The Role of Coordinating Knowledge in Expert Coordination: Evidence from the Healthcare Field

by

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(Under the Direction of Elena Karahanna)

Abstract

This dissertation seeks to understand how experts in the healthcare context know how to coordinate, how that knowledge affects coordination, and how information systems interplay with the coordination process. In order to address these questions we explore the meta-knowledge around the coordination process and introduce *coordinating knowledge as information that enables a person to identify how to exchange information to achieve a shared goal. Specifically, this set of knowledge enables coordination by allowing the actors to know the involved actors, the timing, the content, and the method, in order to coordinate*. To study this phenomenon, we recognize that the coordination process is a series of coordination instances, and we use the coordination instance as our unit of analysis.

We dissect each component of coordinating knowledge into fourteen more actionable component-specific types of coordinating knowledge and identify four sources of coordinating knowledge (coordination mechanisms, domain expertise, team familiarity, and team awareness) that individuals draw upon in order to coordinate. By specifying these 14 types of coordinating knowledge, we are able to develop propositions of the effects of each on the performance of a coordination instance. Using the coordinating knowledge framework as a new lens, we explore how coordinating knowledge can be embedded in or enhanced by information systems, and develop propositions about these effects.

Though the primary focus of the dissertation is on theory building, to provide preliminary empirical evidence for the existence of coordinating knowledge and our propositions, we gather data via qualitative research methods about 289 coordination instances in the healthcare context. Examples of coordination instances that confirm our propositions are discussed. Next, we perform quantitative analyses to test our propositions further, and conduct two types of post-hoc analyses to explore the patterns and relationships of coordinating knowledge. We conclude with an in-depth discussion of our findings and the future research possibilities that the coordinating knowledge framework brings to light.

INDEX WORDS: Coordination, Coordinating Knowledge, Coordination Instance, Healthcare, Efficiency, Effectiveness, Failed Coordination, Modularity

THE ROLE OF COORDINATING KNOWLEDGE IN EXPERT COORDINATION: EVIDENCE FROM THE HEALTHCARE FIELD

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CHAPTER 1: INTRODUCTION

Coordination is an important concept in understanding and predicting performance in modern organizations (Argote 1982; Gittell 2002; Malhotra et al. 2005; Malone and Crowston 1994; Okhuysen and Bechky 2009; Rico et al. 2008; Willem et al. 2006). Being involved in tasks that require coordination to achieve an end goal implies that individuals engage in (1) processes necessary to achieve the goal and (2) processes necessary to manage the dependencies between themselves and others (Malone and Crowston 1994). This latter set of activities is the domain of coordination. Previous work has considered coordination as a general process that occurs as actors manage task interdependencies. However, this broad process lens has made it difficult to precisely understand *how* coordination takes place.

Our research recognizes that coordination is the result of a series of *coordination instances* (a single episode in which the actors engage in actions necessary to manage dependencies). By theorizing at the coordination instance level, we gain new understanding about what happens during coordination and about the meta-knowledge that is required in order to *enact* a specific coordination instance. Specifically, we suggest that in order to engage in a coordination instance people coordinating must know *whom* to coordinate with, *when* to coordinate, *what* to coordinate, and *how* to coordinate. We, thus, define *coordinating knowledge as information that enables a person to identify how to exchange information to achieve a shared goal. Specifically, this set of knowledge enables coordination by allowing the actors to know the involved actors, the timing, the content, and the method, in order to coordinate*. Therefore, we suggest that coordinating knowledge has four components (the actors [who], the timing [when], the content [what], and the method [how]) that need to be known in order to enact a specific coordination instance.

The objectives of the current research are *(1) to dissect each component of coordinating knowledge into more actionable, component-specific types, (2) to identify the sources of coordinating knowledge that individuals draw upon in order to coordinate, and (3) to use the coordinating knowledge framework to gain insights into how information systems might affect coordination.* In terms of the first objective, the coordinating knowledge components that we have identified determine what needs to be known (e.g., the actors [who?] - one needs to determine with whom to coordinate), but do not yet provide guidance as to how this determination can be made. To address this, we identify specific types of coordinating knowledge that can be leveraged to determine how to engage in a coordination instance. For example, when considering the selection of with whom to coordinate, we specify three types of coordinating knowledge one can draw upon: coordinating knowledge about role that guides selection based on the other actor's role (e.g., need to coordinate with a nurse), coordinating knowledge about assignment (e.g., need to coordinate with the cardiologist assigned to patient John Doe), and coordinating knowledge about the individual (e.g., need to coordinate with Dr. Smith, because he is especially knowledgeable about this particular type of health condition). Specifying these more tangible types of coordinating knowledge, we are able to develop propositions about the effects of these on the performance of a coordination instance and to identify sources of this knowledge.

In considering likely sources (the second objective of the research) of coordinating knowledge, we are able to make recommendations to organizations about how to guide the performance of coordination by understanding and managing the development of coordinating knowledge. We recognize that one source of coordinating knowledge is routinized coordination mechanisms inside organizations. We clarify the definition of *coordination mechanisms to be partial blueprints of how to enact an instance of exchanging information or other resources to achieve a shared goal, by predetermining one or more components of coordinating knowledge.* Though routinized coordination mechanisms are an important source of coordinating knowledge, when enacting an actual instance of coordination, their *partial* blueprint nature and the occurrence of emergent coordination needs imply that coordinating knowledge often has to derive from other sources as well. Through a literature review we identify three additional complementary sources of coordinating knowledge: domain expertise, team familiarity, and team awareness (knowing of another team member's current location, assignment, and availability). We are able to explain the effects of previously identified antecedents to coordination by considering how they act as sources of coordinating knowledge. Identification of these sources and our theorizing about how coordinating knowledge impacts coordination instances prepares us to be able to suggest ways for organizations to improve coordination between experts.

Viewing coordination at the coordination instance level and focusing on the meta-knowledge surrounding these coordination instances makes important contributions to research on coordination. Modern organizations continue to rely on more and more specialized experts, holding specific knowledge and information that is needed to complete the task of the group (Child and McGrath 2001; DeSanctis and Monge 1999; von Nordenflycht 2010). These experts operate in dynamic contexts and must leverage each other's expertise in order to perform well (Faraj and Sproull 2000, 2000; Gardner et al. 2012). Looking at the coordination instance as a level of analysis allows us to understand what needs to be in place in order for them to enact coordination. This contribution provides a new way to consider coordination and opens the door for novel ways to study the coordination process. We leverage this unique level of analysis by recognizing the important role of coordinating knowledge. Specifically, by considering the coordination instance, coordinating knowledge becomes salient and its impacts on the performance of the coordinating process more evident.

Our contribution of a micro-level understanding of the coordination process during a coordination instance allows us the tools to comprehend how new technologies impact coordination by improving the provision of coordinating knowledge. Thus our third research objective allows us to study these information systems interventions by considering how they modify, enable, or embed coordinating knowledge involved in a coordination instance. We develop additional propositions that suggest ways information systems might further impact the coordination instance.

We organize our theoretical exploration of coordination into three parts presented in chapters 2 and 3. Chapter 2 first presents the conceptualization of coordinating knowledge through examining the key components of the coordination process. We recognize 14 component-specific *types* of coordinating knowledge and describe them. In the second part of chapter 2 we identify and discuss four sources of coordinating knowledge (coordination mechanisms, domain expertise, team familiarity, and team awareness). Chapter 3 presents a series of propositions that suggest benefits of each component-specific type of coordinating knowledge and explores how information systems interacts with coordinating knowledge in affecting the coordination instance. Chapter 4 describes our research methodology including data collection and data coding. We present our data analysis and results in Chapter 5. Finally, Chapter 6 provides a discussion about our research findings, limitations, implications for research and practice, and directions for future research.

Context: Healthcare

Hospitals are an excellent example of a modern organization dependent on teams of knowledge workers, and therefore are conducive to studying coordination. Delivering healthcare to an individual during hospitalization requires a team of experts to coordinate in a dynamic, fast-paced environment where performance gains due to successful coordination literally have life and death implications. Coordination research has a rich history of using the healthcare context to study various aspects of coordination, such as the effects of uncertainty on coordination (Argote 1982; Broekhuis and van Donk 2011), how coordination is improved by team relationships (Gittell et al. 2008, 2010; Gittell 2002), the nature of coordination in complex, dynamic task environments (Ren et al. 2008), and how medical expertise is brought to bear through coordination practices (Faraj and Xiao 2006). Following in this tradition, we explore coordination by considering the healthcare context and framing our discussion with healthcare examples.

This dynamic and complex task environment represents an extreme example of experts engaged in constant coordination, due to the large number of patient cases (most of which are intense, but brief) and rotating teams of experts (due to shift scheduling). This latter context trait is especially helpful in our theorizing. Experts often have experience working with a team member, so previous history plays a role in future coordinating episodes. However, these teams of healthcare professionals are not static and each shift may bring together a different combination of experts, which allows us to consider which coordinating decisions are made because of the actors involved and which are made because of the situation. We expect our new insights derived from considering coordination in healthcare settings to generalize to many modern organizations that utilize teams of knowledge workers.

CHAPTER 2: THEORETICAL DEVELOPMENT OF COORDINATING KNOWLEDGE

To conceptualize coordinating knowledge, we review the coordination literature to better understand what occurs during the coordination process and during a coordination instance. In the following three sections we explore the basic definition of coordination briefly, identify the four components (actors, trigger, content, method) of a coordination instance that are addressed with coordinating knowledge, and explore the sources of coordinating knowledge. In this latter section we first clarify our understanding of a coordination mechanism, and then identify three other complementary sources of coordinating knowledge. Figure 1 provides a general overview of these areas of discussion and how they fit together.

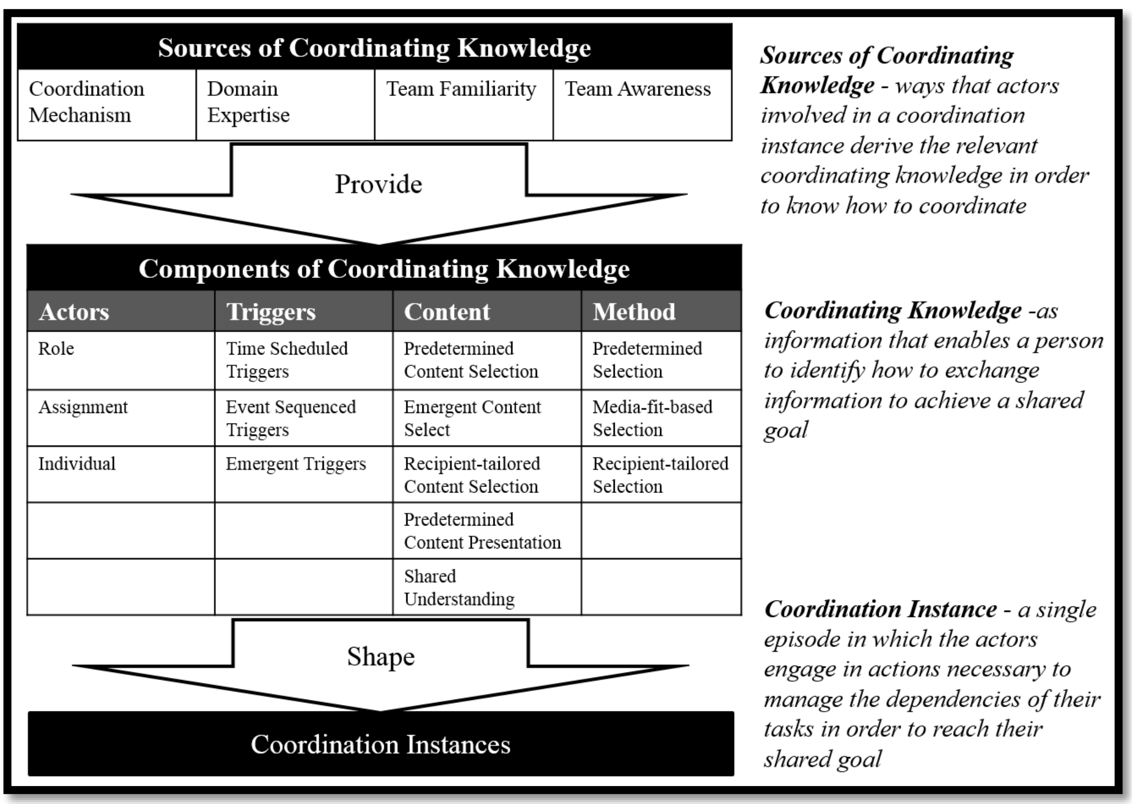


Figure 1: Coordination Instances and Coordinating Knowledge Overview

Refining our Understanding of Coordination

Coordination is a general term for the process that allows individuals to manage *interdependencies* that arise when completing a task (see Appendix A for illustrative definitions of coordination). Coordination theory suggests that an actor engages in (a) processes necessary to achieve the task-related goal (i.e., a task that creates a good or performs a service) as well as (b) processes that serve to primarily manage interdependencies (Malone and Crowston 1994). In studying coordination we focus on the second set, where we identify each *coordination instance as a single episode in which the actors engage in actions necessary to manage the dependencies of their tasks with other actors, in order to reach their goals.* Where knowledge workers coordinate in order to fully leverage a variety of expertise, a coordination instance is usually a situation where information is shared between two or more actors (Boden 1994; Quinn and Dutton 2005).

Achieving the outcome of interest often necessitates a series of coordination instances. For example, suppose a patient is admitted to a hospital for heart surgery. There is likely to be a long series of coordination instances between the nurses, the cardiologist, and the hospitalist involved in his treatment. Each coordination instance is an episode in a larger coordination series, where the goal is to provide the best healthcare treatment possible. This broad goal has a tangle of interdependencies, as the treatment results from a series of decisions that the healthcare professionals need to make that benefit from successful coordination instances between the experts. We detail this relationship in Figure 2. The focus of this manuscript is at the level of a *coordination instance*, regardless of the larger situation in which it is embedded. While the performance of the shared goal (e.g., patient health outcomes) is of ultimate importance, we must first understand the nature of the individual coordination instance, as it is the building block of coordination and the mechanism via which coordination is enacted.

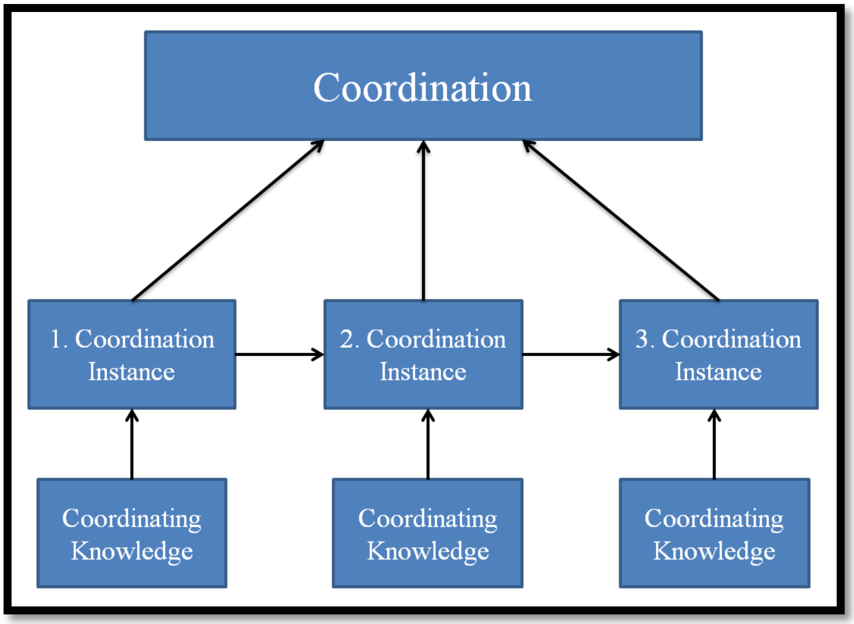


Figure 2: Coordination Instances and Coordinating Knowledge as Part of the Coordination Process

Previous work in coordination has looked at coordination *as a summation of all* coordination instances, and therefore has attempted to use overall performance measures to determine the impact of coordination. Studies have used team productivity and process satisfaction (Andres and Zmud 2001; Hoegl and Gemuenden 2001), time taken to finish tasks or develop products, and the quality of group decisions or physical outputs (Banker et al. 2006; Espinosa et al. 2007a; Ren et al. 2006; Slaughter and Kirsch 2006) as measures of performance. In the healthcare arena studies have looked at quality of care, patient satisfaction, and length of patient stay (Argote 1982; Gittell et al. 2010; Gittell and Weiss 2004; Gittell 2002). Some studies have also attempted to judge quality of coordination by considering the amount of communication (Slaughter & Kirsch, 2006; Van de Ven, Delbecq, & Koenig, 1976) or its frequency (Argote 1982). However, in seeking to unpack the black box of how experts coordinate and how coordination impacts performance, our level of analysis is the coordination instance and we thus focus our discussion of impact on the change in efficiency and effectiveness of the coordination instance.

