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A Study on Time-Space and Information and Communication Technology in Work Groups: A Review and Future Research Challenges

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Abstract
The widening application of information and communication technology (ICT) in organizations alters the temporal and spatial circumstances under which work groups operate. Yet, time and space have not been major foci in the past work group research. Though temporal and spatial dispersion have been widely recognized in studies of work groups interacting with ICT, only few attempts have been made to examine the implications of changed operating logics of time and space as enabled by ICT. In this paper, we address this void. Specifically, we argue that, in addition to temporal and spatial dispersion, ICT in general, and mobile technology in particular, erect novel aspects of time (i.e., instantaneity and simultaneity) and space (i.e., independence from fixed places and fluidity of context), which enables novel forms of time-space configurations (i.e., multi-presence) that need to be carefully explored. We conceive that time and space can act both in independent and dependent variable roles in work group research. Moreover, we consider both the structural (objective) and experienced (interpretive) aspects of time and space as induced by ICT. Using these classifications we identify four major research challenges in time and space research related to ICT use in groups. To this end the paper suggests nine specific research questions that need to be engendered in future research on ICT use within work groups.

Keywords: Time, Space, Work group, ICT, Mobile technology

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A Study on Time-Space and Information and Communication Technology in Work Groups: A Review and Future Research Challenges

Introduction

Time and space, ubiquitous and experienced by all, form two fundamental conditions of human existence. The rapid development of information and communication technology (ICT) in general and mobile technology in particular holds the potential to transcend time and space boundaries (Lyytinen and Yoo 2002), to intertwine deeply virtual and material worlds (Jessup and Robey 2002), and to transform time-space configurations (Green 2002).

Work groups are small collections of people who are organized to achieve common goals and who are interdependent with each other and operate in the context of a larger organization (Friedlander 1987). Members of organizations usually engage in multiple, concurrent projects, and as a result members usually assume multiple, interdependent roles (McGrath 1991). Group projects exist in specific temporal and spatial circumstances, and the roles associated with work groups are thereby performed within certain temporal and spatial contexts. The use of ICT in work groups offers significant opportunities to improve group performance and to create new roles in the group as it helps the group members manage interdependencies among them in different ways by changing the time and space boundaries of their work.

An extensive literature has studied ICT in the context of groups (e.g., Sproull and Kiesler 1986; Maznevski and Chudoba 2001, Sarker and Sahay 2002). A majority of such studies has examined the impact of ICT on group properties such as relationship building (e.g., Walther 1995), cohesion (e.g., Chidambaram 1996), trust (e.g., Jarvenpaa and Leidner 1999), communication intensity and quality (e.g., Sproull and Kiesler 1986), the media perceptions and use (e.g., Yoo and Alavi, 2001) or decision-making effectiveness (e.g., Dennis et al 1999). While there is an increasing attention to the role of time in distributed group communicating with ICT (e.g., Carlson and Zmud 1999, Chidambaram 1996, McGrath et al. 1993, Walther 1995, Yoo and Alavi, 2001), these studies, however, do not investigate how work groups enact, perceive and manage increased temporal and spatial distribution by treating time and space mostly as independent variable. Furthermore, these studies forego novel reconfigurations of time-space that are enabled by the increased and distinct use of mobile ICT capabilities, by treating temporal and spatial distribution as mutually independent.

In this paper, we expand the scope of research on ICT in work groups beyond its current structural focus on spatial and temporal dispersion as an independent variable. In lieu we emphasize the need to recognize the increased complexity of temporal and spatial configurations induced by ICT. Specifically, recognizing the inherent *existential* interdependence between time and space, we argue that, in addition to temporal and spatial (structural) dispersion, ICT in general and mobile technology in particular erect novel aspects of time (i.e., instantaneity and simultaneity), space (i.e., independence from fixed places and fluidity of context), and time-space (i.e., multi-presence) that impact temporal and spatial organization of work groups. These new features of time and space have not received so far sufficient attention within work group research.

In this paper, we suggest that new aspects of time and space in work groups can be investigated by conceptualizing time and space both structurally and phenomenologically, and exploring the roles of time and space as independent or dependent variables in group

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research settings. First, we recognize that temporal and spatial worlds have both structural and interpretive dimensions (Orlikowski and Yates 2002). While the structural parameters emphasize the objective characteristics of a temporal and spatial world, the interpretive (phenomenological) parameters focus on experienced temporal and spatial world. Second, time and space can be studied either as an independent or dependent variable. When time and space assume the role of an independent variable, the research focus is placed on the impacts of temporal and spatial factors on group activity and outcomes. On the other hand, when the research interest is in how the time and space dimension are affected by other group factors, time and space become part of a dependent variable.

