61). Here the technology, CrashLab, improved collaboration while providing a basis for understanding the lab results through the standards employed. Here an advanced technology aided collaborative creativity but the technology was carefully applied: the CrashLab was about testing car safety and not about making the consequent design decisions based on the interpretation of the results. This task was left to the engineers, as was the design of the actual crash tests. Nevertheless, the study testifies to the importance of social and inner time in collaborative creativity within the use of advanced technology and the benefits of its narrow use.

POLICY IMPLICATIONS

In this article, we have explored how advanced technology shapes human temporal capacity through social time and inner time. Temporal capacity is important for collaborative creativity, yet advanced technology can be destructive of both inner and social time: Advanced technology might expand social time at the expense of inner time, extinguishing inner time, or it might make social time ineffective or unavailable for collaboration. Some technology can render both social time and inner time void and hence impair all ability to collaborate creatively. Considering technology's implications for the temporal resources seems crucial at a time when the need to tackle societal and environmental challenges is urgent and the scale is beyond any one individual's or organization's capability (Ferraro et al., 2015).

Our first policy recommendation focuses on *making the temporal assumptions of technology visible* so that technology's potential effects on social time and inner time can be better assessed and managed by users of technology seeking to collaborate. In her study of digital calendars, sociologist Wajcman (2019) analyzes some of the underlying assumptions. The assumptions include the belief that "faster is better"; the construction of time as an individual resource rather than a collective accomplishment; and a perceived ability to use open digital calendars to eliminate temporal "waste." The technology implies not only that we need to be faster, but also that we need to project our mastery of time to others. This projection is called openness: We share our calendar application with others so that we create an opportunity to share time or make appointments, and in doing so, we subject ourselves to peer and supervisor surveillance. This sort of time management "optimizes one's time" (Wajcman, 2019: 1280) by accelerating routine activities, such as scheduling, but it also "makes it hard to make time for longer term thinking" (1283). Time has become a resource that is not to be wasted, and it also is a resource that has no

private or reflective quality: “All I think about is how can I construct every day in half an hour and two-hour increments,” writes Wajcman (2019: 1283). Here, Wajcman sees advanced technology as depriving organizational actors of inner time.

As discussed, in other studies, technology is viewed as a tool that enables virtual work but also collectively diminishes people’s ability to withdraw from being online (Barley et al., 2011; Mazmanian et al., 2013), forcing ever-increasing social time, or “Internet time” (Rosenberg, 2007; see also Zuboff, 2019). Wajcman (2019: 1280) agrees: “...[W]e definitely think in terms of the tools we use.” Being in Internet time seems to cause a feeling of constant work overload (Barley et al., 2011), and also makes being reflective difficult. Alvesson and Spicer (2012) suggest that this absence of reflexivity is what makes organizations stupid. Reddy et al. (2006) discuss HealthStat, a surgical electronic patient record system specific to intensive care units; the system tracks the patient on a minute-by-minute basis and provides “what was going on today [with the patient]” and during the past 72 hours. The authors report that the system potentially impairs the nursing staff’s and doctors’ understanding of the patient’s holistic situation, particularly if the staff were gone for an extensive period of time. The system contains undifferentiated data that is not organized to support the nursing staff’s reflections on patients’ changes in the longer time frame, thus affecting interpretations of past to present conditions and to anticipations of the future in the provision of appropriate care. Not only the quality of the care may be at stake but also the ability of the nursing staff to think of ways of improving the care, hence sacrificing potential for collaborative creativity.

Our second policy implication is that we need to *keep a watchful eye on advanced technology that renders both social time and inner time absent, and hence potentially reduces human*

temporal agency and timely intervention. Data-intensive algorithmic technology plays an increasing role in society's technology infrastructure, both in automating processes and in predicting outcomes. These capabilities might increase efficiency and provide valuable real-time guidance, but such computation also makes causal links between the data and its analysis difficult. In obscuring causalities, the link between past, present, and future is concealed, and human temporal capacity for inner time is weakened. The movement called "Explainable AI," or algorithmic literacy, seeks to address this issue by making the analytics visible or understandable. However, the movement might face increasing obstacles because of emergent forms of artificial intelligence (AI) that are self-learning and thus are not programmed by any human (du Sautoy, 2019). The software AlphaZero taught itself to play the game of GO in three days, playing 4.9 million games against itself. It then won 100 games out of 100 against the earlier version of the software, called AlphaGo – which had earlier defeated a Korean champion player (du Sautoy, 2019). Such results might seem impressive and innovative, but celebrants of such winning often ignore how inner time might be irrevocably lost if we rely on AI to define and even explain causality and to interpret past, present, and future. Temporal capacity to choose augmentation over automation in AI might not be available if humans have already been automated away, or if they have to manage a paradox that a computer does not recognize (Raisch and Krakowski, 2020). Famously, recruitment algorithms have been notorious for hiring only white young males (Raisch and Krakowski, 2020: 16) to the point where amazon.com and some other savvy AI-firms have abandoned them (Justin (2018)). Such a decision is, of course, hopeful for human agency – a manifestation of inner reflexivity – and yet, more problematically, it also might be temporary in the world of advanced technology.