Effectiveness is concerned with successful achievement of an objective. Effectiveness of a coordination instance is increased when the communication empowers actors to achieve the objective by bringing their expertise to bear. Recall that according to coordination theory, we expect to see actors engaged in processes necessary to achieve their task-related goal as well as processes that serve to manage these dependencies (Malone and Crowston 1994). Coordination instances are the vehicles actors use to share information and knowledge, to manage the dependencies, in order to be able to engage in processes necessary to achieve their goals (e.g., healthcare delivery). Coordination instances maximize performance when they are able to deliver the right information, to the right person, at the right time. Research on information quality suggests that the right information can be conceptualized in terms of its completeness, relevance, accuracy, timeliness, and the right level of detail relative to the specific task (Bailey and Pearson 1983; DeLone and McLean 2003; Ives et al. 1983; McKinney et al. 2002; Wixom and Todd 2005). The execution of a coordination instance is likely to influence the completeness, relevance, and level of detail of the content being shared and to influence the timeliness of the communication. Therefore, we expect the effectiveness of the coordinating instance to be indicated by (1) the quality of the information being shared in the coordination instance (completeness, relevance, or level of detail), (2) actor selection with whom to coordinate, or (3) the timing of the coordination instance (Cummings et al. 2009).

Efficiency involves minimizing the associated costs (time or effort) used in completing a task (Evans and Davis 2005). The efficiency of a coordination instance is increased when the time and effort used to complete the necessary coordination is decreased. However, economizing coordination also means minimizing the amount of communication required to transfer information (Grant 1996). Therefore we expect the efficiency of the coordinating instance to be indicated by (1) the cognitive effort expended by the involved actors, (2) the time spent by the involved actors or (3) the amount of follow-up (sequential) coordination instances that occur (e.g., perhaps the receiver asks for follow-up information in additional coordination instances that could have been included originally). We summarize these indicators of coordination performance in Table 1.

Table 1: Summary of Indicators of Coordination Instance Performance

Effectiveness of a Coordination Instance Indicated by…	**Shorthand**[1]
(1) the quality of the information being shared in the coordination instance (completeness, relevance, or level of detail)	Information Quality
(2) actor selection with whom to coordinate	Person Selection
(3) the timing of the coordination	Timeliness
Efficiency of a Coordination Instance Indicated by…	**Shorthand**
(1) the cognitive effort of the involved actors	Cognitive Effort
(2) time spent by the involved actors	Time Spent
(3) the amount of follow-up (sequential) coordination instances that must occur	Follow-Up CIs

[1] In subsequent figures we may refer to these six types of coordination instance performance improvements by the abbreviated forms seen in the "shorthand" column.

Defining Coordinating Knowledge

Coordination is often broadly defined as the management of interdependencies among tasks (Malone and Crowston 1994), but research that has specifically focused on coordination between experts offers us definitions of coordination that yield insights into the actual process that occurs between these individuals. Gittell and Weiss (2004 p. 132) explain that coordination "is fundamentally about the connections among interdependent actors who must transfer information and other resources to achieve outcomes." This identifies the fundamental importance of two or more *actors* in coordination and the transfer of *content* between them. Faraj and Xiao (2006) point out that coordination is "a temporally unfolding and contextualized process" and suggest that a reconceptualization of coordination should focus on the content and circumstances of coordination. In other words, coordination occurs between two or more people, at a *specific time*, when they share *specific* content via a *method of communication*, and all of these circumstances are important to understanding what happens during a coordination instance. By using these insights, we conceptualize an instance of coordination as an episode that includes four major *components* that shape the process: (1) the actors (who?), (2) the trigger (when?), (3) the content (what?), and (4) the method (how?). These four components form the basis for the definition of coordinating knowledge, since for a coordination instance to be enacted all four of these questions must be answered (be it by person or information system).[1]

Thus, we define *coordinating knowledge as information that enables a person to identify how to exchange information to achieve a shared goal.* Specifically, this set of knowledge enables coordination by allowing the actors to know the involved actors, the timing, the content, and the method, in order to coordinate. Coordinating knowledge is what needs to be known in order to engage in a coordination instance – that is, with whom to coordinate, when to do so, what to communicate, and how to communicate in order to manage a specific interdependency.

Studying coordination at the granular level of the coordination instance makes the coordinating knowledge components salient, and allows us to elaborate each component of coordinating knowledge into specific types and to identify their likely sources. These relationships are not evident when considering the coordination process at a higher level of analysis, but their discovery grants us new insights into the coordinating process which lead to

[1] Another consideration is that in every coordination instance, the four components of coordinating knowledge (who, when, what, how) have been necessarily realized. Even if the performance of the coordination seemed happenstance at the time, it still occurred at a certain time, between certain actors, etc. However, the purpose may not be understood by the actors even after the coordination instance (e.g., they were just following policy and do not actually know the purpose of the coordination) or the actual effects and resulting purpose may not be known until much later. Therefore, while the purpose of the coordination instance is important in the broader scheme of things, it is outside of the scope of our set of coordinating knowledge.

actionable suggestions about how to improve coordination instances. Given that these are the building blocks of coordination, they in turn position us to better address broader coordination problems and suggest ways to improve their related performance outcomes. Understanding the sources of coordinating knowledge further allows us to formulate strategies for how to change and improve coordinating knowledge and, consequently, performance related to improved coordination. Further, it gives us a framework to understand how information systems might enhance or encapsulate coordinating knowledge in order to effect coordination, and allow future work to use coordinating knowledge in order to design better information systems. Figure 3 summarizes the conceptual model we explore in the following sections.

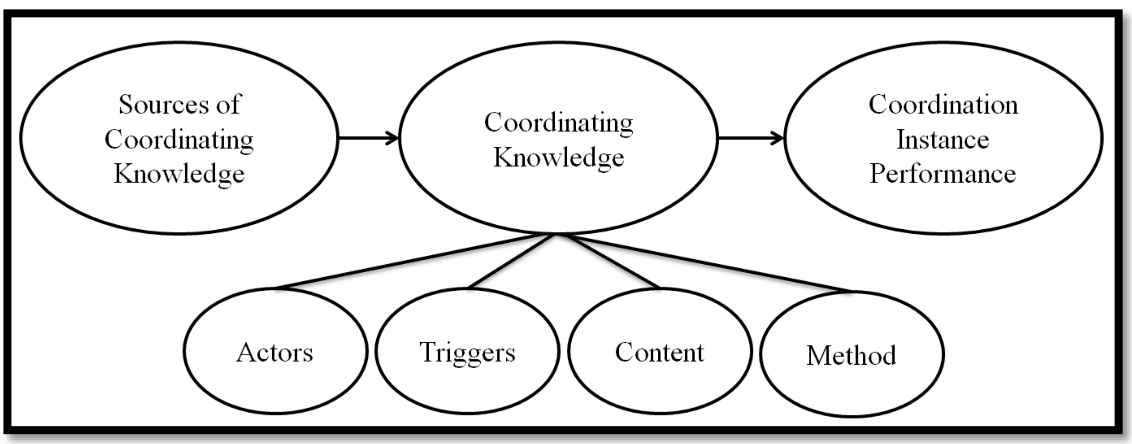


Figure 3: Conceptual Model around Coordinating Knowledge

Coordinating Knowledge about Who: Selecting the Actors Involved

The first set of coordinating knowledge we explore is knowledge that helps an actor know with whom to coordinate. Prior literature, most notably work in transactive memory systems (TMS), has talked about the necessity of knowing where specific expertise is in a team (Hollingshead 2001; Jarvenpaa and Majchrzak 2008; Kanawattanachai and Yoo 2007; Majchrzak et al. 2007; Wegner 1986). Initial work described the process of building a TMS as encoding the location of knowledge by memorizing what each team member might know

(Wegner 1986). The existence of a TMS, particularly the foundational component that is knowledge about who knows what, allows coordination to be executed in a more efficient and effective fashion (Faraj and Sproull 2000; Hollingshead 2001; Hsu et al. 2012; Lewis et al. 2005, 2003). Although there is substantial evidence that knowing who holds specific expertise and relevant knowledge to the task at hand leads to better coordination (and ultimately performance), this literature has not specified exactly what types of knowledge allow for this advantage. We suggest that there are three types of coordinating knowledge that aid an actor in knowing who holds relevant expertise and knowledge: coordinating knowledge about (1) role, (2) assignment, and (3) individual.

The growing complexity of organizations forces division of labor, and a logical way of dividing labor is by specialties or roles (Kogut and Zander 1996). A role describes the functional group the actor is part of, and helps signal to other actors what knowledge the actor has and what functions he can perform (Lewis and Herndon 2011). Consider a situation where a nurse recognizes a patient's loss of appetite and knows the appropriate role (perhaps a nutritionist) with whom to coordinate. This is *coordinating knowledge about role* and is defined as information *regarding the functional position and the skills and abilities that this position implies of an actor that informs the selection of an actor with whom to exchange information or other resources.*

Another important circumstance that occurs within many team contexts is that of functional assignment to specific cases (Cummings 2004). In early work on the problem of coordination, it was recognized that dependencies may arise from the assignment of activities to actors (Crowston 1997). A common situation in hospitals is that each patient will have an assigned nurse and an assigned hospitalist during each shift. Consider the situation where a physician needs to coordinate with a nurse about a patient's medication. That type of coordination needs to involve not just any nurse (role), but the nurse assigned to the patient in question (assigned role). The first condition for assignment-based selection is for an actor to know that assignments exist (e.g., each patient in the ICU area is assigned to one particular floor nurse). This understanding usually occurs during initial training of the organization's or group's procedures. In order to use these assignments in coordination instances, an actor must know the relevant assignment at the moment of a coordination instance (e.g., Nurse Collins is assigned to patient Jim Blake). Therefore, the relevant piece of coordinating knowledge is which nurse is assigned to which patient. We refer to this type of coordinating knowledge as *coordinating knowledge about assignment* and it is defined as information *regarding a person's designated task, case or post that informs the selection of an actor with whom to exchange information or other resources*.

Actors can also be chosen because a person knows something about the individual. The recognition of individual knowledge domains is an important tool of teamwork (Grant 1996) and social ties between members helps an individual know "where to go" in the network for knowledge (Hansen 1999). For example, perhaps the general hospitalist sees a concerning heart problem in an elderly patient, and decides coordination with a cardiologist (role) is necessary. However, when enacting this coordination instance he selects cardiologist Patel over cardiologist Singh, because he knows that cardiologist Patel (individual) is particularly knowledgeable about heart conditions in older patients. Or, perhaps he selects cardiologist Singh, because he knows that Patel is tied up in surgery all day (individual). Knowing about individualized team member areas of expertise, personality, experience, availability, situation, and preferences is an example of coordinating knowledge that may be used in addition to selection based on role, or on its own. *Coordinating knowledge about individuals* is defined as information *regarding a particular* *person's skills, capabilities, traits, or situation that informs the selection of an actor with whom to exchange information or other resources.*

Coordinating Knowledge about When: Triggers to Coordination

Before a coordination instance occurs, something must cause an actor to start the process. Little attention has been paid to the circumstances that surround and prompt coordination (Faraj and Sproull 2000; Faraj and Xiao 2006), but it is important to understand the coordinating knowledge needed to initiate coordination. Previous literature has recognized the distinction between scheduled and unscheduled meetings (Hage 1974; Hage et al. 1971; Van de Ven et al. 1976) and the importance and limitations of spontaneous, emergent communications (Massey et al. 2003). We suggest that coordinating knowledge about both scheduled and unscheduled triggers to coordination instances is important and suggest three types of coordinating knowledge that aid an actor in knowing when to initiate coordination: coordinating knowledge about (1) time schedule triggers, (2) event sequence triggers, and (3) emergent-triggers.

Two types of predictable triggers to coordination instances are time-triggers and event-triggers (Broekhuis and van Donk 2011). Coordination instances can be time scheduled to occur, such that their occurrence is expected and anticipated. For example, a team may always have meeting to discuss current patients every morning at 8 o'clock. *The information regarding a temporal plan that informs when to initiate an exchange of information or other resources* is known as *coordinating knowledge about time schedule triggers*. The other predictable trigger type is when coordination always occurs as part of a larger business process, such that the sequence of events triggers the coordination. For example, suppose a hospital's procedure for transferring a patient between departments always includes a form that the releasing physician must fill out and send to the accepting department. In these cases, knowledge about the sequence of events triggers the coordination in a predictable way. We define *coordinating knowledge about event sequence triggers* as information *regarding the order of related activities that informs when to initiate an exchange of information or other resources.*

There may be triggers that materialize due to situational circumstances that are not explained by predictable triggers. These coordination instances occur due to judgment calls and team interactions of the experts involved, and are related to what others have observed as spontaneous communication opportunities that improve team coordination (Espinosa et al. 2007a; Hinds and Mortensen 2005; Massey et al. 2003). For example, suppose a nurse recognizes that a patient's subtle change in appetite and energy may indicate a more serious health concern given the patient's other health conditions. The nurse decides to contact a physician about this new information, even though it is not part of a scheduled or routine communication. The interpretation of the unusual symptoms by the nurse served as an emergent coordination trigger. We define *coordinating knowledge about emergent triggers* as information *that allows an actor to recognize novel and previously unpredicted pieces information to include during the exchange of information or other resources.*

Coordinating Knowledge about What: Selecting and Formatting the Content

At the heart of each coordination instance is content that must be shared between two or more team members. There are two groups of decisions that must be made regarding the content that necessitate coordinating knowledge: the selection of the content and the presentation or format of the content. Regarding the first group of decisions, we suggest there are three types of coordinating knowledge that inform the selection of the content to share during a coordination instance: (1) coordinating knowledge about predetermined content, (2) coordinating knowledge about emergent content, and (3) coordinating knowledge about recipient-tailored content.

Coordinating knowledge about predetermined content refers to *information regarding pre-existing routines that guide the selection of specific pieces information to include during the exchange of information or other resources.* For example, suppose a normal routine is for a nurse ending a shift to meet with the nurse taking over his patients during the following shift. Part of this routine is for the exiting nurse to always tell the new nurse exactly which medications he administered and when. Therefore, the medication information has been predetermined and the nurses know to (and expect to) share that content.

However, sometimes the nurse ending his shift adds additional content that is not normally part of the predetermined set of content shared during meeting. For example, the added content might be an anomaly in a patient's behavior he believes merits further observation. An actor can possess expertise that allows him or her to recognize content that is relevant and useful as it emerges from the situation. When experts make decisions about the selection of content in this manner we refer to it as *coordinating knowledge about emergent content* and define it as information *that allows an actor to recognize novel and previously unpredicted pieces information to include during the exchange of information or other resources.*

The final type of coordinating knowledge used in selecting content involves the customization of the content to the intended recipient. This can occur if the actor selects content because he knows something about the work preferences of that particular expert (e.g., Dr. Xui always wants the last three blood pressure readings, even though the form asks only for the last one). It can also occur if the actor anticipates what a person will need because of the type of expertise that person has (e.g., urologists will always want a copy of these particular lab results). Both of these examples utilize *coordinating knowledge about recipient-tailored content*, which we define as information *that allows an actor to anticipate pieces information to include during the exchange of information or other resources.*

The second group of decisions involving the content in a coordination instance relates to how to present or format the information, and is guided by two types of coordinating knowledge: (1) coordinating knowledge about predetermined presentation and (2) coordinating knowledge about shared understanding. Much like coordinating knowledge about predetermined content, predetermined presentation is embedded in a coordination routine and the presentation decisions have been predetermined. For example, perhaps a coordination mechanism is in place that is used when an ICU physician is paged. Hospital staff using the paging software enter in patient name, room number, and a summary of their primary concern in less than 100 characters. The paging software then automatically formats a message to send to a physician's in-house phone device in the lay-out: *Patient Name (Room #), Concern*. The decision about how to format and present the information is predetermined, including the order of the three pieces of information and the punctuation of the text message. We refer to this as *coordinating knowledge about predetermined presentation* and define it as information *regarding pre-existing routines that informs the presentation of information during the exchange of information or other resources*.