The rest of the paper is organized as follows. The next section discusses briefly the definitions of time and space relevant to this paper. This is followed by a short review of the extant ICT research on time and space in the context of work groups. Then we explore new aspects of time and space as enabled by ICT. After this, we identify the new research challenges by proposing four research themes on new aspects of time and space in work groups. The final section concludes the paper with discussions of research and managerial implications.

Conceptualizations of Time and Space

Time and space have both structural and interpretive "being". Structural nature of time and space is conceived in objective aspects of our temporal and spatial world that exist independent of people's action (Hassard 1991, Sahay 1997). Structural features are measurable and quantifiable as represented in clocks and maps. Interpretive attributes of time and space focus on experienced phenomenology of time and space (i.e. their cognitive and perceptual aspects) (Bluedorn and Denhardt 1988, Parkes and Thrift 1978). Interpretations of the external attributes of our temporal and spatial world compose the internal lived experiences of temporal and spatial world. Adopting such conceptualizations of time and space, we conceptualize *structural time* as clock time with an absolute existence, and *experiential time* as socially and culturally constructed "senses" of time and space. Likewise, we conceptualize *structural space* as distance, place, or relation between objects, while *experiential space* forms a socially constructed and enacted context in which interactions take or do not take place.

Furthermore, we treat time and space as existentially inseparable as advocated by the time-geography research (Carlstein 1982) and the structuration theory (Giddens 1984). Time and space are inherently intertwined because a movement in space is also movement in time, and time is always structurally defined by movement in space. Moreover, time and space constrain one another: no two individuals or objects can occupy the same point in space at the same time because of the limited packing-capacity of time-space (Carlstein 1982) and no two objects can be at the same time point in two different spaces in physical world. Socially constructed time and space are also inherently intertwined: specific activities are always associated with particular time and space zones (locales). Moreover social interactions are routinized in time-space and form the ground-layer of all social interactions (Giddens 1984).

Previous ICT Studies in Work Groups

Though computing was initially invented to overcome time constraints in human computing capability, the current infrastructural nature of ICT makes it intricately bound up with fundamental issues of time and space that organize human life. ICT first provides a

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medium that allows digital material to be stored under different time and space conditions (space compression, time expansion). Along with its storage capability, the transmission and open network capabilities of ICT enable the distribution of digital material across time and space fast (time compression) and in huge quantities (volume expansion). The recent developments in ICT such as ubiquitous computing (Lyytinen and Yoo 2002) promise unprecedented access to digital information in nearly any time and any place, and can render work processes that involve information as inputs or outputs or as processing rules to take place in varying physical places or even virtually (where physical place does not count).

These time and space related properties of ICT have significant implications for work groups, which is increasingly dependent on ICT capabilities as communication media, boundary objects (Star and Ruhleder 1996) and repositories of work outcomes. We can identify several related but distinct research streams: group support systems (GSS), virtual teams, and computer supported collaborative work (CSCW). Each of them has a somewhat varying topical focus, and they deal with overlapping but not identical phenomena with respect to the use of ICT in work groups.

GSS Research

GSS combines "communication, computer, and decision technologies to support problem formulation and solution in group meetings" (DeSanctis and Gallupe 1987, p.589). The bulk of the GSS research in the past two decades has been interested in whether GSS improves the process and outcomes of group meetings (Dennis et al 2001) normally located simultaneously in one or several places over a limited period (or periods) of time. Hence groups are usually assumed to carry out their work in a number of sessions each with a different session length (e.g., Chidambaram et al 1991). Time to decision is regarded as one of the key indicators of the efficiency of the GSS intervention (e.g., Dennis et al 1999). The main variables that have been studied in the GSS research can be categorized into four groups: contextual (independent), intervening, adaptation, and outcome (dependent) variables (Fjermestad and Hiltz 1999). Table 1 shows how time and space have been examined in each of these categories.