Our third policy implication warns about *humans' becoming increasingly detached from their shared environment, impairing collaboration*. Humans might have increasing difficulty as they try to “find themselves, the surrounding world, and others alongside them” (Bakken et al., 2012: 18) and to “project themselves into action.” Without human capacity for social time as in finding oneself in relation to others, and inner time as in intentional, projective action, advanced technology might exercise excessive control over human destiny at the “endtime.” Diminished temporal capacity can reduce the motivation for collaborative creativity and potentially impair human collaboration more generally. Some authors argue that the social compact, suggesting that all people have a shared future on earth, might be breaking (Latour, 2019). Without such a shared commitment, the pursuit of society’s (grand) challenges might be futile as a participatory, shared-future project. The potentially transformative changes resulting from climate change will affect the poor and the rich differently and at different times; the resourced-privileged are more able to move to more favorable climates than those without resources. In a fight over resources, the wealthier always win: They can access water, cooler environments, and new comfort technology. As the prospects for securing a future that everyone has reason to value are fading, as Latour (2019) argues, the politics of our current context might already reflect a breakdown of the mutual compact of a joint future. The shadow of the future is increasingly dark. The ultra-rich are preparing their escape vehicles for space voyage. In the era of the Anthropocene, the present future (Adam, 2008: 7) is dominating over the future present, as those with resources are “taking from the future for the benefit of the present.” Yet the value of life becomes significantly diminished if the future is bleak or nonexistent for all but the extremely wealthy beyond our own grandchildren (Scheffler, 2016).

CONCLUSION

We conclude that the increasing ubiquity of advanced technology in society might deprive humans of their temporal capacity for inner time, which is constitutive of collaborative creativity. As inner time is diminishing, computation alone provides the linking of past, present, and future. Meanwhile, social time is expanding as advanced technology provides unprecedented opportunities to be absently present online. However, many researchers find that such virtual time is not collaboratively fruitful. We call for research on the temporal implications of advanced technology, making the implications explicit. We also call for the support of opportunities to sustain human temporal capacity amidst automating and mediating advanced technology. Despite the attractions of technological solutions, our caution is to consider the consequences of ever more deeply penetrating advanced technology on human temporal capacity – before inner time is irrevocably lost and social time no longer supports collaborative creativity. At that point, “[a]ncient customs and practices, such as going out to meet people, have been made obsolete” (Lindebaum et al., 2019: 9). Perhaps then, humans using advanced technology as their creative and collaborative artifact has become the advanced technology using the humans as its artifact to manipulate (Demetis and Lee, 2019).

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Table 2. Prior Literature on Advanced Technology and Time Through the Lens of Inner Time and Social Time

Selected Article	Empirical Context	Effects of Technology on Social Time	Effects of Technology on Inner Time	Implications on Creativity and Collaboration	Temporal Capacity
Barley, 1988	A study of temporal organization of radiological	How radiologists and technologists coordinated their joint work tasks,	The frustration felt by technologists trying to	New technologies being introduced,	The coordination of work tasks with timing,

	work in a hospital department	including other medical staff	engage radiologists' attention	changing work practices	sequencing, duration
Barley et al., 2011	A study of the communication patterns by employees in a company producing workstations and servers (an engineering organization)	Full email boxes, symbolizing overload at work; Email excluded from usual social norms in terms of appropriate time to communicate; Expectations required quick response even outside work hours; Asynchronicity appeared to contribute to stress	Fear of missing out	Technologies such as email contribute to, or remind employees of, the feeling of being overloaded at work.	Asynchronicity seems to add temporal flexibility, but it creates feelings of being constantly short of time.
Barrett & Scott, 2004	A study of emergence of electronic trading in London and Chicago futures exchanges	A linkage to "global time," with the elimination of regional monopolies	Changing skill profiles and identities; Limited life cycle as a trader; Jumping time zones to operate in markets where profits can best be made at any particular time	Susceptibility to becoming a work "dope"; Using technology to "colonize time zones and reinforce time-money-power cycle"; High performance pressures with time consciousness	"Global time" gives instant profitmaking opportunities but erodes skills fast(er)
Cramton, 2003	A study of an archival dataset of a collaborative project in a graduate school among students and faculty located in three continents	Failure to gather and remember contextual information regarding remote project partners; also difficulty of communicating their own context and constraints	Difficulty of communicating and assessing the salience of information to remote partners and self	Difficulty of maintaining mutual knowledge in remote teams	Speed of communication ; interactional dynamics
Kallinikos, Aaltonen, & Marton, 2013	A Study of Internet archive	Exclusion of social time (e.g., distributed reprogrammability)	"Freezing content"	A snapshot view on ordered content; an emphasis on	No human temporal capacity; time is machine programmed