Actors may leverage coordinating knowledge to make decisions about how to present information during a coordination instance because of shared understanding. Groups often establish communication norms that are used when presenting content during coordination. These communication norms occur when actors share common mental models. Mental models are held internal images about how the world works, that in turn influence how new information is processed and how previously stored information might be relevant to a particular situation (Kim 1993). Mental models are different from static memory, because they provide the context by which the world is viewed. Individuals operating in similar contexts (i.e., the healthcare industry) or in the same organization (i.e., a certain hospital) are likely to have *shared mental models*, meaning that there are significant similarities between individuals' mental models (Cannon-Bowers et al. 1993; Kim 1993; Klimoski and Mohammed 1994). This allows them to interpret information in a similar way. Shared mental models allows for shared language, taken-for-granted understandings and implications, and nuances in vocabulary (Madhavan and Grover 1998). One important factor of shared understanding is that it is knowledge you have in common and that the involved individuals know they have it in common (Cramton 2001).

For example, vitals of a patient could be presented as "James Jones, in ICU room 5, was found to have especially high blood pressure this morning. I took a reading at 8am and found his systolic pressure to be 160 mmHG and his diastolic pressure to be 110 mmHG." However, in a team used to coordinating patient blood pressure, and familiar with blood pressure ranges, measurement units, etc., this same information might be presented in abbreviated form as, "ICU #5 – 8am – BP: 160/110." In our example, due to an underlying perception of what is shared understanding, the actor chooses to present the blood pressure information in a very succinct format and use abbreviations like "BP" that he believes will be understood by the receiving actor. We refer to this type as *coordinating knowledge about shared understanding* and define it as information *regarding shared norms and mental models that informs the presentation of information during the exchange of information or other resources.*

Coordinating Knowledge about How: Choosing the Method

Coordination transmits information between two or more actors in order to manage interdependencies (Broekhuis and van Donk 2011; Malone and Crowston 1994), but the methods that the actors select to transmit the information can vary greatly. A method can be thought of as the vehicle which transmits the information between the two actors. In a healthcare setting, just like most organizations, there are often multiple ways for team members to communicate. E-mail, phone calls, in-person conversations, text messages, and EHR solutions all offer ways for two actors to coordinate. We identify three types of coordinating knowledge related to selecting the coordination method: (1) coordinating knowledge about predetermined method (2) coordinating knowledge about media fit method, and (3) coordinating knowledge about recipient-tailored method.

Coordinating knowledge about predetermined selection can influence the selection of method chosen for a coordination instance. For example, a coordination routine may exist that dictates a weekly, in-person meeting occurs between the ICU nurses. Within this routine is the implicit decision that the method of coordination will be verbal communication. We refer to this as *coordinating knowledge about predetermined method* and define it as information *regarding pre-existing routines that informs the selection of a form of communication to use during the exchange of information or other resources.*

The second type of coordinating knowledge that may guide the selection of the coordination method involves understanding what media best fit the nature of the coordination from the choices available. If there are multiple methods available to coordinate, this coordinating knowledge helps the actor select one method over the others. Many methods involve some type of information system, and there is a rich body of literature that studies media choice and the use of information and communication technologies (e.g., Carlson & Zmud, 1999; Te'eni, 2001; Watson-Manheim & Bélanger, 2007). In order to better understand how coordinating knowledge might influence the selection of a coordination method, we first turn to the research streams of media richness and media synchronicity.

Media richness refers to the capacity of the medium to overcome diverse frames of reference in order to support communication across channels, and allow actors to coordinate (Daft and Lengel 1986). Work has looked at how media richness improves quality and speed of coordination, particularly in complex situations with high uncertainty (Banker et al. 2006; Maznevski and Chudoba 2000). When selecting a method to coordinate, actors are likely to consider both urgency of the communication and availability of the recipient in order to achieve task closure (Straub and Karahanna 1998). These studies often expect performance gains when the communication media capabilities match the coordination task (e.g., a task needs rich media and the technology medium provides rich communication capabilities). Media synchronicity theory (Dennis et al, 2008) further elaborates on this concept by describing five media capabilities that shed insight into this selection process: transmission velocity, parallelism, symbol sets, rehearsability, and reprocessability.[2] These decomposed capabilities offer five considerations for selecting a coordination method that may be understood as part of the coordinating knowledge of method selection. Where previous theorizing suggests that the "best fit" will improve performance over less ideal fits, we suggest that experts will attempt to select a medium that provides a fit between communication media capability and coordination task. For example, when faced with a decision between calling someone on the phone and sending an email, it seems logical that people will consider the coordination task (e.g., Is it urgent? Would having a synchronized conversation be helpful in this particular coordination? Is having a written copy of the communication valuable?) as part of their coordinating knowledge that guides the

[2] Transmission velocity refers to the speed the content is shared with the recipient. High parallelism allows for multiple messages, from multiple participants, to be sent at the same time. Symbol sets refers to the different ways a medium allows the content to be encoded (e.g., language variety, body language visible, tone of language, etc.). Rehearsability is the term used to describe how much the medium allows the sender to craft and re-craft the message before transmittance, and reprocessability refers to how many times the receiver can process the message (e.g., a phone conversation cannot be easily played again, where as an email can be read many times). For more information, see Dennis et al. 2008.

method selection. All five media capabilities may not be important to every coordination instance, and it is possible that actors select the "right" method without consciously considering all of them. This is *coordinating knowledge about media fit method* and is defined as information *regarding the situation and the media capabilities that informs the selection of a form of communication to use during the exchange of information or other resources by matching the media capabilities with the needs of the situation.*

The final type of coordinating knowledge that informs the selection of the coordination method is knowledge of recipient media style or preferences. Individuals have personal styles and use some media differently (e.g., more frequently) than others, in ways that are not attributable to task or organizational variation (Karahanna and Limayem 2000). Knowledge of the sender's media style preferences may affect the selection of coordination method in a coordination instance. Knowing the habits and preferences of team members regarding technology media can also influence the selection of the method of coordination. For example, perhaps one team member checks his email every five minutes, where as another checks it only a couple of times a shift. An actor may consider email a viable method in an urgent situation when coordinating with the first team member, but not the second. Also, knowing what they prefer and are more likely to respond to might make a certain method the better choice, above and beyond considering the technology traits. We refer to this as *coordinating knowledge about recipient-tailored method* and define it as information *regarding a team member's media style preferences or situation that informs the selection of a form of communication to use during the exchange of information or other resources.* A summary of the 14 types of coordinating knowledge that we have identified is located in Table 2.

Table 2: Coordinating Knowledge Types & Definitions

Coordinating Knowledge Category	Specific Types: Coordinating knowledge …	Definition (Coordinating knowledge…)
Actors (who)	Role	*... about the functional position and the skills and abilities that this position implies of an actor that informs the selection of an actor with whom to exchange information or other resources*
	Assignment	*... about a person's designated task, case or post that informs the selection of an actor with whom to exchange information or other resources*
	Individual	*... about a particular person's skills, capabilities, traits, or situation that informs the selection of an actor with whom to exchange information or other resources*
Triggers (when)	Time schedule Triggers	*...about a temporal plan that informs when to initiate an exchange of information or other resources*
	Event sequence Triggers	*...about the order of related activities that informs when to initiate an exchange of information or other resources*
	Emergent Triggers	*... that allows an actor to recognize novel and previously unpredicted needs to initiate an exchange of information or other resources*
Content (what)	Predetermined Content Selection	*...about pre-existing routines that guide the selection of specific pieces information to include during the exchange of information or other resources*
	Emergent Content Selection	*...allows an actor to recognize novel and previously unpredicted pieces information to include during the exchange of information or other resources*
	Recipient-Tailored Content Selection	*...originating from other team members that allows an actor to anticipate pieces information to include during the exchange of information or other resources*
	Predetermined Content Presentation	*...about pre-existing routines that informs the presentation of information during the exchange of information or other resources*
	Shared Understanding	*...about shared norms and mental models that informs the presentation of information during the exchange of information or other resources*
Method (how)	Predetermined Method Selection	*...about pre-existing routines that informs the selection of a form of communication to use during the exchange of information or other resources*
	Media-Fit Method Selection	*... about the situation and the media capabilities that informs the selection of a form of communication to use during the exchange of information or other resources by matching the media capabilities with the needs of the situation*
	Recipient-Tailored Method Selection	*...about a team member's media style preferences or situation that informs the selection of a form of communication to use during the exchange of information or other resources*

Sources of Coordinating Knowledge

We have explored the four categories of coordinating knowledge and identified 14 specific types of coordinating knowledge that may be used in order to shape a coordination instance. However, in order for our understanding to be practically useful we must address how organizations cultivate and improve coordinating knowledge available to experts. We must also understand from where it originates. We identify four sources of coordinating knowledge by reviewing the literature: (1) coordination mechanisms, (2) domain expertise, (3) team familiarity, and (4) team awareness. Previous work in coordination and team performance has identified these as beneficial to coordination; however, it is often unclear exactly *how* these antecedents improve coordination. The coordinating knowledge framework provides one mechanism via which these sources impact coordination – that is, by providing coordinating knowledge to coordination instances.

Understanding the sources of coordinating knowledge is important in order to formulate strategies for how to change and improve coordinating knowledge and, consequently, performance related to improved coordination. These sources point us to the 'levers' available for organizations to manipulate in order to alter and improve coordination instances. We discuss each one in further detail and consider which types of coordinating knowledge each source provides.

Coordination Mechanisms - Organizations influence coordination instances by implementing coordination mechanisms (Simon 1957). These provide actors some type of a blueprint with which to coordinate. Coordination mechanisms involve situations where coordination has been (at least partially) routinized and should dictate the solution to one or more of the components involved in the process of coordination (actors, triggers, content, or method).

Specifically, we define coordination mechanisms *as (often partial) blueprints of how to enact a coordination instance.*[3]

Coordination that has become routinized by using mechanisms can be understood by considering the duality of the ostensive and performative aspects (Feldman and Pentland 2003; Jarzabkowski et al. 2012). The ostensive aspect of coordination stems from the perception of the coordination mechanism. It is an understanding of the coordination process in the abstract or the generalized concept. For example, consider the coordination mechanism around admitting a new patient that dictates that a nurse collects and records a set of vital signs into an electronic health record and pages the physician to let him or her know a new patient is waiting in an assigned room with completed admitting notes.

In contrast, the performative aspect considers an actual enactment or use of the coordination mechanism – it involves a specific set of people, at a specific time and location, engaging in specific actions. In our example, a performance of the coordination process occurs when an actual patient, John Doe, walks through the front door. The triage nurse admits him by measuring and recording his vital signs in the electronic health record software and pages the physician on duty with the correct information. This performance consists of specific actions, by specific people, in a specific time and place; and is inherently improvisational, as every episode

[3] Coordination mechanisms are a popular idea in coordination literature, and seek to address the means (Mintzberg 1979) or organizational arrangements (Okhuysen and Bechky 2009) that allow individuals to coordinate. However, there are several inconsistencies in the way the concept has been applied, and future research in coordination would benefit from a sharpening of the concept of coordination mechanism. First, several of the "mechanisms" used in various typologies would be more precisely classified as antecedents or simply situational traits. For example, training and performance reviews (Brown 1999; Simon 1957), availability of communication channels (Simon 1957), role clarity, timely decision making (Andres and Zmud 2001), and proximity (Okhuysen and Bechky 2009) are all situational traits that would arguably aid in coordination, but do not provide a clear mechanism in which to enact coordination. In contrast, routines or procedures (Gittell 2002; Mintzberg 1979; Okhuysen and Bechky 2009; Simon 1957; Thompson 1967), rules (Argote 1982; Okhuysen and Bechky 2009), and meetings (Argote 1982; Gittell 2002) all seem closer aligned to the concept of an actionable mechanism where coordination can occur. Therefore, we suggest coordination mechanisms be limited to contrivances that specifically guide the coordination process (e.g., being in close proximity to a co-worker may facilitate coordination, but it does not provide that clear mechanism for coordination that a standing weekly meeting with the co-worker does).

must be adjusted to the specific context (Feldman and Pentland 2003). However, we see that the nurse's ostensive understanding of the coordination mechanism is a key source of coordinating knowledge. It causes him to know when to start a coordination instance (as part of the admitting process), the content to record in the admitting notes (the vital signs of the patient and room number), and whom to coordinate this information to (the physician on duty). For brevity, we refer to this source of coordinating knowledge as 'coordination mechanism', but want to emphasize that this refers to the ostensive understanding of a coordination mechanism.

Coordination mechanisms, by their nature, bring routinization and standardization into the situation and have been shown to improve performance, especially efficiency (Argote 1982; March and Simon 1958).We have discussed numerous specific types of coordinating knowledge that arise from these routinized coordination mechanisms, specifically coordinating knowledge about *role, time schedule and event sequence triggers, predetermined content, predetermined presentation, and predetermined method*.

Domain Expertise - Managers have long since known that the presence of expertise on a team usually leads to performance improvements. However, studies have shown that collaborative groups can out-perform even the best individual expert (Laughlin et al. 2002). Team performance seems to be the product of the knowledge resources available in individual team members and the degree to which they are fully accessed and coordinated (Gardner et al. 2012; Wegner 1986). In terms of the latter, we suggest that one mechanism that explains why domain expertise improves performance is that it is a source of coordinating knowledge. The role of domain expertise is particularly important in emergent situations where established coordination mechanisms cannot be relied upon for guidance. In these situations, the experience and training that culminate into domain expertise provide knowledge that allows an actor to know the best way to shape a coordination instance, when the actor must interpret a situation. For example, domain expertise may yield coordinating knowledge that an actor uses to recognize a patient situation is out of the ordinary and requires a non-routine coordination instance (i.e., *emergent trigger*). In a similar manner, it is likely to be a source of coordinating knowledge that allows experts to recognize *emergent content* that should be included in a coordination instance. When selecting between types of media to use as the method of coordination, domain expertise provides coordinating knowledge to understand the situational needs that influence *media-fit*.

In addition to interpreting emergent situations, domain expertise informs coordinating knowledge by providing information about the tasks and expertise associated with various roles. For example, a cardiologist does not have the same expertise as a neurologist, but the cardiologist understands (through his medical training and experiences) the type of expertise a neurologist generally possesses and may be able to recognize when that expertise is necessary. In this way, we expect domain expertise to inform coordinating knowledge about *role* in order to select the appropriate type of actor. Domain expertise can also provide additional information about what type of content should be included in communications with other experts of a specific role. In this way, domain expertise leads to an expert knowing not only what type of expertise actors of a certain role have, but what type of content needs to be coordinated with them (i.e., *recipient-tailored content*). Finally, domain expertise is a likely source for coordinating knowledge about *shared understanding*. Actors in the same role or actors in similar roles are likely to share very similar mental models, even if those actors have not yet worked together. In our example, medical training will provide a set of vocabulary, common acronyms, standard operating procedures, and embed similar ways to understand and interpret the situation. Even without working together previously, two nurses are likely to be able to communicate very succinctly by leveraging this coordinating knowledge about shared understanding.

Team Familiarity- Team knowledge refers to what a team member knows about the rest of the team and we suggest it falls into two broad categories: *team familiarity* and *team awareness*. The primary difference is that familiarity refers to long-term knowledge that is permanent and applicable in numerous situations (such as an expert's preferences or specialty) (Espinosa et al. 2007b), while awareness refers to knowing a team member's current location and engagement and is therefore ephemeral - only useful for a short period of time (Cooke et al. 2000).