	Time	**Space**
Contextual Variable	• Synchronous vs. asynchronous (e.g., Hiltz and Turoff 1991) • Sequential vs. parallel process (e.g., Zigurs and Buckland 1998) • group history (e.g., Mennecke et al 1992)	• Same vs. different places (proximity) (e.g., Jessup and Tansik 1991)
Intervening Variable	• Session length and number (e.g., Chidambaram et al 1991)	
Outcome Variable	• Efficiency measures (e.g., time to decision) (e.g., Dennis et al 1999)	

Table 1. Time and space in GSS research

In most GSS research, group members are assumed to be either at the same place or in different place(s) (e.g., Jessup and Tansik 1991). This simple spatial dichotomy pervades most of the literature. A similar dichotomy in temporal dimension prevails - groups work either synchronously and asynchronously in time (e.g., Hiltz and Turoff 1991). Consequently, group members enter information either simultaneously or sequentially (e.g., Zigurs and

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Buckland 1998). Group history (behaviors over time) is also considered as an important factor influencing group outcome (Mennecke et al 1992).

Laboratory experiments have been the main research strategy in GSS research in that GSS intervention and some of its main capabilities like concurrency, display are recognized as the main controlled treatment (other being e.g. task, group size etc). A significant number of laboratory experiments have been conducted to examine specific effects of the structural time and space variation on task performance measured normally in terms of decision quality and speed. These experiments operationalize structural time in terms of synchronicity, and space in terms of physical proximity or distance, and examine their impact on group meetings, which vary from single to multiple sessions with different durations. Hence, GSS research has explored mainly effects of synchronicity and physical proximity on the group meeting outcomes through analyses of the meetings of ad hoc groups under different manipulations of synchronicity and physical proximity.

Virtual Teams

Virtual teams can be defined as groups of geographically, organizationally and/or temporally dispersed team members brought together by ICT to accomplish specific tasks (Jarvenpaa and Leidner 1999). Hence, the focus is here physically distributed interactions through ICT medium that are sustained over extended periods of time. Like the GSS literature, most virtual team research has thus focused on how the structural aspect of time and space affects work group properties and performance. In addition, it has examined not only group outcomes (e.g., performance, satisfaction) but also group processes (i.e., task processes and socio-emotional processes). As summarized in Table 2, virtual team research has studied the impact of time and space in terms of four categories of variables - input, socio-emotional processes, task processes, and outputs (Saunders 2000).

	Time	**Space**
Inputs	• Duration of virtual team (short- and long-term) (e.g., Jarvenpaa and Leidner 1999, Malhotra et al 2000)	• Co-located vs. dispersed team members (e.g., Sproull and Kiesler 1986, Sarker and Sahay 2002)
Socio-emotional Processes	• Cohesion development over time in geographically distributed teams (e.g., Chidambaram 1996) • Relationship building over time geographically distributed teams (e.g., Walther 1995) • Trust development over time geographically distributed teams (e.g., Kanawattanachai and Yoo 2001)	
Task Processes	• Time delay in sending feedback (e.g., Cramton 2001) • Coordination across time zones (e.g., Sarker and Sahay 2002) • Temporal rhythm in interactions (e.g., Maznevski and Chudoba 2001)	• Communication with remote team members (e.g., McDonough et al 2001)

Table 2. Time and space in virtue team research

Most virtual team research is conducted in an extended time frame, which varies from weeks (e.g. Jarvenpaa and Leidner 1999) to months (e.g., Malhotra et al 2000). The impact of

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time in distributed virtual teams have been investigated in terms of outcome cohesion (e.g., Chidambaram 1996), relationship building (e.g., Walther 1995), and trust (e.g., Kanawattanachai and Yoo 2002). The challenges imposed by time delays in sending feedback (e.g., Cramton 2001) and by team members being dispersed in different time zones (e.g., Sarker and Sahay 2002) have been explored in terms of group satisfaction and performance. Aligning temporal rhythms with work rhythms has also been observed to be important for the success of virtual teams (Maznevski and Chudoba 2001). Also, coordinating temporal rhythms among members who are distributed in different space was found be to be an important aspect of leadership in virtual teams (Yoo and Alavi 2004).

With regard to space, a large portion of the virtue team literature assumes that physical distance among team members results in the reduced of social presence and richness in communication media (e.g., Sproull and Kiesler 1986). Some virtual team studies have compared the effect of the lack of social presence and communication cues in traditional teams with that of virtual team and found that virtual teams tend to communicate less effectively than their traditional counterpart (e.g., McDonough et al. 2001). In virtual teams where some team members are co-located while other are dispersed, it is found that information exchange is complicated because of the dispersed team members' suspicion that the information shared by the co-located members is not communicated to others (e.g., Cramton 2001, Sarker and Sahay 2002).