				artifact manipulation	
Lee, 2003	A survey of use of a groupware calendaring system in a large computer manufacturer	Open calendar system used for viewing colleagues' calendars for locating them and assessing whether they are busy	Less willingness to alter a colleague's calendar than view it; sending a calendar invite may depend on organizational rank and relationship	Reduction of face-to-face meetings and may; Less easy to schedule meetings among team members distributed, possibly globally	Socio-temporal order
Leonardi, 2015	A quasi-natural experiment in customizing a social networking technology for internal communication in a large financial firm	Awareness of ambient communications occurring among members in the organization	Importance of awareness of coworkers' knowledge: "respondents improved the accuracy of their cognitive knowledge structures if they happened to notice what others were saying in their messages" (p. 755)	Knowing more about the kind of knowledge coworkers have improves metaknowledge of the organization	Time as a potential constraint for exposure to colleagues' messages
Lindebaum et al., 2019	An analysis of algorithmic decision making from the perspective of formal rationality in the context of in E. M. Forster's novel <i>The Machine Stops</i>	Algorithms as supercarriers of formal rationality; Implications being that their calculus necessarily produces an outcome, precluding the idea of a choice (assumed as a human or organizational prerogative)	Lack of transparency of algorithmic calculus, and decision-making, thus inscrutable for the nature of the decision (whether responsible or based on high quality input)	The elimination of collaborative creativity as in <i>The Machine Stops</i> ; Humans fall into decadence	A move from human to machine time
Mazmanian et al., 2013	Interviews with 48 knowledge professionals,	Escalating engagement while also increasing work stress	Gaining personal autonomy while	Mobile communication technologies redefine	Temporal autonomy is susceptible to organizational

	2004–2005, on their daily work and use of mobile email devices	through diminished collective autonomy (raising expectations of availability, for example)	continuously controlling communication (checking email)	temporal–spatial collaboration while reshaping practices, and even identity, of professional knowledge workers	demands on time
Prasopoulou et al., 2006	The use of mobile phones by 15 professionals working in business organizations	Increased accessibility and instant communication; Erosion of temporal boundaries, such as standard working hours	The phone's attachment to a single user makes temporal properties more evident and blends private and public (work); Affects the user's own behavior	Makes managing socio-temporal spaces more challenging for collaborative activity; Enforcing temporal boundaries might be easier in more senior positions	Public and private time blends together
Ryden & El Sawy, 2019	A survey of U.S. executives combined with interviews with Danish executives on real-time management perceptions and issues; Use of enabling technologies and organizational mechanisms	Managers' time perceptions matter for building real-time management processes; Slow and fast as a temporal distinction adds value to the enterprise activities	Thinking beyond fast to creating flow; Temporal reflexivity important	Need for ambitemporality for creating enterprise value	Ambitemporality
Reddy et al., 2006	A study of temporal patterns for coordination and information-seeking by professionals working in a surgical intensive care	Structured timelines for work coordination and collaboration; Persistent information flows connecting hospital units	Information-seeking as an individual behavior and perceived need (building expectations, awareness)	Temporal structuring allows for collaboration and coordination of activities and flexibility as part of the temporal structure	Time as trajectories, rhythms, horizons, and flows

	unit				
Rutkowski et al., 2007	Virtual teams tasked to build an e-book chapter	The impact of individual characteristics (e.g., cognitive absorption) on team conflict, performance, and technology preference	Personality–technology fit in focus immersion and temporal dissociation	Team characteristics (focus and temporal dissociation) matter for performance	Experience of temporality and its intensification
Sarker & Sahay, 2004	Virtual teams located on two different continents	The documentation of problems and remedial efforts in collaboration stemming from locational, cultural, and temporal differences	Social time in service of inner time (short-term project goals)	Importance of social strategies based on social ingenuity and on sensitivity about the formation of norms; Developing solidarity and becoming comfortable with polychronicity	The need to be creative and adaptive as a team, related to temporal challenges
Sawyer & Southwick, 2002	The introduction of enterprise-wide information systems (i.e., ERP)	Tools for project management and process standardization	Temporal asymmetry between users and developers of technology	Technology becomes embedded in the socio-technical organization, and its effects become obscured.	Multiple temporalities with different action potential
Silva & Mousavidin, 2015	World of Warcraft (MMORPGs)	Social nature of strategic thinking (following and imitating)	Learning to think strategically (as in “telescoping”)	A playground for rehearsing collaborative strategy (through partial interpretation)	Potential transfer of learnings from virtual to real time
Tyre & Orlikowski, 1994	Three organizational settings of process technologies in use	Good-enough technological adaptation drives (social interaction for) further improvement	A window of opportunity for considering the technology’s performance and its adaptation opens and closes.	Episodic rather than continuous	Past has inertial influence over present and future