Team familiarity is the understanding that team members have of one another (Okhuysen and Bechky 2009) and has been shown to improve general team performance (Espinosa et al. 2007a; Goodman and Leyden 1991; Reagans et al. 2005). The long-term team knowledge that informs a team member about the nuanced expertise, habits, and preferences of another team member is usually the result of experience with the team member, and enhances over time spent together in a team. In fact, length of time spent working with one another is assumed to affect performance so much so that "team longevity" is a common control variable in team performance studies (Jansen et al. 2005; Zhang et al. 2007). The framework of coordinating knowledge elucidates how and why team familiarity affects coordination instances, and consequently performance.

Studying team familiarity resonates with the work on transactive memory systems (TMS), and how groups of experts learn about who possesses what types of relevant expertise (Kanawattanachai and Yoo 2007; Lewis et al. 2003). Recognition of specific areas of expertise is an important part of teamwork (Grant 1996) and personal experience with individuals helps build knowledge about what expertise that specific individual possesses, especially as teams begin to develop familiarity (Jarvenpaa and Majchrzak 2008; Pearsall et al. 2010). Therefore, we see evidence of team familiarity developing coordinating knowledge about the *individual*.

Team familiarity also enables actors to *anticipate* important aspects of a coordination instances because of knowledge about the other actors involved. Tacit coordination is the psychology term describing team members modifying their coordination behaviors due to cues from group members (rather than explicit discussion), such as social status, past behavior, and belief in member expertise (van Dijk et al. 2009; Schelling 1980; Wittenbaum G.M. et al. 1996). Rico and his co-authors (2008) refer to this anticipation of team member needs and task demands, that cause an expert to dynamically adjust their own behavior, as implicit coordination. This observed anticipation or implicit coordination is likely to be because team familiarity has provided coordinating knowledge. Actors may learn situational patterns that inform them of a specific team member's preferences about when to coordinate (*event sequence trigger*). For example, perhaps normal hospital policy is for a nurse to inform a hospitalist if a patient's fever rises above 102 degrees Fahrenheit (39 degrees Celsius). This is coordinating knowledge about an event sequence trigger derived from a coordination mechanism. However, one particular hospitalist prefers to know about any fever, regardless of the severity. The nurses know that if that hospitalist is on duty, they should report any fevers. This is coordinating knowledge about an event sequence trigger derived from team familiarity. Team familiarity may also allow an actor to anticipate specific content (i.e., *recipient-tailored content*) and preferred methods (i.e., *recipient-tailored method*) based only on the preferences and patterns of the individual with whom he is coordinating. Coordinating knowledge about *shared understanding* will also be improved as teams become more familiar with their shared contextual language and cues (Hinds and Mortensen 2005).

Team Awareness - Team awareness develops in situ and revolves around the current situation (Cooke et al. 2000). The core of team awareness is knowing about the current status of a team member and is important in situations that require coordination (Watson-Manheim and Bélanger 2007). Unlike team familiarity, we do not expect team awareness to improve with the length of time the team members have worked together, as awareness in previous situations does not inform current awareness. The literature stresses the importance of team awareness in coordination (Cooke et al. 2000; Okhuysen and Bechky 2009; Watson-Manheim and Bélanger 2007), and our consideration of the healthcare context, help us identify three possible types of awareness regarding team members: (1) location, (2) assignment, and (3) availability. The first is a determinant of where a team member is currently located. For example, in our context team awareness location may answer questions such as: Which hospital floor or patient room are they currently in? Are they away at lunch? The second type of awareness relates to a team member's current workload. This can be specific case assignments (Nurse Smith is assigned the patient in room 303) and overall information about the total workload (Physician Jones is already the assigned hospitalist on 35 current cases). The final type of team awareness is whether or not the person is available. This can be a product of location (i.e., they are sitting at the nursing station), but involves what they are currently engaged in and an understanding of whether they are available for coordinating. For example, if a physician is in the middle of performing a medical procedure, he is not available.

Since team awareness must be re-established in every situation, teams must develop ways to distribute this type of knowledge daily. While many solutions are conceivable, there are two common ones that are worth mentioning. First, visibility increases awareness by showing other team members what activities they are currently engaged in (Okhuysen and Bechky 2009). Visibility may be a natural by-product of working in the same physical location or be created by awareness displays that show team member assignments for the day or shift, and be updated as the situation changes. Showing team member workload was shown to allow actors to time their coordination to periods where the recipient is experiencing a lower workload (Dabbish and Kraut 2008). Second, some team members, either by specific assignment or personal attributes, become team awareness "hubs" of information. These people act as guardians to the locations and statuses of all of the team members and can quickly relay team awareness knowledge. Imagine the nurse assigned to stay at the nursing station for the day that knows which nurse is assigned to which rooms and who is currently on lunch break, on another floor taking a patient to have an x-ray, or available to help. Instead of every nurse keeping track of every other nurse, they know to "check-in" with this nursing station assigned nurse before leaving the area. If another team member, nurse or otherwise, needs to know the location of a specific nurse they are likely to ask the nurse positioned at the nursing station for immediate team awareness knowledge.

Regardless of how it is managed, team awareness will provide important insight to selecting the best person with whom to coordinate and how to coordinate with them. Specifically, it informs coordinating knowledge about current *assignment* (which actors are assigned to which patients) and *individuals* (where the individuals might be located and what they are currently engaged in). Team awareness can also provide coordinating knowledge about which media would best fit the situational needs of a coordination instance. Coordinating knowledge about *media-fit method* considers the traits of the media for each method and the situational needs of the coordination instance, and seeks to find the best fit. Knowing where the involved actors are and what they are engaged in provides important pieces of situational knowledge that influence this fit. For example, if an actor is currently located in a different building, method choices that require face-to-face interactions are not feasible or may cause long delays in the coordination instance occurring successfully.

Table 3 summarizes these four sources of coordinating knowledge and Table 4 summarizes the theorized relationships between the 14 specific types of coordinating knowledge and these four sources.

Table 3: Summary of the Four Sources of Coordinating Knowledge

Coordination Mechanism	Knowledge embedded in the ostensive understanding of the routinized mechanisms that provide *an (often partial) blueprint of how to enact a coordination instance*
Domain Expertise	Domain knowledge that informs a team member about coordination needs that arise from an expert's understanding of situational circumstances
Team Familiarity	Long-term team knowledge that informs a team member about the nuanced expertise and preferences of another team member is usually the result of experience with the team member, and enhances over time spent together in a team
Team Awareness	Short-term team knowledge that informs a team member about the physical location, work assignments, and availability of other team members

Table 4: Coordinating Knowledge Types & Associated Sources of Coordinating Knowledge

Category	Coordinating Knowledge Type	Coordination Mechanism	Domain Expertise	Team Familiarity	Team Awareness
Actors (who)	Role	X	X		
	Assignment				X
	Individual			X	X
Triggers (when)	Time schedule Triggers	X			
	Event sequence Triggers	X			
	Emergent Triggers		X	X	
Content (what)	Predetermined Content Selection	X			
	Emergent Content Selection		X		
	Recipient-Tailored Content Selection		X	X	
	Predetermined Content Presentation	X			
	Shared Understanding		X	X	
Method (how)	Predetermined Method Selection	X			
	Media-Fit Method Selection		X		X
	Recipient-Tailored Method Selection			X	

CHAPTER 3: RESEARCH PROPOSITIONS ON THE BENEFITS OF COORDINATING KNOWLEDGE AND THE ROLE OF INFORMATION SYSTEMS

Using our set of coordinating knowledge types (summarized in Table 2), we develop a set of propositions that propose a more nuanced understanding of how each type could affect the efficiency or effectiveness of a coordination instance. Specifically, we consider the three components of effectiveness and the three components of efficiency summarized in Table 1. We make several assumptions in order to bind the scope of this discussion to a manageable size. We assume that coordination instances are "good" coordination instances, and beneficial to the patient. It is possible that a team member could possess flawed coordinating knowledge that causes them to coordinate in situations that are not beneficial or that a coordination mechanism has been thoughtlessly implemented to force extraneous coordination. In these situations, more coordination could harm performance by taking up resources without being beneficial. However, this situation is outside the scope of this discussion.

We present propositions about how information systems might interplay with coordinating knowledge and affect coordination, but wish to emphasize the word might. These propositions are based on current and commonly implemented information systems in the healthcare domain. This is not meant to suggest that all healthcare organizations are using these technologies or even that the organizations possessing these types of information systems are utilizing them well. For example, anyone who has compared EHR systems can testify that the functionality of the software packages and the unique implementations create a wide disparity of technical functionality. In general, information systems offer a way to encode coordinating knowledge into a coordination mechanism, or to increase the scope and rigidity of the "blueprint".

Propositions Related to Coordinating Knowledge about Selecting an Actor

Effects of coordinating knowledge about role and assignment - These two types of coordinating knowledge can increase the effectiveness of a coordination instance, by selecting more appropriate experts with whom to coordinate. Consider situations where actors employ coordinating knowledge about role. Using this coordinating knowledge allows an actor to identify a sub-set of actors that possess expertise (identified by their role) that will be helpful to the situation. In our earlier example, the nurse coordinates with an expert possessing specialized knowledge about nutritional needs and diet (i.e., a nutritionist) instead of other healthcare professionals that may lack this specialized knowledge. Leveraging coordinating knowledge about assignment has a similar effect. The person assigned to a case (e.g., the nurse assigned to a patient on the ICU floor) is the most appropriate nurse with whom to coordinate in coordination instances involving that patient since he possesses the most current knowledge about the patient.

Roles and assignments allow an economical way for actors to identify the basic knowledge sets, capabilities, tasks, and responsibilities of each other. Roles bring standardization and efficiency to tasks which require coordination (Mintzberg 1979; Okhuysen and Bechky 2009; Simon 1957). Therefore, when coordinating knowledge about role is used to select an actor, it helps realize this efficiency and allows actors to quickly identify the type of expert or the assigned expert to involve in the coordination instance with minimal cognitive effort. Assignments are used to assign an actor to a case (in our healthcare context, most commonly a patient). Usually this is an actor of a specific role. For example, a patient might be assigned a nurse in order to manage certain aspects of his healthcare, and a hospitalist to address others. If coordinating knowledge about assignment is known and used, it often avoids follow-up coordination instances by communicating with the right person at the first time. Imagine if a cardiologist stopped the wrong nurse and asked him about a patient he was not assigned to. It is likely that a sequence of coordination instances would then ensue to get the information to the cardiologist from the *assigned* nurse who possesses this information.

P1a: Coordinating knowledge about role improves the selection of the appropriate person with whom to coordinate in the coordination instance (i.e., person selection effectiveness).

P1b: Coordinating knowledge about role reduces the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency).

P2a: Coordinating knowledge about assignment improves the selection of the appropriate person with whom to coordinate in the coordination instance (i.e., person selection effectiveness).

P2b: Coordinating knowledge about assignment reduces follow-up coordination instances (i.e., improves follow-up CI efficiency).

Effects of coordinating knowledge about individuals - Coordinating knowledge about individuals is the result of knowing extra information about other actors' expertise, preferences, availability, and habits. Many of these are likely to develop and deepen as actors continue to work together. Extant literature suggests that as team relationships strengthen, performance is improved (Espinosa et al. 2007b; Gardner et al. 2012; Goodman and Leyden 1991; Reagans et al. 2005). While we expect that strong team bonds will improve coordination via many categories of coordinating knowledge, we suggest one of these reasons is due to an enhanced ability to select the best person with whom to coordinate in any given instance, above and beyond what may be dictated by other forms of coordinating knowledge.

P3: Coordinating knowledge about individuals improves the selection of the appropriate person with whom to coordinate in the coordination instance (i.e., better person effectiveness).

Information Systems Interactions – Information Systems have the ability to improve or replace coordinating knowledge related to selecting an actor with whom to coordinate. Once team member roles and assignments are entered into an information systems solution, the technology can facilitate coordination without other actors needing to know this relevant coordinating knowledge. For example, a nurse assigned to a patient might automatically receive updates when a physician alters the patient's medication dosage. The coordination instance was successful, because the message of a patient's altered dosage was sent by the relevant physician and received by the relevant nurse. Yet the physician did not need to know the coordinating knowledge about role and assignment (i.e., which role needs to know this information and more specifically, who is assigned to that role for this patient). In other cases, the information system may act as a reference for these types of coordinating knowledge. Perhaps instead of altering the medication dosage, the physician wishes to speak to the assigned nurse about the effects of the medication. Since the information system holds the name of the assigned nurse on duty for that patient, the physician can find this necessary coordinating knowledge efficiently. In either case, embedding the coordinating knowledge about role or assignment decreases the cognitive effort expended by the actors involved in the coordination instance.

P4: By managing coordinating knowledge about role, information systems reduces cognitive effort (i.e., improves cognitive effort efficiency), above and beyond the effect due to coordinating knowledge about role simply being present in a situation.

P5: By managing coordinating knowledge about assignment, information systems reduces cognitive effort (i.e., improves cognitive effort efficiency), above and beyond the effect due to coordinating knowledge about assignment simply being present in a situation.

While information systems have the ability to automate selection of coordination actors based on role and assignment, it might discourage the use of coordinating knowledge about individuals. If information systems have actor selections pre-programmed or automated, it may limit coordination with specific actors the sender would have selected if given the autonomy. Consider a hospital that moves the pharmacists off-site and encourages all coordination between pharmacists and physicians to occur via a digital messaging service similar to email. The system very efficiently pairs the physician with an available pharmacist (selection on role), but does not allow the physician to select a pharmacist that he knows has specialized knowledge about this type of medical situation (selection on the individual). In these types of situations, information systems may hinder team effectiveness of picking the best actor with whom to coordinate.

P6: Coordinating knowledge about role or assignment embedded in an information system can weaken the selection of the appropriate person with whom to coordinate (i.e., person selection effectiveness).

Propositions Related to Coordinating Knowledge about Triggering Coordination

Effects of coordinating knowledge about time schedule and event sequence triggers - The standardization of coordination via predictable triggers (time schedule and event sequence) is reminiscent of early work in coordination, which suggests that operational arrangements will increase efficiency between interdependent parties by putting a structure in place (March and Simon 1958). In a field experiment, groups with temporal coordination manipulations (similar to scheduled triggers) had better performance (Massey et al. 2003), and in a case study on virtual teams, regular meetings improved performance and affected the output schedule by causing a temporal rhythm in the groups (Maznevski and Chudoba 2000). Coordinating knowledge about predictable patterns of scheduled coordination (time schedule triggers) or embedded coordination as part of a larger business process (event sequence triggers) allows experts to initiate coordination instances efficiently by reducing the cognitive effort involved in recognizing the need for a coordination instance and determining when to initiate it.

Knowing about the embedded trigger of a coordination instance inside a larger business process (i.e., event sequence triggers) may have advantages in addition to those brought about by standardization. If the business process is well designed, then the knowledge of an event sequence trigger informs the actor about the need for a coordination instance and when the coordination instance should occur. This has two possible advantages. First, they often serve to prompt an actor to initiate a coordination instance without being asked by the receiving actor. For example, in a situation where the sending actor did not know to create and send a transfer form when transferring a patient between departments, the receiving department would presumably have to contact them requesting the information. When the event sequence trigger is known and acted upon, this simplifies the process and minimizes the amount of coordination instances back and forth to complete the task. Second, the embedded trigger prompts a coordination instance at a time that should be ideal to transfer the information between sender and receiver. Consider the effects of the knowledge that the transfer form it part of the process to transfer a patient from one department to another. The creation and receipt of this form between the involved physicians occurs at a critical moment when the information involved in the coordination instance is most salient.

P7: Coordinating knowledge about time schedule triggers reduces the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency).

P8a: Coordinating knowledge about event sequence triggers delivers the information in a timelier manner (i.e., timeliness effectiveness).

P8b: Coordinating knowledge about event sequence triggers reduces the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency) and reduces the number of sequential coordination instances (i.e., improves follow-up CI efficiency).