In summary, in virtual team research, space is typically defined in terms of either social presence or physical proximity. In addition, a structural view of time is adopted in examining group outcomes and processes. Specific structural temporal issues, such as delay, time zone, or rhythm, have been integrated some research designs but have not received significant attention which would enable theoretical insights to emerge.

CSCW Research

Computer supported cooperative work examines small(er) ensembles of people (i.e., group) working together to produce a product or service over extended periods of time either in the same place or in different places. CSCW research aims at the design of applications or sets of applications that can support or improve cooperative work arrangements (Schidmt and Bannon 1992). Relevant CSCW research that recognizes time and space aspects of cooperative work is summarized in Table 3. As noted time and space can affect the structure and functionality of CSCW applications or they are designed to be managed by CSCW applications.

	Time	**Space**
Affecting CSCW systematic application	• Temporal inter-dependencies (e.g., Schmidt and Simone 1996, Malone and Crowston 1994)	• Spatial conditions (e.g., physical distance, multi-media space, virtual space, context) (e.g., Luff and Heath 1998, Bly et al 1993)
Being Managed by CSCW systematic application	• Temporal coordination (e.g., Bardram 2000)	Visible and invisible work (e.g., Star and Strauss 1999) Regionalization (e.g., Tellioglu and Wagner 2001)

Table 3. Time and space in CSCW research

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At the core of cooperative work is the idea of inter-dependent work. This inter-dependency raises the need for coordination. Within CSCW research, coordination has been addressed by alternative coordination mechanism (Schmidt and Simone 1996) and principles of coordination (Malone and Crowston 1994). With the respect of structural time, development of coordination mechanism emphasizes the relying of one's work inputs on the timeliness of another person's work outputs. Coordination theory identifies two temporal inter-dependencies – prerequisite (i.e., the output of one activity is the input for the next) and simultaneity (i.e., cooperative activities can happen at the same time). How groups can manage such temporal inter-dependencies has been examined in some empirical studies (Bardram 2000).

CSCW research has also examined various aspects of space, including but not limited to physical distance (e.g., Luff and Heath 1998), multi-media space (e.g., Bly et al 1993), and the physical context in which the work is situated (e.g., Agostini et al 1996). Theoretical analyses (e.g., Star and Strauss 1999) and ethnographic studies (e.g., Tellioglu and Wagner 2001) have explored how cooperative work is organized in space and operates using spatial metaphors in CSCW systems.

Whereas GSS and virtue team literatures concentrate on group outcomes and processes, CSCW research is driven by information needs and communication protocols in cooperative settings. Temporal issues are largely addressed in terms of temporal inter-dependencies between activities. When compared with research in GSS and virtual teams, CSCW research has made significant efforts to understand spatial nature of group work. It has dealt not only with effects of structural aspect of space as a distance and or a region, but also how the space is experienced in the context, and how effects of structural or experiential variations are managed. Most empirical data have been collected qualitatively from observations, interviews, and observatory ethnographic studies.

Summary of Review

A review of the pertinent literature studying ICT in group work surfaces at least four issues with respect to time and space: (a) unproblematic use of simple dichotomies of time and space, (b) the lack of research on the phenomenology of time and space, (c) the lack of focus on time and space as dependent variables and (d) the lack of conceptualization of existential independency between time and space.

First, while these literatures have extensively studied the impact of ICT on work groups from a number of rich and interesting perspectives, most of the existing research adopts simplistic dichotomies of temporal and spatial dispersion of group activity as enabled by ICT. Time is treated simply in terms of the dichotomy of synchronicity and a-synchronicity, and space in terms of the dichotomy of presence and absence.

Second, our review reveals that prior ICT-mediated work group literature focuses dominantly on the structural rather than on the interpretative attributes of time and space. A majority of the literature does not deal with how individual, situational and environmental factors affect the ways in which time and space are interpreted and experienced. There is a dearth of research on the interpretive parameters of time and space despite its importance in understanding complex group behaviors (for exception, see Lee and Sawyer 2002). Moreover, there is a paucity of research which considers both space and time in process terms (as a set of events and locations where events take place).

Third, time and space, in essence, can play two roles in work group research: as a set of independent variables and as a set of dependent variables. Our review shows that past research focus time and space as independent variables focusing on the impacts of temporal factors on group development and process, and of organization of spatial elements on group activities and outcomes. When the research interest is in how the time and space dimension

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are affected by various group factors, time and space become part of a dependent variable though this research - especially at the level of experienced time and space- is non-existent.

Finally, despite the inherent intertwined nature of time and space as they are experienced in our everyday lives, the past ICT work group research has rarely discussed the interdependencies in time-space configurations. For example, the use of ICT to communicate from long-distance (space compression) not only affects the physical proximity, but also decreases the shared temporal experiences among group members. As such, one important question that has not been examined carefully is the novel time-space configuration in work groups as a result of using ICT and its impact on group outcomes.

New Temporal and Spatial Aspects

The capability of ICT has been greatly enhanced by the recent advances in data processing and transmitting, storage powers, network capabilities, and wireless infrastructure. Such technical developments improve the flow of communication, enable point-to-point and multi-point communications, promise anytime anywhere rich information access, extend the available range of human vicarious experiences, and provide greater opportunities for people to interact with each other over time and space.

These new capabilities of ICT erect new aspects of time and space, and redefine temporal and spatial prerequisites for the organization of work. In this section, we discuss new aspects of time (i.e., instantaneity and simultaneity) and of space (i.e., independence from fixed places and fluidity of context), as enabled by ICT. We also explore how these aspects may radically reconfigure time-space relationships (i.e., multi-presence) in group work as shown in Table 4, and how they impinge on our experience.

	New Aspects
Time	• Instantaneity (e.g., Kakihara and Sorensen 2002) • Simultaneity (e.g., Jaureguiberry 2000)
Space	• Independence from Fixed Places (e.g., Lyytinen and Yoo 2002) • Fluidity of Context (e.g., Kakihara and Sorensen 2002)
Time-Space	• Multi-presence (e.g., Lee and Perry 2001)

Table 4. New aspects of time and space

New Temporal Aspects

Instantaneity. Instantaneity refers to the instantaneous transmission and exchange of digital information over space (Kakihara and Sorensen 2002). Telephones and fax machines already reduced the time lag between sending and receiving information and ideas from weeks and days to a few minutes and seconds. With open networks like Internet and new applications like instant messaging, data and information can be exchanged interactively within nano-seconds. This interactivity is maintained also while moving across space by using mobile phones to provide a point-to-point or multi-point communications either in audio (Push-to-Talk, P2T) or in text (Instant messaging) making people instantly reachable regardless where they are. In this sense, ICT makes possible real-time responses to remote behaviors. This new level of instantaneity provides ample opportunities to improvise and coordinate flexibly work arrangements and thus to respond rapidly and with broader variance. It also renders individuals' actions less predictable and creates more uncertainty.

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Simultaneity. Simultaneity means that people can and must deal with multiple tasks simultaneously at any point of time. Simultaneous and unconstrained information access and processing allow activities to be superimposed on one other during the same time-span and the same location (Jaureguiberry 2000). As a result, people do not structure activities by planning for future activities, but accept events as they arise and engage in multiple tasks at any point in same time through mutual adjustment (Lee and Sawyer 2002). The growing use of networked ICT provides opportunities to re-organize and manage time flexibly. It alters the pace of work, and poses a significant question as to how people can coordinate and manage their multiple concurrent activities.

New Spatial Aspect

Independence from Fixed Place. While transportation technologies have shrunk the distance in terms of the time taken to move from one location to another, ICT in general and mobile technology in particular reduce people's dependence on fixed place (location). With mobile phones, laptop computers, wireless modems and portable printers, people don't have to come to a specific physical site to receive a digital service, and the digital service can even move across and between physically distant devices during the delivery (Lyytinen and Yoo, 2002). People are becoming increasingly physically mobile but are still able to communicate and interact with other people and processes as if they were immobile- i.e. they are becoming mobile immobiles. Being freed from fixed place reduces people's reliance on physical location for interpersonal interaction and among others redefines the meaning of "near" and "far".

Fluidity of Context. People interacting with each other rest on a background of common knowledge called common grounds and/or shared understanding (Clark 1996). Being aware of what goes on or has gone on constitutes the context in which people interact. In this sense human interaction is always context specific. As work becomes increasingly poly-chronic as a result of widened application of ICT in organizations, people must constantly switch activities, whilst the contexts to which people connect undergo frequent change. These frequent changes challenge the modes and circumstances of interaction and create the fluidity of context which is not present when interactions are bound in fixed physical locations (Kakihara and Sorensen 2002).