Effects of coordinating knowledge about emergent triggers - Coordination instances caused by actors using coordinating knowledge about emergent triggers are not scheduled in advance, but happen ad-hoc, as deemed necessary, by team members. Without the use of emergent triggers, some coordination instances would never occur or perhaps occur too late. Experts that recognize appropriate emergent triggers due to situational circumstances and their own expertise are likely to initiate a coordination instance that delivers the information or knowledge at the most opportune time in order to maximize its utility. Consider our earlier example of a nurse recognizing a patient's subtle change in appetite and energy. Her expertise provided her with the coordinating knowledge necessary to recognize the need to trigger a coordination instance (an emergent trigger) with the physician. This coordination instance provides the additional patient information to the physician in a timely manner, allowing him or her to utilize it in decision making before the patient's condition worsens.

P9: Coordinating knowledge about emergent triggers delivers the information in a timelier manner (i.e., timeliness effectiveness).

Information Systems Interactions – Information systems solutions have a history of bringing efficiency to business processes and we submit that information systems have the potential to make triggers for coordination more efficient. In coordination instances that have scheduled (either time schedule or event sequence) triggers, information systems play an obvious role by making schedules and sending reminders easier. For time scheduled coordination, digital organization calendars (e.g., Outlook) can be used to list standing meetings and send reminders to involved team members. These reminders can partially alleviate the need for team members to possess the time schedule trigger details as coordinating knowledge, since the digital reminders act as triggers.

Most business processes move through a digital world on an enterprise system instead of utilizing physical, paper copies. In the healthcare arena, electronic health records are usually packaged in a larger software package that aids with hospital work processes. If implemented thoughtfully, the triggers to coordination can be embedded within the electronic work flows, easing the need for coordinating knowledge about event sequence triggers to be known by individuals. Let us return to our example of a triage nurse collecting patient data when a patient is being initially checked into the emergency room. This information needs to be shared with the physician on duty. Without an information systems infrastructure in place, the nurse would need to be cognizant (i.e., possess the coordinating knowledge about the event sequence trigger) of the need to share the information with the physician, in order for coordination to take place. However, many hospitals have systems that guide the triage nurse to collect patient information directly into their EHR system. In addition to helping guide the data collection, the system can automatically prompt the nurse to share the relevant information with the physician (or in some cases, share the information without any additional action from the triage nurse). We expect coordinating knowledge about time schedule and event sequence triggers, used to initiate an instance of coordination, to improve team efficiency by removing all or part of the cognitive effort the actors expend on triggering the coordination and reducing the time spent on the coordination instance.

P10: Information systems that enhance or automate time schedule triggers, reduce the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency) and reduce the time spent by the actors (i.e., improves time spent efficiency), above and beyond the effect due to coordinating knowledge about time schedule triggers simply being present in a situation.

P11: Information systems that enhance or automate event sequence triggers, reduce the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency) and reduce the time spent by the actors (i.e., improves time spent efficiency), above and beyond the effect due to coordinating knowledge about event sequence triggers simply being present in a situation.

Propositions Related to Coordinating Knowledge about the Selection of Coordination Content

Effects of coordinating knowledge that guide content selection - Coordinating knowledge about predetermined content is embedded in an established coordination routine. Procedural knowledge (such as predetermined content) is remembered better than declarative knowledge and speeds up tasks that involve cooperation and coordination (Cohen and Bacdayan 1994; Kogut and Zander 1996). In this way, a template exists in order to gather pieces of information that are believed to be pertinent content for this type of coordination instance and the actor does not need to spend cognitive effort to determine what needs to be communicated.

Also, a routine or procedure that has coordinating knowledge about predetermined content embedded into it insures that information understood to be pertinent to the situation type is included in the initial coordination instance. If this coordinating knowledge was not leveraged and the receiving actor recognized the deficiency, he or she would have to initiate follow-up coordination instances to elicit the missing information. A similar situation is likely to occur in the absence of coordinating knowledge about recipient-tailored content. The receiver will have to initiate additional communication in order to request the desired content. This additional communication can be avoided when the other actor possesses the coordinating knowledge about recipient-tailored content which affords the anticipation of the content request. In this way we see that coordinating knowledge about predetermined content and recipient-tailored content can aid in efficiency, by minimizing additional follow-up coordination instances.

What happens when none of the actors in the situation recognize the deficiency of the content in the coordination instance? The inclusion of relevant information also prevents the omission of this information. Coordinating knowledge about predetermined content and emergent content can influence decisions to include content that would otherwise fail to be communicated. For example, if the medical form did not prompt the nurse to include a medication list (i.e., predetermined content) or if the nurse did not use expertise and recognize a concerning patient behavior (emergent content) and mention it to his teammate, then these pieces of information would never be communicated. We expect both of these coordinating knowledge types to improve the effectiveness of a coordination instance via this improvement in the quality of information communicated.

P12a: Coordinating knowledge about predetermined content improves the quality (completeness, relevance, and level of detail) of the information being shared in the coordination instance (i.e., information quality effectiveness).

P12b: Coordinating knowledge about predetermined content reduces cognitive effort and reduces the amount of sequential coordination instances (i.e., improves cognitive effort and follow-up CI efficiency).

P13: Coordinating knowledge about emergent content improves the quality (completeness, relevance, and level of detail) of the information being shared in the coordination instance (i.e., information quality effectiveness).

P14: Coordinating knowledge about recipient-tailored content reduces the amount of sequential coordination instances (i.e., improves follow-up CI efficiency).

Effects of coordinating knowledge that guide content presentation - Both types of coordinating knowledge that influence the presentation of content are likely to improve the efficiency. Coordinating knowledge about predetermined presentation is used to standardize the presentations between similar coordination instances, increasing the efficiency of the sending and receiving of the content. The sender has less cognitive effort involved because decisions about presentation are removed from the situation. The receiver has less cognitive effort involved because every similar instance is presented in a similar manner. Coordinating knowledge about shared-understanding allows an actor to leverage shared vocabulary, shared mental models, and other context cues to efficiently communicate the content. An expected result of shared understanding is the ability to very efficiently format the content to be shared via coordination (Gardner et al. 2012). Consider the case when acronyms common in a hospital are used to shorthand some of the content. If both actors in the coordination instance know that these acronyms are common knowledge and appropriate to use in coordination messages, then they improve efficiency by being both faster to send and faster to receive.

P15: Coordinating knowledge about predetermined presentation reduces the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency).

P16: Coordinating knowledge about shared understanding reduces the time spent by the involved actors (i.e., improves time spent efficiency).

Information Systems Interactions – Information systems are often the medium over which coordination mechanisms manifest. For example, instead of a nurse filling out a paper form to transfer a patient to another department, the nurse is likely to complete an electronic form in a hospital management application. Predetermined content selection coordinating knowledge will be present in both paper and electronic versions of the transfer form, and bring about increased efficiency to coordination instances. However, information systems have the potential to influence coordination in two additional ways. First, unlike a paper form, software can be programmed to dynamically change depending on previous values entered. For example, one question might be ‘Does the patient have a pre-existing heart condition?’ and if the answer is ‘yes’ then another series of questions that are important to consider when dealing with heart conditions might appear on the next screen. If the answer is ‘no’ these questions are not shown.

Embedding coordinating knowledge about predetermined content selection and prompting the user for information is likely to improve the quality of information gathered and its timing. By dynamically changing prompts depending on conditions entered, thorough and relevant content is gathered.

Not only is it possible that embedding coordinating knowledge predetermined content selection in an information system gathers information that actors may forget or not know to gather, it is likely to make it faster and easier for them to gather. Being prompted for each piece of information is certainly less cognitively taxing than thinking of all the relevant information needed, and dynamically hiding irrelevant questions makes gathering data faster.

P17a: Information systems that embed coordinating knowledge about predetermined content selection improve the quality of the information being shared in the coordinating instance (i.e., information quality effectiveness), above and beyond the effect due to coordinating knowledge about predetermined content selection simply being present in a situation.

P17b: Information systems that embed coordinating knowledge about predetermined content selection reduce cognitive effort and reduce time spent (i.e., improve cognitive effort and time spent efficiency), above and beyond the effects due to coordinating knowledge about predetermined content selection simply being present in a situation.

Information systems can play an enormous role in content presentation, because they have the ability to alter the presentation between the sender and the receiver involved in the coordination instance. Consider an EHR solution that allows a nurse that monitors the telemetry station to quickly input hourly readings of patient blood pressure and body temperature. The input form is likely to be text boxes for numerical values of these readings. However, a physician may find it difficult to consider a list of numerical values when using the information to determine treatment. The EHR software could generate a report that automatically presents the recorded vital sign as a color-coded graph for the physician. Information systems can easily allow for team members to customize the way content is presented. For example, perhaps the reporting software allows the actor to specify Celsius vs. Fahrenheit temperatures or the date range of vital signs to display.

In our examples, information systems affect the content presentation in two fundamental ways. First, it may allow for the content presentation that the sender sends to be different than the receiver receives. This separation means that the sender does not necessarily need to know the best format in which to present the content to the other actor in order to coordinate. In other words, the information system eliminates the need for the actor to know about predetermined content presentation. Removing this burden is likely to make the presentation aspect of a coordination instance easier and faster for the actors (take less cognitive effort and less time).

It also means that neither side (sender nor receiver) needs to compromise on efficiency gained by agreeing on an ideal content presentation. In our example, the sender presents the content with maximum efficiency for data entry– numerical text boxes, and the receiver is presented the context with maximum efficiency for pattern recognition – a color-coded graph. Second, it may allow for the receiver to alter the content presentation thus enhancing interpretation effectiveness. In coordination instances not leveraging information systems, this is not possible. Consider coordination instances of spoken word or paper forms. In both of those examples, the receiver in the coordination instance has no ability to alter the content presentation. However, information systems can allow content presentation of digital information to be represented in a variety of ways to help recognize patterns and understand the phenomenon.

P18a: Information systems that embed coordinating knowledge about predetermined content presentation reduce cognitive effort and reduce time spent (i.e., improve cognitive effort and time spent efficiency), above and beyond the effect due to coordinating knowledge about predetermined content presentation simply being present in a situation.

P18b: Information systems that enhance content presentation by separating the presentation between sender and receiver reduce cognitive effort and reduce time spent (i.e., improve cognitive effort and time spent efficiency).

Propositions Related to Coordinating Knowledge about the Selection of a Coordination Method

Effects of coordinating knowledge about predetermined method - Much like other coordinating knowledge about predetermined components, we expect coordinating knowledge about predetermined method to yield efficiency results by standardizing coordination processes and minimizing the cognitive effort of the actors since the sender does not need to expend cognitive effort deciding how to communicate. Efficiencies may also result for the receivers involved in these coordination instances, as they know which method to expect the routinized coordination instances through (e.g., a physician may always be notified of an emergency via a page, so she knows to monitor her pager at all times and spend less time monitoring other communication media).

P19: Coordinating knowledge about predetermined method reduces cognitive effort of the actors involved in the coordination instance (i.e., improve cognitive effort efficiency).

Effects of coordinating knowledge about media-fit method - One of the key findings in previous media richness and synchronicity research is that performance gains are expected by ideal matches between the task and the communication technology, regarding the media capabilities (Daft and Lengel 1986; Dennis et al. 2008). In other words, if the coordination instance only needs a lean media, then one is better off using a lean media; but if the task needs a rich media then performance will suffer if a rich media is not used. When coordinating knowledge is used to select the coordination method by considering media fit, we expect an improvement in the quality of the information being shared and in the timeliness of the coordination instance. Let us consider a complex diagnosis that is better explained if both physicians can look at the same x-ray, and the receiver of the information can ask questions during the explanation. If an actor has the necessary media-fit coordinating knowledge, he can select a method that will provide these rich capabilities (e.g., in person consultation or a virtual meeting with file sharing capabilities). The resulting coordination instance will provide better information to the receiving actor (explanation with visual cues, additional information due to real-time question/answer conversation, etc.).

Coordinating knowledge about media-fit method may also take the form of knowing what other actors are currently engaged in and how it might affect the method selection. In addition to task and media characteristics, personal awareness help select the best media fit. If an actor possesses knowledge about the proximity and availability of the recipient, then he or she can select the coordination method that brings about task closure most efficiently (Straub and Karahanna 1998). Consider a nutritionist that needs to coordinate with a physician, and would normally seek the physician out on the hospital floor and have the coordination instance in person. On a typical day, speaking with the physician in person takes the least amount of time to conduct the coordination instance. However, the nutritionist knows the physician is working at a remote site all morning, so she decides that the best way for her to quickly reach task closure and complete the coordination instance is to send the physician an email with the information. Not only does this take her less time than attempting to seek out a physician that is not on the floor (i.e., not available for that type of communication), but it could also help insure the physician receives the information in a timely manner.

P20: Coordinating knowledge about media-fit method improves the quality (completeness, relevance, and/or level of detail) of the information being shared in the coordination instance (i.e., information quality effectiveness) and delivers the information in a timelier manner (i.e., timeliness effectiveness).

Effects of coordinating knowledge about recipient-tailored method - Personal media patterns and preferences cause some actors to use media differently (e.g., more frequently) than others (Karahanna and Limayem 2000). When these personal media style choices are known, coordination methods can be selected with more precision in order to time the coordination instance ideally. When defining coordinating knowledge about recipient-tailored method, we considered an actor who checks his email once a shift versus one that checks it nearly every 5 minutes. If those media styles are known and used as coordinating knowledge, a sender understands when an email message is likely to be received by each actor. This allows for more effective coordination instances, because method can be selected with more understanding about when a receiver is going to receive it.

P21: Coordinating knowledge about recipient-tailored method delivers the information in a timelier manner (i.e., timeliness effectiveness).

Information Systems Interactions - It is difficult to tease apart the effects of information systems on this category of coordinating knowledge, because the methods themselves are utilizations of information systems (EHR systems, cell phones, e-mail, text pages, telemedicine, etc.). The traits of the technology are considered as part of method selection. Media synchronicity theory yields five helpful traits to consider, which were discussed previously.

Table 5 shows a summary of our propositions, by considering the proposed relationships between specific types of coordinating knowledge and coordination performance indicators. Propositions involving information systems are underlined. In the next section we discuss the methodology we employed to collect data in order to provide preliminary evidence of these propositions.

Table 5: Summary of Propositions

	Coordination Instance Performance Indicator					
	Related to Effectiveness			Related to Efficiency		
Coordinating Knowledge Types Involved…	Information Quality	Person Selection	Timeliness	Cognitive Effort	Time Spent	Follow-Up CIs
Role		P1a		P1b, P4		
Assignment		P2a		P5		P2b
Individual		P3, P6				
Time schedule Triggers				P7, H10	P10	
Event sequence Triggers			P8a	P8b, P11	P11	P8b
Emergent Triggers			H9			
Predetermined Content Selection	P12a , P17a			P12b, P17b	P17b	P12b
Emergent Content Selection	P13					
Recipient-Tailored Content Selection						P14
Predetermined Content Presentation				P15, P18a	P18a	
Shared Understanding					P16	
Predetermined Method Selection				P19		
Media-Fit Method Selection	P20		P20			
Recipient-Tailored Method Selection			P21			

Note: Underlined propositions are related to information systems.

CHAPTER 4: RESEARCH METHODOLOGY

Our research design employs qualitative research methods. Qualitative research is especially useful for situations where the research and theory are in early formative stages (Benbasat et al. 1987; Markus and Robey 1988), which is the case in the current project where we study the existence and role of coordinating knowledge. The coordinating knowledge framework is in a nascent stage, where we are proposing new constructs (i.e., coordinating knowledge and its types) and seeking preliminary evidence for these and for their effects on efficiency and effectiveness. We do so at a level of analysis (that of a coordination instance) that has been previously overlooked. As such, our research at this stage of development is best suited for qualitative research, in order to allow for new constructs and their effects to be explored and understood (Edmondson and McManus 2007). In order to be understood, coordination instances must be considered within the organizational context where they occur, which is also a situation well suited for qualitative research (Benbasat et al. 1987; Orlikowski 1993; Yin 2008). Therefore we believe qualitative methods are especially appropriate to shed explanatory insights on our research questions at this early stage.