New Time-Space Aspect

Combined effects of novel aspects of ICT induced time and space can potentially reconfigure experienced time-space. The continued developments in transportation and telecommunications during the last century have already brought significant changes in perceptions of time-space configuration as defined by modern societies. In fact, it is argued that the net ideas of time and space constitute the most significant feature of modernity (Giddens 1984). Recent discoveries in mobile and ubiquitous computing will allow for increased decoupling of time and space. Such radical decouplings will allow novel forms of time-space configuration in our activities like the possibility of multi-presence. Multi-presence refers to the existence of our "identity" in multiple places simultaneously as seen by others or as seen by us. In this sense ICT enables human sensorial and verbal ubiquity through the artificial extension of hearing and speech (Jaureguiberry 2000). As a result, social

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presence can be felt in many physical locations simultaneously (Lee and Perry 2001), and our experiences can be extended across time and space boundaries in unforeseen ways.

Future Research Themes

The new aspects of time and space enabled by ICT in general and mobile technology in particular reconstruct the temporal and spatial circumstances under which work groups operate, redefine the temporal and spatial prerequisites for the organization of work, and impinge on groups' experiences of time and space. In this section, we underscore the lack of attention in research on work groups interacting with ICT in these new aspects of time and space, and propose four research themes (challenges) to study this unexplored area.

A Framework to Study Time and Space Relationships in Work Groups

The connections between work group and the novel aspects of time and space as induced by ICT have remained under-researched, as illustrated in Figure 1. Traditional research on work groups in face-to-face settings has addressed how variations in time and space affect work group structure, properties and outcomes (i.e., Arrow A in Figure 1) (e.g., Tuckman 1965, Oldham and Rotchford 1983), and how work groups organize and use time and space (i.e., Arrow B in Figure 1) (e.g., McGrath and Rotchford 1983, Ancona and Chong, 1996).

GSS, virtual team and CSCW research has in the past extensively studied the impact of ICT induced features of structural time on work groups from a number of perspectives (i.e., Arrow C in Figure 1). As shown most of the past research in GSS and virtual team have treated time and space in terms of temporal and spatial dispersions, which have been operationalized in simple dichotomies of synchronicity and asynchronicity, or of presence and absence, respectively. CSCW research has approached time and space in more nuanced ways, but like the other research streams, has not fully incorporated its research agenda new aspects of time and space induced by ICT (i.e., Arrow D in Figure 1).

We argue that the true implications of novel aspects of time and space induced by ICT on work groups have not been fully acknowledged in the extant literature. There is a paucity of research on how new features of time and space affect work group organization and performance (i.e., Arrow E in Figure 1) and how work groups, in turn, perceive and organize these new aspects (i.e., Arrow F in Figure 1). Furthermore, the impacts of ICT on time and space have been studied *separately* in all previous studies. Yet the on-going radical decoupling of time-space configuration demands their simultaneous treatment in studying new ways of organizing these dimensions as supported by ICT technologies.

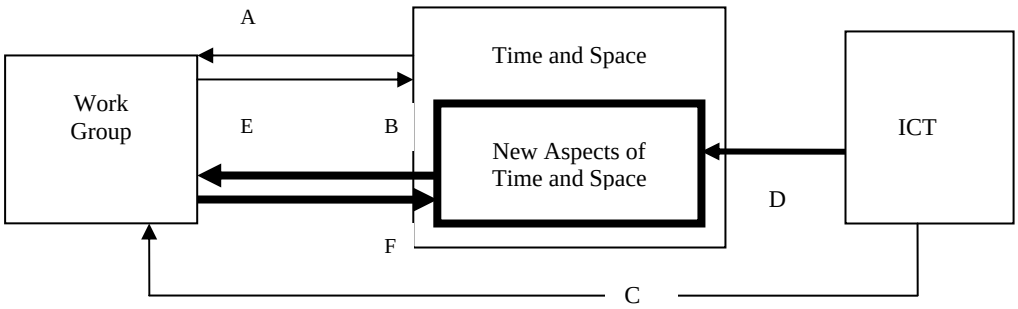

Figure 1. Relationships among ICT, time and space, and work group

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Four Emerging Research Themes

To promote future research in the new aspects of time and space, we identify four emerging research themes for future research. These themes intersect both the structural and interpretive parameters of a temporal and spatial world and assume that time and space will adopt both the independent and dependent variable roles. Within the four research challenges, we will formulate overall nine research questions that can guide the future research agenda (see Table 5). For brevity, these questions will be formulated in quite general level so we will forego of outlining specific propositions or constructs to investigate these research questions in detail. Such a task is clearly beyond the goals of this paper and remains a research task ahead.

Time-Space	Independent Variable	Dependent Variable
Structural Parameters	Research theme 1 • Effect of instantaneity and simultaneity on communication effectiveness and performance of work groups. • Effects of the decoupling of time-space on trust, cohesion and coordination of knowledge.	Research theme 2 • How groups manage their temporal and spatial boundaries to accommodate instantaneity and simultaneity enabled by ICT. • Effect of task characteristics enabled by ICT on the ways group members to create new time-space configurations. • Effect of context awareness and the mobility of context on the ways in which workgroup members create and manage new time-space-configurations. • How groups manage multiple tine-space configurations of group and of work.
Interpretive Parameters	Research theme 3 • Impacts of newly negotiated social norms regarding time and space as induced by ICT on task and communication performance. • Impacts of newly negotiated social norms regarding time and space as induced by ICT on trust, cohesion and coordination of knowledge.	Research theme 4 • How groups manage emerging interactions between ICT and other organizational elements on meanings and norms of time-space configurations.

Table 5. Future research themes

Research Theme 1 (Structural Parameters – Independent Variable). Research theme 1 focuses on the structural parameters of time and space as independent variables. This research theme assumes that the new features of time and space as enabled by ICT will significantly affect future group behaviors.

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Instantaneity and simultaneity enabled by ICT will increase improvisation, multi-tasking and contingent scheduling. All this necessitates that individuals participating in multiple work groups have to work in more elastic and dynamic ways. This higher level of unpredictability may lead to an increase in uncertainty and generate new contingencies in work organization, which, in turn may affect important group variables such as communication effectiveness and performance.

> **Research Question 1:** What is the effect of instantaneity and simultaneity on communication effectiveness and overall performance of work groups?

Due to the use of mobile ICT, mobile people can perform the same task (both personal and public) in different places, times and contexts. Resulting changes in the physical locality and temporality can further affect group cohesion, trust and their socio-cognitive capability to coordinate knowledge and expertise.

> **Research Question 2:** What are the effects of the decoupling of time-space on trust, cohesion and coordination of knowledge?

Research Theme 2 (Structural Parameters – Dependent Variable). Research theme 2 focuses on the structural parameters of time and space as a set of dependent variables. As shown in figure 1, new ICT and intervening factors in workgroup can affect a group's time-space configurations, and the way in which a group manages its time and space.

The new technical features of ICT such as mobility, instant connectivity and synchronicity set individuals in a position where they will not easily miss anything and can switch with ease to issues that seem to be more important or pressing. Such technical capabilities may lead to fundamentally different behaviors toward time and space management.

> **Research Question 3:** How do work groups create new time-space configurations in order to accommodate instantaneity, simultaneity and polychronicity enabled by ICT?

A host of group factors can affect the way group members manage their time and space configuration. For example, task characteristics can affect how group members establish their temporal and spatial boundaries as part of appropriating their ICT enabled time-space configuration.

> **Research Question 4:** How do task characteristics affect the ways group members establish new time-space configurations as enabled by ICT?

Past research suggests that the context plays important role in workgroup performance. New technical capabilities can affect the context awareness and increase the sense of fluidity. For example, communications among group members via ICT are not as spontaneous and natural as those in face-to-face settings, and consequently it is difficult to maintain peripheral awareness of events in cyber-space (Belotti and Bly 1996). On the other hand, new functionalities of ICT, such as instant messaging or P2T, keep group members constantly updated on the state of their work environment and facilitate their assessment of the situations.

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Research Question 5: How do context awareness and the mobility of context affect the ways in which workgroup members create and manage time-space configurations?

Empowered by ICT capability, group members can be available but not present, distant but yet connected. The boundary between group work and non-group activities appears harder to retain as the spill-overs of work activities into non-group activities become frequent. The distinction between group space and non-group space, between group time and non-group time, is no longer as clear as it used to be.

Research Question 6: How do work groups supported by ICT create and maintain *multiple* time-space configurations of their group work both in the physical and in the virtual world?