We follow the positivist perspective in developing and assessing the set research propositions about coordinating knowledge. There are three approaches to positivist case studies (Dube and Pare 2003). Descriptive case studies have a clear research question, but do not have pre-specified constructs, theories of interest, or predictions. As the name suggests, these are primarily descriptive in nature. Exploratory case studies differ from descriptive in that they approach the situation with constructs of interest, and seek to explore more focused research questions about these constructs. The third approach is explanatory case studies, which have theoretically derived predictions that the research attempts to test by way of case studies. We utilize this third approach, since a theoretical foundation and an *a priori* set of constructs guided our data collection and data coding. Thus, with our theoretically derived propositions developed in advance, we conducted an explanatory case study (Dube and Pare 2003; Yin 2008).

The unit of analysis for this dissertation is a coordination instance, which we collected via an embedded, multiple-case design, as defined by Yin (2008). Data were collected at one medium-sized hospital in the southeastern United States, which we believe to be representative of how the average hospital operates regarding knowledge coordination between team members. We identified and described 289 coordination instances between healthcare professionals, in order to (a) understand and validate coordinating knowledge components and types and their role in a coordinating instance, and (b) provide preliminary empirical evidence for the study's research propositions.

Data Collection

Data were collected in two departments of the hospital. The Intensive Care Units (ICU) area of the hospital has eight beds (patients stay in individual rooms), and during the day the hospital has two hospitalists that spend some of their time in the ICU. The ICU has a dedicated nursing staff, which includes a patient nurse (RN certification) assigned to a maximum of two patients, a tele-monitor nurse (CNA certification) watching vital signs on multiple monitors at the nursing station, and the director of nursing. Other specialists (e.g., specialty physicians, pharmacists, dieticians, therapists) are in and out of the ICU as they help provide care to patients. The emergency department (ED) has approximately 30 beds, and its staffing fluctuates during the day and night in anticipation of high volume periods. One physician is assigned to the ED all the time (two 12 hour shifts cover a 24 hour period). Physician assistants (PAs) and nurses arrive at different times of the day, such that a typical busy period for the ED will be staffed with one physician, two PAs, and approximately eight nurses.

Four data sources were used: 1) Semi-structured interviews, 2) Direct observation in the ICU and ED wings, 3) Informal question and answer periods during the observation sessions with the staff, and 4) Documents and forms used in the patient care process.

Semi-structured interviews with five key hospital staff members were conducted (two physicians, two nurses in leadership roles, and a respiratory therapist), ranging from approximately 25-55 minutes in duration (summarized in Table 6). The primary goal of the interviews was to better understand the coordination and knowledge processes that occur during patient care inside the hospital (see Appendix B for interview guide). Some of the more prominent information systems (electronic health records and telemedicine) were also discussed, specifically how they fit into providing patient care. We recorded each interview and the transcriptions were used to help us prepare for our observation days and to inform our interpretation of the data.

Table 6: Interview Data Summary

Interviewee Role	Mode	Length
Hospitalist Director	Face-to-face	26 minutes
ICU Director	Face-to-face	54 minutes
Lead Respiratory Therapist	Face-to-face	51 minutes
ER Medical Director	Face-to-face	36 minutes
ER Nurse Manager	Face-to-face	29 minutes
Total: 5 Interviewed Healthcare Professionals		**3.2 hours**

Next, we spent time observing the ICU and ED areas of the hospital. We chose periods of the day that were most likely to show instances of coordinating knowledge (e.g., shift changes, interdisciplinary meetings, and “rounding” activities – which is when a healthcare professional visits each patient’s bedside to check-in). We observed multiple shifts, for a total of 40 hours (summarized in Table 7). During the observations, we talked to staff members briefly to ask about the processes they were engaged in, how assignments and responsibilities were determined, etc. No recordings were allowed in the hospital during our observations (due to HIPAA regulations), but detailed field notes were compiled immediately following the observations. Finally, we obtained 29 different types of documents, including many instances of forms, charts, reports, meeting hand-outs, and notes that are used to document patient information and communicate information between healthcare professionals. These documents are summarized in Table 8, and two example documents are found in Appendix C.

Table 7: Observation Data Summary

Observation Area	Length
ICU Department	6.5 hours
ICU Department	7.5 hours
ICU Department	1.5 hour
ICU Department	8.5 hours
Emergency Department	2.5 hours
Emergency Department	6.5 hours
Emergency Department	7 hours
Total: 2 Departments Observed	**Total: 40 hours**

Table 8: Summary of Documents Collected

Document Type	Pages
Hospital Patient List & Summary	1
Tele-monitor Worksheet	2
Pre-census Report	3
Full Census Report	4
Telemed Instructions – Flowchart	2
Telemed Form for Psychology Patients	2
Telemed Form for Neurology Patients	1
Telemed Results for Neurology Patient	6
Operating Room Information Packet	10
Customized Nurse Form – "Mary's Brain"	1
Patient Progress Notes	17
ICU Interdisciplinary Care Team Rounds	1
Patient Notes from Previous Hospital	8
Telemed Consultation Report Package	4
Patient Fact Sheet – Consultation Summary	4
Telemed Results for Psychology Patient	4
Emergency Department Daily Assignments	1
EMS Report Sheet	1
STEMI Notecard	1
Triage Nurse Notes	4
ICU Register Sheet	1
ICU Shift Huddle Overview	1
Transfer Summary	2
Specialist Consultation Patient Notes (Different Hospital)	3
Transfer Process (Between Hospitals)	1
Scheduled Medication Report	1
ICU Staff Meeting Notes	4
Radiology Report	1
Patient Survey Results	1
Unique Document Types: 29	**Total Pages: 92**

Data Coding

Using all sources of data (3.2 hours of recorded interview, 40 hours of observation notes, and 92 pages of example healthcare coordination documents), we identified 289 specific coordination instances. The observed coordination instances were fairly evenly split between the ED (151) and the ICU (138) departments. Coordination instances took place via a variety of methods. The most common methods were in-person conversations (132), phone calls (55), electronic health record messages and memos (43), and posted notices (14). A table with the frequency details of the coordination instance methods is located in Appendix D.

Each coordination instance was coded via the coding scheme shown in Table 9. Our coding scheme is based on our theoretical development of a coordination instance, which includes 14 types of coordinating knowledge spanning four categories (actors, triggers, content, and method) and six ways that coordination instance performance can be improved for better efficiency and effectiveness. In addition to coding if a particular type of coordinating knowledge was present, we also coded whether or not the coordinating knowledge was embedded in an information system (e.g., the electronic health record software automatically routing a form to the assigned nurse) or known by one of the actors involved (e.g., a nurse knowing which cardiologist has been assigned a particular patient). We refined the coding scheme during the coding process, which is a recommended practice in case study research (Eisenhardt 1989; Miles and Huberman 1994).

Systematic coding helps to validate interpretation of the data and reduce biases via inter-rater reliability techniques (Dubé and Paré 2003). Two coders independently coded 25 coordination instances to establish inter-rater reliability according to the coding scheme in Table 9. The result of the first round of coding was an inter-rater agreement of .84. Disagreements were resolved through discussion, and several definitions were sharpened due to these discussions. For example, time scheduled triggers were clarified to include specific events that happened once per shift (e.g., posting room assignments on a whiteboard at the beginning of a nursing staff shift change) in addition to at a set time (e.g., 8am). This helped separate temporal events that happened a predictable number of times (i.e., things that happened once at the beginning of a shift) from event sequence triggers which occur when a particular event occurs. The latter could happen several times in a short period of time (e.g., admitting a new patient) or not at all during a shift. Although an inter-rater agreement of .80 or above is considered acceptable for qualitative coding (Miles and Huberman, 1994), both coders coded another 15 coordination instances during a second round of coding under these clarified definitions of the codes. The result of the second round of coding was an inter-rater agreement of .91. A single author coded the remaining 249 coordination instances.

Table 9: Coding Scheme

Descriptors of the Coordination Instance	
Actors Involved	Identification of the roles of the actors involved in the coordination instance
Trigger to Initiate	Brief description of the trigger that prompted the coordination instance
Content Transferred	Identification of the content transferred during the coordination instance
Method of Coordination	Identification of the method used to coordinate during the coordination instance
Coordinating Knowledge Types	
Component: Actors	
Role	Knowledge about an actor's role that informs the selection of an actor with whom to coordinate in a coordination instance.
Assignment	Knowledge about an actor's assignment to a specific case or project that informs the selection of an actor with whom to coordinate in a coordination instance.
Individual	Knowledge about an actor's individual traits or situation that informs the selection of an actor with whom to coordinate in a coordination instance.
Component: Triggers	
Time Scheduled Triggers	Knowledge about a temporal schedule of coordination that informs when to initiate a coordination instance.
Event Sequence Triggers	Knowledge about an event sequence that informs when to initiate a coordination instance as a response to previous events.
Emergent Triggers	Knowledge that enables one to recognize when to initiate a coordination instance in the absence of programmed (time scheduled or event sequence) triggers.
Component: Content	
Predetermined Content	Knowledge about the selection of content in a coordination instance that has been previously identified and exists embedded inside a procedure or routine.
Emergent Content	Knowledge that aids in the assessment of the relevance of situational facts that informs the selection of content in a coordination instance.
Recipient-Tailored Content	Knowledge relevant to anticipating the needs of the recipient that informs the selection of content in a coordination instance.
Predetermined Presentation	Knowledge about the presentation of content in a coordination instance that has been previously identified
Shared Understanding	Knowledge about shared norms, shared understandings and available context cues that inform the presentation of content in a coordination instance.
Component: Method	
Predetermined Method	Knowledge about the method of coordination in a coordination instance that has been previously identified and exists embedded inside a coordination routine.
Media Fit Method	Knowledge relevant to understanding the media capabilities and the situation that informs the selection of coordination method in a coordination instance based on matching the media capabilities with the needs of the situation.
Recipient-Tailored Method	Knowledge about the media styles and preferences of the intended recipient that informs the selection of coordination method in a coordination instance.
Coordination Instance Results	
Effectiveness	
Information Quality	Effectiveness change due to the quality of the information being shared in the coordination instance (completeness, relevance, or level of detail).
Person Selection	Effectiveness change due to actor selection with whom to coordinate.
Timeliness	Effectiveness change due to the timing of the coordination instance.
Efficiency	
Cognitive Effort	Efficiency change due to the cognitive effort of the involved actors.
Time Spent	Efficiency change due to time spent by the involved actors.
Follow-Up Coordination Instances	Efficiency change due to the number of follow-up (sequential) coordination instances that must occur.

Data Coding Examples

To illustrate the nature of our coordination data and the coding process, we detail four example coordination instances below and show which data codes were selected and why (Tables 10-13). These descriptions are summaries of the coordination instances comprised of observations and insights via direct observation, previous interview descriptions of the processes and/or brief question and answer opportunities after the coordination instance with the involved healthcare professionals. We followed this process for all 289 coordination instances, and coded them via the scheme shown in Table 9.

Note that coordination instance three does not have any improvements to the coordination instance coded. The effectiveness and efficiency improvements were the most challenging part of the coding process. We took a conservative stance on coding these effects, and only coded these as improvements (pos) or harmed examples (neg) if it was obvious in the coordination instance or we received feedback from a healthcare professional in a follow-up question and answer period. In 145 out of the 289 coordination instances, we obtained feedback from the healthcare professionals after the recording coordination instance that helped confirm our coding decisions.

Coordination Instance 1

Nurse A found it very odd one of her patients declined a pneumonia vaccine. This particular patient was an 80 year old woman, who was a prime candidate for the vaccine and hadn't declined any other of the recommended, but optional procedures. The patient was scheduled for discharge from the ICU in a few hours, and although everything was ready to go, Nurse A questioned the note in the file about the vaccine. Specifically, she wanted to contact Dr. E, the hospitalist assigned to the patient, and ask her if the note was correct or not and discuss the reason for not vaccinating the patient before discharging. Only the assigned hospitalist could approve a change order to add the pneumonia vaccine. Nurse A explained she knew Dr. E was the physician assigned because of previous experiences with the patient and Dr. E.

In order to contact Dr. E, Nurse A used a computer at the nursing station to send Dr. E a text page. She explained that this was due to the hospital's rule that if you needed to contact a physician and it wasn't an emergency, you were to send a page via the internal paging website.

The website form she used took Nurse A's login information to generate the "from" field, and let her select Dr. E from a drop-down list. The text was auto-generated from her drop-down selection.

After several minutes, the physician still had not called Nurse A back.

Table 10: Coordination Instance 1 Coded - Nurse A's Page

Coded Construct	**Outcome**	**Justification of Code**
Role		
Assignment	X	Dr. E was selected because she was the hospitalist assigned to the patient.
Individual		
Time schedule Triggers		
Event sequence Triggers		
Emergent Triggers	X	Nurse A recognized that it was odd the patient hadn't been given the vaccine, and decided to investigate it.
Predetermined Content Selection	X	Paging software determined the page information and it wasn't flexible to include other information.
Emergent Content Selection		
Recipient-Tailored Content Selection		
Predetermined Content Presentation	X	Paging software determined the page lay-out and format.
Shared Understanding		
Predetermined Method Selection	X	Hospital procedure is to send a page through this software.
Media-Fit Method Selection		
Recipient-Tailored Method Selection		
Info Quality		
Actor Selection	Pos	Correct actor selected.
Timing	Neg	Coordination instance didn't happen in a timely manner.
Cognitive Effort		
Time Spent		
Follow-Up CIs	Neg	Failed delivery caused another coordination instance.

Coordination Instance 2 (related to #1):

With a sigh of frustration, Nurse A said, "I knew that would happen. Dr. E hates pages and never returns them. She prefers for me to just call her cell, but I had to follow procedure first." She picked up the phone and called Dr. E, who immediately answered her cell. In a brief discussion where Nurse A explained why she thought the file note was odd, Dr. E confirmed that Nurse A's *suspicions were correct. The file note was an error and the patient was to receive the pneumonia vaccine. Dr. E changed the file note and approved the vaccine, and Nurse A was able to administer it before the patient left.*

Table 11: Coordination Instance 2 Coded - Nurse A's Phone Call

Coded Construct	**Outcome**	**Justification of Code**
Role		
Assignment	X	Dr. E was selected because she was the hospitalist assigned to the patient.
Individual		
Time schedule Triggers		
Event sequence Triggers		
Emergent Triggers	X	Nurse A recognized that it was odd the patient hadn't been given the vaccine, and decided to investigate it + response to failed previous coordination instance
Predetermined Content Selection		
Emergent Content Selection	X	Nurse A explained the situation to Dr. E and why she thought it was odd.
Recipient-Tailored Content Selection		
Predetermined Content Presentation		
Shared Understanding		
Predetermined Method Selection		
Media-Fit Method Selection		
Recipient-Tailored Method Selection	X	Nurse A knew that Dr. E preferred and responded better to cell calls.
Info Quality	Pos	Nurse A brought up important information to Dr. E that allowed her to correct a mistake.
Actor Selection	Pos	Dr. E was the only physician that could correct the error.
Timing	Pos	Conversation happened in time for the order to be processed before the patient was discharged.
Cognitive Effort		
Time Spent		
Follow-Up CIs		

Coordination Instance 3:

A patient came into the ER with a complaint about a sore shoulder. The triage nurse took his information, as per the normal triaging procedure. The patient is asked all of his relevant contact and medical history information, and the triage nurse fills it in, in the electronic medical record solution. Then the triage nurse selects the primary complaint of the patient. The software walked him through a series of questions that prompted him for details about the complaint based on his *previous answers. He also wrote short notes about the patient's condition from his own observations and questions to the patient. The triage nurse records them without a particular coordination partner in mind; these are the general case notes that start the visit's documentation. The physician can choose to read the detailed notes from the triage report at any time. The notes are auto-formatted from the input screens the triage nurse goes through. In other words, the answers are summarized and reformatted into a report by the software.*