Research Theme 3 (Interpretive Parameters – Independent Variable). Research theme 3 focuses on interpretive parameters of time and space as independent variables. Ubiquity enabled by ICT can easily create a sense of urgency. Distance, walls and official work hours no longer provide protection from work duties, control, surveillance, and group members can be obliged to be 24/7 on call thus changing the dead time into work time (Perry et al 2001). ICT allows also people to modify their group timetables according to last-minute information. This suggests that people negotiate new temporal and spatial norms in social interactions and they can more and more negotiate such norms over distance. Such newly negotiated temporal and spatial norms and new spatial configurations of negotiating such norms can affect team task and communication performance.

Research Question 7: What are the impacts of newly negotiated social norms regarding time and space induced by ICT on task and communication performance?

Newly negotiated social norms on time and space not only affect team performance, but also the trust, cohesion and their ability to coordinate their knowledge and capability.

Research Question 8: What are impacts of new social norms regarding time and space as induced by ICT on trust, cohesion and coordination of knowledge?

Research Theme 4 (Interpretive Parameters – Dependent Variable). Finally, research theme 4 focuses on interpretive parameters of time and space as dependent variables. ICT not only affects the configuration of time-space, but also how workgroup members negotiate the meaning and boundary of time-space configurations. ICT does not exist independently from other elements of organization in which work groups are embedded. Rather, it interacts with other components. The influences of such interactions are manifested in technical and economic gains and losses, as well as in new physical, social, symbolic, cultural aspects of the environment in which work groups operate. These may strengthen or weaken the meanings of and norms related to time and space. The modification in meanings and norms may in turn alter group members' perception of their tasks and roles, and have its effect felt in groups' on-going work practice.

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Research Question 9: How do work groups manage the impacts of emerging interactions between ICT and other elements of organizations on the meanings and norms of time-space configurations?

Conclusion

In this paper, we have identified instantaneity, simultaneity, independency from fixed place, fluidity of context, and multi-presence, as the new aspects of time and space as enabled by ICT. Our review reveals that the extant literature on ICT and groups has focused mainly on temporal and spatial dispersion and ignored the novel changes of time-space configuration as induced by ICT. Our analysis suggests that new ICT capabilities are likely to abruptly decouple traditional time-space configurations which have been the basis of traditional social life and enables novel forms of time-space configurations. Furthermore, it is expected that such changes will have significant implications for workgroup performance, management of time and space, and long-term sustainability of organizational work.

Our study calls for increased attention to important but unexplored research areas in groups interacting with ICT. We identified four such research themes, which cover both structural and interpretive parameters of a temporal and spatial world, and consider both the independent and dependent variable roles time and space can assume. These four research themes are organized in terms of nine research questions which endeavor to fill the widening gap between the current knowledge (what we know) and the radical changing temporal and spatial circumstances (what we should know). The research questions that we have formulated can hopefully direct future research in fruitful areas.

For academic researchers, the paper directs their attention from a very narrow view of temporal and spatial conditions as induced by ICT to a broader appreciation of a rich set of aspects of time and space related to the new capabilities offered by ICT. The emerging novel forms of time-space configurations as a result of recent developments in ICT demand systematic studies and new theorizing about the ICT artifacts and their roles in work groups. While admitting the importance of structural changes in the temporal and spatial world that result from the growing use of ICT in groups, the paper also stimulates new interest in examining how groups internalize new temporal and spatial configurations in their work. In other words, we call to fill the void in research of the interpretive aspects of time and space in groups. Deeper understanding and conceptualization of the experiential parameters of time-space configurations and their social meanings can help better theorize in future the relationships between ICT artifacts and work groups.

Theorizing about ICT artifacts, their role in group work, and work practices with respect to both physical and experiential aspects of time and space has practical significance for organizations adopting new ICT capabilities. For example, new research findings can provide guidelines for implementing effectively technologies in work groups, designing spatially or temporally distributed work arrangements, and supporting group work under new temporal and spatial circumstances.

The research agenda proposed in this paper is not without limitations. The review of existing literatures on ICT studies in work groups is brief, as we sought to reveal more what has been done than what has been exactly found in terms of time and space issues in work groups. We seek to substantiate the findings of this review by a further in-depth examination of the literature of what we truly know about time and space. In addition, the research agenda we proposed did not address the raised concerns of new research methods. While the four research themes in the research agenda propose research questions, they do not provide any suggestions as to what kinds of research methods are appropriate for different research

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themes. Finally there is a need for more careful theorizing how different ICT capabilities and applications relate to different time and space configurations- in short we need a more carefully crafter notions of ICT artifacts and their time and space ramifications.

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