Table 12: Coordination Instance 3 Coded - Nurse Triage via EMR Software

Coded Construct	Outcome	Justification of Code
Role		
Assignment		
Individual		
Time schedule Triggers		
Event sequence Triggers	X	Normal procedure when seeing a patient into the ER.
Emergent Triggers		
Predetermined Content Selection	X	Software guides most of the content selection, as the nurse navigates through the software screens.
Emergent Content Selection	X	While most of the content was prompted, the nurse did fill in additional note sections with his own observations about the patient.
Recipient-Tailored Content Selection		
Predetermined Content Presentation	X	Software controls the presentation, both during the data entry and how the report looks to the physician.
Shared Understanding		
Predetermined Method Selection	X	Using the software is dictated by the triage process.
Media-Fit Method Selection		
Recipient-Tailored Method Selection		
Info Quality		
Actor Selection		
Timing		
Cognitive Effort		
Time Spent		
Follow-Up CIs		

Coordination Instance 4 (related to #3):

After filling out the EMR software solution during the triage process described above, the triage nurse walked into the physician's office and verbally gave him the basic information about the patient with the sore shoulder. His description was abbreviated, containing much less detail than he recorded in the software. Later I asked why he did that, since the physician could read his triage notes (which would contain much more detail) and the triage nurse explained he liked to give the physician a heads up because it was much faster and easier for the physician to hear the *basic problem from him [verbally] than to dig through the notes. The physician seemed to appreciate the heads up and did not access the triage nurse's notes before seeing the patient.*

Table 13: Coordination Instance 4 Coded - Nurse Triage via Verbal Discussion

Coded Construct	Outcome	Justification of Code
Role	X	Talked to the on-duty physician.
Assignment		
Individual		
Time schedule Triggers		
Event sequence Triggers		
Emergent Triggers	X	Took it upon himself to find the physician and pass on the information.
Predetermined Content Selection		
Emergent Content Selection	X	Triage nurse chose which pieces to tell the physician.
Recipient-Tailored Content Selection		
Predetermined Content Presentation		
Shared Understanding		
Predetermined Method Selection		
Media-Fit Method Selection	X	Triage nurse felt this was a better medium (spoken) to easily transfer the information than the required documentation in the EMR software.
Recipient-Tailored Method Selection		
Info Quality		
Actor Selection	Pos	ER Physician was the appropriate person who needed that information
Timing	Pos	Physician received the information right in time to address patient.
Cognitive Effort	Pos	Triage nurse comments and physician actions seem to indicate this was a faster and easier way to bring the physician up to speed.
Time Spent	Pos	Triage nurse comments and physician actions seem to indicate this was a faster and easier way to bring the physician up to speed.
Follow-Up CIs		

CHAPTER 5: DATA ANALYSIS AND RESULTS

The objective of the dissertation is to provide *preliminary* evidence to test our conceptualization of coordinating knowledge and the stated propositions. The major thrust of the dissertation is our development of the coordinating knowledge framework and surrounding theory, rather than a comprehensive test of the proposed propositions. In fact, it would be very difficult to test all of the propositions in one project. Using the data gathered and coded as described in Chapter 4, we present qualitative and quantitative data analysis to provide preliminary evidence for our conceptualization of coordinating knowledge and for many of the propositions developed in Chapter 3.

First, descriptive statistics are discussed, which show initial evidence of the various types of coordinating knowledge (CK) in a healthcare context. Second, we explore the qualitative data by describing several coordination instances that show contextualized examples of coordinating knowledge affecting coordination instance performance as proposed. Third, using ordinal logistic regression models we test the propositions related to the presence of types of CK affecting the performance of the coordination instance in terms of the various components of effectiveness and efficiency. Next, we test propositions related to the effects of certain types of CK being embedded in an information system solutions, using a comparison on contingency tables. Finally, we undertake two types of post-hoc analyses on our set of data. We separate the models that failed the Score Test for the Proportional Odds Assumption[4] (as tested in the statistical analysis section of ordinal logistic regression models) into two binomial logistic regression models. This allows us to examine the differences that might exist in the effect of CK between coordination instances where performance declined versus those where performance improved. In our final post-hoc analysis we use exploratory factor analysis to identify five latent factors that may represent commonly co-occurring CK groups (i.e., portfolios of CK) and explore how the latent factors (CK groups) affect the performance of coordination instances.

Descriptive Statistics

The coded coordination instances were uploaded into MaxQDA software, in order to visualize the frequency and possible relationships between the types of coordinating knowledge. All proposed coordinating knowledge types were observed during the coordination instance observations, as seen in Table 14. Recipient-tailored content and recipient-tailored method were observed at much smaller frequencies than the other types of coordinating knowledge. We believe this is due to the nature of those types of coordinating knowledge. It is difficult to determine if an actor is changing behavior because of specific knowledge about the recipient via an outsider's third-person observation.

[4] This test indicated that for certain models the effect of CK on performance was not uniform across values of the dependent variable. Given that our dependent variables were coded as "performance declined (-1), no effect (0), performance improved (1)" this implies that effects are different when examining effects that harm performance than those that improve performance. The post-hoc test allows us to shed light on these non-uniform effects.

Table 14: Frequencies of Coded Examples of Coordinating Knowledge Types

Type of Coordinating Knowledge	Known by an Actor	Embedded in an Information System	Total Frequency of the codes indicating presence of the CK[1]	Percentage of CK Type in its Specific CK Type Group
1 Role	80	1	**81**	**38%**
2 Assignment	91	7	**98**	**46%**
3 Individual	35	0	**35**	**16%**
4 Time Scheduled Triggers	72	0	**72**	**23%**
5 Event Sequence Triggers	113	10	**123**	**39%**
6 Emergent Triggers	122	0	**122**	**38%**
7 Predetermined Content	156	47	**203**	**34%**
8 Emergent Content	172	0	**172**	**29%**
9 Recipient-Tailored Content	21	0	**21**	**4%**
10 Predetermined Presentation	36	58	**94**	**16%**
11 Shared Understanding	110	0	**110**	**18%**
12 Predetermined Method	183	2	**185**	**54%**
13 Media-Fit-based Selection	140	0	**140**	**41%**
14 Recipient-Tailored Method	16	0	**16**	**5%**
E1: Info Quality	N/A	N/A	**225**	N/A
E2: Person Selection	N/A	N/A	**135**	N/A
E3: Timing	N/A	N/A	**104**	N/A
E4: Cognitive Effort	N/A	N/A	**122**	N/A
E5: Time Spent	N/A	N/A	**102**	N/A
E6: Follow-Up Instances	N/A	N/A	**33**	N/A

[1] It is possible, though rare, for a single coordination instance to have multiple codes related to one type of coordinating knowledge.

Relationships between the types of coordinating knowledge and the efficiency and effectiveness of a coordination instance were first explored using MaxQDA's code matrix tool (Figure 4). The larger the circle, the more the co-occurrences of the specific CK-type with the specific performance effect in the data, which suggests a possible relationship. However the size of the circle is also partially a product of the frequency of the CK type. For example, CK about predetermined content selection was coded in this data set more times than recipient-tailored content selection, so it is not surprising that, in general, the circles under the predetermined content and larger than the ones under recipient-tailored content. The raw numbers behind Figure 4 can be seen in Table 15.

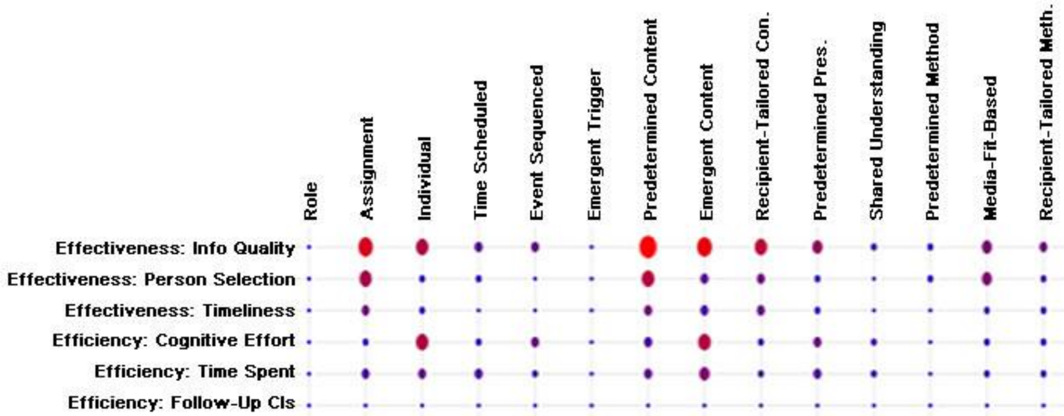


Figure 4: Visualization of Coordinating Knowledge Code Matrix

Table 15: Number of Coordinating Instance where Codes Co-Exist (Used to create Figure 4)

	Role	Assignment	Individual	Time Scheduled	Event Sequenced	Emergent Trigger	Predetermined Content	Emergent Content	Recipient-Tailored Con.	Predetermined Pres.	Shared Understanding	Predetermined Method	Media-Fit-Based	Recipient-Tailored Meth.
Effectiveness: Info Quality	62	66	28	36	79	98	118	129	18	58	49	91	111	10
Effectiveness: Person Selection	38	68	30	15	37	62	52	95	13	14	27	27	88	9
Effectiveness: Timeliness	30	39	9	14	28	58	45	63	3	18	18	28	62	8
Efficiency: Cognitive Effort	26	26	7	39	60	29	93	45	4	60	29	91	29	3
Efficiency: Time Spent	31	26	13	27	47	36	69	54	4	37	45	57	44	4
Efficiency: Follow-Up CIs	8	17	3	9	13	15	20	21	8	7	9	15	18	6

Some patterns that we expected based on our theorizing begin to emerge in Figure 4. For example, there are many coordination instances where coordinating knowledge about predetermined content or emergent content is present that were also coded as being more effective due to a higher quality of information being present. These co-occurrences are suggestive of relationships between CK types and outcomes. To explore these further we first look at a selection of specific coordination instances to see examples of the relationships theorized in our propositions and use counts to detect basic pattern matching of the proposed relationships. Next, we use ordinal logistic regression in order to test for statistical significance of our observed pattern matching.

Qualitative Analysis

Recall in chapter four we described four coordination instances and detailed how and why they were coded using our coding scheme. Using those four instances and the additional instances described below, we show support for our propositions in the contextualized stories the qualitative data yields. We describe coordination instances five through nine below (see chapter four for details about instances one through four), and Table 16 summarizes which propositions are supported in which described instance(s).

(Previously Described) Coordination Instance 2 & 4

The second coordination instance we explored involved Nurse A calling Doctor E on the cell phone and questioning her about the declined pneumonia vaccine. This situation illustrates CK about assignment improving the selection of a person with whom to coordinate (P2a). Nurse A's recognition of the need to talk to Doctor E about the situation was an emergent trigger (P9) and she knew the best way to reach her (recipient-based media selection - P21); these things helped improve the timing of the coordination instance. Also, Nurse A's recognition of the relevant information (emergent content selection) helped make sure the right information was communicated with the physician (P13).

The fourth coordination instance took place in the ER department when the triage nurse elected to seek out the ER physician and summarize the patient details to him. The nurse used CK about role to select the right person with whom to coordinate (P1) and he recognized the advantage of initiating the coordination instance (emergent trigger), which seemed to improve the timing of the coordination instance (P9). Finally, the decision to verbally convey the information (media-fit method selection) was ideal for quickly and efficiently communicating the information (P20).

Coordination Instance 5

> *Each shift is assigned a telemonitor nurse, who sits in front of the telemonitor station in the ICU department. The telemonitor nurse monitors and records patient vitals that are displayed on a series of screens in front of her station. Patient vitals consist of blood pressure, heart rate, and temperature. The telemonitor nurse records these vital readings for each patient every four hours onto a worksheet.*
>
> *One use of this information is by nurses each time they fill out their end-of-shift report. They need to request the previous 12 hours vital sign readings from the telemonitor nurse* (role) *to record in their report* (predetermined content selection). *Each telemonitor nurse has preferred ways to communicate this information to the nurses. The telemonitor nurse in this coordination instance explains that she prefers that each nurse call her about their patients so that they can have a conversation about the vital readings. She went on to explain that she feels this is a better method to communicate on* (media-fit method selection), *because better information is transferred* (positive improvement to information quality) *as they can have a conversation about the patient if necessary. She also feels this is a faster and easier way to convey the information* (improvement to cognitive effort and time spent).
>
> *Therefore, when this telemonitor nurse is working, each floor nurse knows to call* (recipient-based method selection) *her to receive the information. The nurses typically call the telemonitor station* (improvement to person selection) *each shift when they are writing their report* (event-sequenced trigger). *This allows them to receive the information as they need it* (improvement to timing) *and they can immediately type it into their report while on the phone. This coordination instance was an example of that situation. A floor nurse from the second floor called the telemonitor station and requested the vital signs of a patient so she could finish her report. The conversation was very abbreviated, as both parties used acronyms and did not use the units of the vital readings (e.g., the telemonitor nurse just read a series of numbers, and the floor nurse knew which numbers referred to blood pressure, which to heart rate, and when each occurred during the day, etc.)* (shared understanding).

In this example we see the floor nurse use CK about role in order to select the right person with whom to coordinate (P1A). The trigger of the coordination instance was when the nurse was filling out her report, and is part of her normal sequence of events. This allowed her to get the information at the correct time (P8A) and while she was already focused on the report (P8B). Cognitive efficiency was observed because both actors knew the kind of information necessary in the coordination instance (predetermined content selection – P12B) and they communicated it efficiently due to their shared understanding (P16).

Coordination Instance 6

> *At 7AM every morning* (time-scheduled trigger), *the ICU nursing staff has a huddle meeting, which is an in-person verbal* (predetermined method selection) *discussion. This involves the charge nurse from the evening shift that is about to go off-duty, and all the RNs about to go on-duty for the day shift. Each nurse independently knows to go to the huddle meeting location, so coordinating knowledge about whom to coordinate with is not employed. The evening charge nurse very quickly goes through information (patient description, major medical complaint(s), medication changes, major changes in condition, etc.) about each patient. For the most part, this information is standardized and the same for each patient* (predetermined content selection). *Occasionally, at the charge nurse's discretion, he decides to add additional information he thinks is pertinent* (emergent content selection). *The information is communicated very quickly, and is frequently abbreviated such that someone unfamiliar with medical terminology could not follow the conversation* (shared understanding).
>
> *Prior to observing the huddle meeting, the ICU Nursing director explained that the purpose of the huddle meeting is to very efficiently convey basic patient information and updates from one shift to the next. It is faster and easier* (improvement to cognitive effort and time spent) *than reading patient charts, and it allows the most relevant information* (improvement in information quality) *to be conveyed without burdening the next shift nurses down with unimportant details. This sentiment was echoed after the observed huddle meeting by one of the day shift nurses who explained she would never go back and read the previous shift's written notes. She trusted the verbal information passed along by the night shift as an effect substitute and found it much easier to absorb.*

The presence of many types of coordinating knowledge seem to improve the efficiency of this coordination instance. The time-scheduled nature of the meeting at 7AM (P7), predetermined content (P12B) and method (P19), all seem to explain how the coordination instance is less cognitively taxing on the involved actors. Further, the fast communication due to shared understanding (P16) causes the coordination instance to take-up less time. Finally, both sources indicated the information quality was high in the huddle meeting, which is likely the result of the predetermined content selection (P12A) and the emergent content that the nurse added (P13).

Coordination Instance 7

> *Dr. G was the current ER doctor on duty, and he very much wanted the cardiologist, Dr. V, to provide consultations* (emergent trigger) *for two of the patients currently in the ER because of his unique expertise* (individual selection). *He explained that Dr. V was likely to want to consult on one of the patients, but probably not the other. He knew this because of the types of cases Dr. V preferred. In order to convince Dr. V to take on the second case, he waited until Dr. V was already in the ER to discuss it in person. Later he explained that "it was all about the pitch" to get the consultation. Specifically, Dr. G felt like Dr. V was more likely to take the case if it was explained in person* (recipient-based media selection*) and if certain information was explained first to catch his attention. He also knew what kind of information Dr. V required* (recipient-based content selection) *and was able to provide it all at once so Dr. V had all of the necessary information for the consultation* (reduce need for follow-up coordination instances). *He knew both of these things from previous experience working with Dr. V. Dr. V did agree to the consultation, which Dr. G felt was a very successful coordination instance as Dr. V was the best person for the consultation and the right information has been exchanged* (improvement of information quality and person selection).

In this example we see evidence of P3 as CK about an individual is used to find the best person for the coordination instance. Dr. G's use of recipient-based content selection allowed him to provide all of the necessary information at once without follow-up coordination instances (P14).

Coordination Instance 8

> *The electronic medical record software in the ER area stored each nurse and physician's assignment to patients* (CK about Assignment – Embedded in Technology). *When the lab technicians completed any lab work about a patient they recorded it in the software, and the software automatically forwarded the results* (CK about Event Sequence – Embedded in Technology) *to the appropriate ER hospital staff members. In other words, when the lab technician finished their lab work procedure, the software automatically managed a coordination instance that sent the results to the ER nurses and physicians that most needed to know the information* (improvement to person selection). *The lab result content of the coordination instance* (predetermined content selection) *is embedded in the software, as are the display decisions* (predetermined content presentation).
>
> *From the nurse or physician's point of view, the software displayed a unique, flashing icon when lab results were ready for them to see. This insured that they could see the results as soon as they were complete* (improvement to timing) *and that the results were pushed to them without their needing to think about it* (reduction in cognitive effort).

In this example we see that embedding assignment CK into the technology causes the lab results to get to the right person (P5) without any of the actors in the situation spending cognitive effort on the coordination instance (P6). The content selection (lab results) and presentation (display of the lab results) is also embedded into the technology, which further reduces cognitive effort expended by the actors (P17b & P18a). Further, by automating the process with an embedded event scheduled trigger, the lab results are available at the right time (as soon as possible) the nurses and physicians involved in the patient's healthcare (P11).

Coordination Instance 9

> *The ICU department utilized a safety locking system to dispense medications. Specifically, this coordination instance is an automated way the pharmacy department helps coordinate information (i.e., which medications to distribute to patients) with each ICU nurse at the beginning of their medication dispensing routine. Each patient in the ICU department is assigned a nurse, and that information is kept in the software* (CK about Assignment – Embedded in Technology). *Before making medication rounds* (event-sequence trigger), *a nurse logs into the medication dispensing system using his credentials and the system automatically looks up the list of medications he needs to dispense to his patient(s)* (CK about Predetermined Content Selection – Embedded in Technology). *Only the drawers corresponding to the medications the nurse needed will unlock and open* (CK about Predetermined Content Presentation – Embedded in Technology).
>
> *This provides added security and helps insure the correct medications are given to each patient. It is fully automated* (improvement to cognitive effort) *and takes no additional effort by the pharmacy department or nurse. During their dispensing routine* (improvement to timing), *only the drawers unlock that have drugs prescribed to the patient, it helps eliminate dosing errors* (improvement to information quality).

In this example, the embedding of assignment CK (P5), event sequence triggers (P11), content selection (P17b) and content presentation (p18a) help automate this procedure so that little cognitive effort from the actors is involved. Further, it helps improve information quality by enforcing the prescribed medication list in a physical way during medication preparation (P17a).

Table 16 summarizes the propositions that are supported in these nine coordination instances we have described. While our selection did not cover all propositions, we see that there is evidence of most of our proposed relationships, even in this small collection of coordination instances. Looking for evidence in our coded coordination instance of our previously theorized propositions is known as pattern matching, which is a recommended and preferred way to conduct an explanatory case study (Dube and Pare 2003). In order to show the results of our pattern matching exercise in a more space efficient manner, the last column of Table 16 displays the number of coordination instances where the relevant data codes co-exist. In other words, for proposition 1a, which states that CK about role will improve the selection of an actor, we display the number of times a coordination instance occurred that is coded as having CK about role and an improvement of actor selection. While these counts do not prove causality, they do provide further evidence that the relationships in our propositions occur in our observed data set.

Table 16: Summary of Propositions Supported in Coordination Instance Descriptions

#	Formal Statement	CI2	CI4	CI5	CI6	CI7	CI8	CI9	Total CIs in Data Set
P1a	Coordinating knowledge about role improves the selection of the appropriate person with whom to coordinate in the coordination instance (i.e., person selection effectiveness).		X	X					38
P1b	Coordinating knowledge about role reduces the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency).		X						26
P2a	Coordinating knowledge about assignment improves the selection of the appropriate person with whom to coordinate in the coordination instance (i.e., person selection effectiveness).	X							68
P2b	Coordinating knowledge about assignment reduces follow-up coordination instances (i.e., improves follow-up CI efficiency).								17
P3	Coordinating knowledge about individuals improves the selection of the appropriate person with whom to coordinate in the coordination instance (i.e., better person effectiveness).					X			30
P4	By managing coordinating knowledge about role, information systems reduces cognitive effort (i.e., improves cognitive effort efficiency), above and beyond the effect due to coordinating knowledge about role simply being present in a situation.								1[1]
P5	By managing coordinating knowledge about assignment, information systems reduces cognitive effort (i.e., improves cognitive effort efficiency), above and beyond the effect due to coordinating knowledge about assignment simply being present in a situation.						X	X	6[1]
P6	Coordinating knowledge about role or assignment embedded in an information system can weaken the selection of the appropriate person with whom to coordinate (i.e., person selection effectiveness).						X		N/A
P7	Coordinating knowledge about time schedule triggers reduces the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency).				X				39
P8a	Coordinating knowledge about event sequence triggers delivers the information in a timelier manner (i.e., timeliness effectiveness).			X					28
P8b	Coordinating knowledge about event sequence triggers reduces the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency) and reduces the number of sequential coordination instances (i.e., improves follow-up CI efficiency).			X					60
P9	Coordinating knowledge about emergent triggers delivers the information in a timelier manner (i.e., timeliness effectiveness).	X	X						28

P10	Information systems that enhance or automate time schedule triggers, reduce the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency) and reduce the time spent by the actors (i.e., improves time spent efficiency), above and beyond the effect due to coordinating knowledge about time schedule triggers simply being present in a situation.								0/0[2]
P11	Information systems that enhance or automate event sequence triggers, reduce the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency) and reduce the time spent by the actors (i.e., improves time spent efficiency), above and beyond the effect due to coordinating knowledge about event sequence triggers simply being present in a situation.						X	X	8/7[2]
P12a	Coordinating knowledge about predetermined content improves the quality (completeness, relevance, and level of detail) of the information being shared in the coordination instance (i.e., information quality effectiveness).				X				118
P12b	Coordinating knowledge about predetermined content reduces cognitive effort and reduces the amount of sequential coordination instances (i.e., improves cognitive effort and follow-up CI efficiency).			X	X				93
P13	Coordinating knowledge about emergent content improves the quality (completeness, relevance, and level of detail) of the information being shared in the coordination instance (i.e., information quality effectiveness).	X			X				98
P14	Coordinating knowledge about recipient-tailored content reduces the amount of sequential coordination instances (i.e., improves follow-up CI efficiency).					X			8
P15	Coordinating knowledge about predetermined presentation reduces the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency).								60
P16	Coordinating knowledge about shared understanding reduces the time spent by the involved actors (i.e., improves time spent efficiency.			X	X				37
P17a	Information systems that embed coordinating knowledge about predetermined content selection improve the quality of the information being shared in the coordinating instance (i.e., information quality effectiveness), above and beyond the effect due to coordinating knowledge about predetermined content selection simply being present in a situation.							X	40
P17b	Information systems that embed coordinating knowledge about predetermined content selection reduce cognitive effort and reduce time spent (i.e., improve cognitive effort and time spent efficiency), above and beyond the effects due to coordinating knowledge about predetermined content selection simply being present in a situation.						X	X	38/20
P18a	Information systems that embed coordinating knowledge about predetermined content presentation reduce cognitive effort and reduce time spent (i.e., improve cognitive effort and time spent efficiency), above and beyond the effect due to coordinating						X	X	45/0

	knowledge about predetermined content presentation simply being present in a situation.								
P18b	Information systems that enhance content presentation by separating the presentation between sender and receiver reduce cognitive effort and reduce time spent (i.e., improve cognitive effort and time spent efficiency).								N/A
P19	Coordinating knowledge about predetermined method reduces cognitive effort of the actors involved in the coordination instance (i.e., improve cognitive effort efficiency).				X				91
P20	Coordinating knowledge about media-fit method improves the quality (completeness, relevance, and/or level of detail) of the information being shared in the coordination instance (i.e., information quality effectiveness) and delivers the information in a timelier manner (i.e., timeliness effectiveness).		X	X					111/62[2]
P21	Coordinating knowledge about recipient-tailored method delivers the information in a timelier manner (i.e., timeliness effectiveness).	X		X		X			8

[1]These propositions involving information systems cannot be fully tested via pattern matching. We only show the counts of coordination instances where the involved constructs were coded, and cannot assess if these are stronger effects than if they had not been embedded in technology. We do attempt to explore this aspect of the propositions in our contingency table results as a statistical analysis.

[2]Propositions involving two performance indicators (e.g., cognitive effort and time spent) show two numbers in the counts column. One for each of the performance indicators in the proposition, respectively.

Statistical Analysis

This section presents the propositions in a different order than seen in Chapter 3. Chapter 3 was organized by the theoretical journey of considering the existence of CK types and how they might affect coordination instances. This chapter groups the propositions by statistical method used to test them (ordinal logistic regression or contingency tables), and then by specific models relevant to each type of coordination improvement. A summary of our quantitative proposition testing results is shown in Table 17.

Table 17: Propositions and Findings Summary

#	Formal Statement	Analysis	Supported?
P1a	Coordinating knowledge about role improves the selection of the appropriate person with whom to coordinate in the coordination instance (i.e., person selection effectiveness).	OLS (M2)	Supported***
P1b	Coordinating knowledge about role reduces the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency).	OLS (M4)	Not Supported
P2a	Coordinating knowledge about assignment improves the selection of the appropriate person with whom to coordinate in the coordination instance (i.e., person selection effectiveness).	OLS (M2)	Supported***
P2b	Coordinating knowledge about assignment reduces follow-up coordination instances (i.e., improves follow-up CI efficiency).	OLS	Supported***
P3	Coordinating knowledge about individuals improves the selection of the appropriate person with whom to coordinate in the coordination instance (i.e., better person effectiveness).	OLS (M2)	Supported***
P4	By managing coordinating knowledge about role, information systems reduces cognitive effort (i.e., improves cognitive effort efficiency), above and beyond the effect due to coordinating knowledge about role simply being present in a situation.	Not Tested	
P5	By managing coordinating knowledge about assignment, information systems reduces cognitive effort (i.e., improves cognitive effort efficiency), above and beyond the effect due to coordinating knowledge about assignment simply being present in a situation.	CCT	Supported***
P6	Coordinating knowledge about role or assignment embedded in an information system can weaken the selection of the appropriate person with whom to coordinate (i.e., person selection effectiveness).	CCT (Partially Tested)	Not Supported
P7	Coordinating knowledge about time schedule triggers reduces the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency).	OLS (M4)	Supported***
P8a	Coordinating knowledge about event sequence triggers delivers the information in a timelier manner (i.e., timeliness effectiveness).	OLS (M3)	Not Supported
P8b	Coordinating knowledge about event sequence triggers reduces the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency) and reduces the number of sequential coordination instances (i.e., improves follow-up CI efficiency).	OLS (Part 1 - M4); (Part 2 – M6)	Supported**; Not Supported
P9	Coordinating knowledge about emergent triggers delivers the information in a timelier manner (i.e., timeliness effectiveness).	OLS (M3)	Supported**
P10	Information systems that enhance or automate time schedule triggers, reduce the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency) and reduce the time spent by the actors (i.e., improves time spent efficiency), above and beyond the effect due to coordinating knowledge about time schedule triggers simply being present in a situation.	Not Tested	
P11	Information systems that enhance or automate event sequence triggers, reduce the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency) and reduce the time spent by the actors (i.e., improves time spent efficiency), above and beyond the effect due to coordinating knowledge about event sequence triggers simply being present in a situation.	CCT	Not Supported

P12a	Coordinating knowledge about predetermined content improves the quality (completeness, relevance, and level of detail) of the information being shared in the coordination instance (i.e., information quality effectiveness).	OLS (M1)	Not Supported
P2b	Coordinating knowledge about predetermined content reduces cognitive effort and reduces the amount of sequential coordination instances (i.e., improves cognitive effort and follow-up CI efficiency).	OLS (Part 1 – M4); (Part 2 – M6)	Not Supported; Not Supported
P13	Coordinating knowledge about emergent content improves the quality (completeness, relevance, and level of detail) of the information being shared in the coordination instance (i.e., information quality effectiveness).	OLS (M1)	Supported***
P14	Coordinating knowledge about recipient-tailored content reduces the amount of sequential coordination instances (i.e., improves follow-up CI efficiency).	OLS (M6)	Supported***
P15	Coordinating knowledge about predetermined presentation reduces the cognitive effort of the actors involved in the coordination instance (i.e., improves cognitive effort efficiency).	OLS (M4)	Not Supported
P16	Coordinating knowledge about shared understanding reduces the time spent by the involved actors (i.e., improves time spent efficiency.	OLS (M5)	Supported***
P17a	Information systems that embed coordinating knowledge about predetermined content selection improve the quality of the information being shared in the coordinating instance (i.e., information quality effectiveness), above and beyond the effect due to coordinating knowledge about predetermined content selection simply being present in a situation.	CCT	Not Supported
P17b	Information systems that embed coordinating knowledge about predetermined content selection reduce cognitive effort and reduce time spent (i.e., improve cognitive effort and time spent efficiency), above and beyond the effects due to coordinating knowledge about predetermined content selection simply being present in a situation.	CCT	Not Supported
P18a	Information systems that embed coordinating knowledge about predetermined content presentation reduce cognitive effort and reduce time spent (i.e., improve cognitive effort and time spent efficiency), above and beyond the effect due to coordinating knowledge about predetermined content presentation simply being present in a situation.	CCT	Not Supported
P18b	Information systems that enhance content presentation by separating the presentation between sender and receiver reduce cognitive effort and reduce time spent (i.e., improve cognitive effort and time spent efficiency).	Not Tested	
P19	Coordinating knowledge about predetermined method reduces cognitive effort of the actors involved in the coordination instance (i.e., improve cognitive effort efficiency).	OLS (M4)	Supported***
P20	Coordinating knowledge about media-fit method improves the quality (completeness, relevance, and/or level of detail) of the information being shared in the coordination instance (i.e., information quality effectiveness) and delivers the information in a timelier manner (i.e., timeliness effectiveness).	OLS (Part 1 – M1) (Part 2 – M3)	Not Supported; Supported***
P21	Coordinating knowledge about recipient-tailored method delivers the information in a timelier manner (i.e., timeliness effectiveness).	OLS (M3)	Not Supported

Legend: OLS – Ordinal Logistic Regression Analysis, M1-M6 – Refers to Model 1, Model 2, etc., CCT – Comparison of Contingency Tables; ** indicates p<.05; *** indicates p<.01

Logistic Regression Models - Logistic regression is a type of probabilistic statistical classification model that is used to predict a binary or categorical dependent variable. The presence or absence of 14 types of coordinating knowledge are used as predictors and are coded as dichotomous variables. Our 6 dependent variables (3 types of effectiveness and 3 types of efficiency in coordination instances, detailed in Table 1) each have three possible values: an improvement of the coordination instance (coded as 1), code not present (coded as 0 and implying no change), or a deterioration or harmed effect of the coordination instance (coded as -1). Since these categories have a meaningful order, we use ordinal (also known as ordered) logistic regression. Ordinal logistic regression retains and utilizes the inherent ordinality of the data in the outcome variable (Scott et al. 1997). The propositions related to the basic effects of coordinating knowledge (i.e., the ones not specific to information systems) were divided into 6 groups, such that each type of performance (i.e., each dependent variable) was considered in a separate model. See Figure 5 for details.

Appendix F shows the correlation matrix of all of our coded constructs used to test our propositions. It should be noted that multicollinearity is only a concern if highly correlated variables end up in the same ordinal logistic regression model. For example, the correlation between CK about predetermined content and event sequence triggers is 0.54. However, these two types of CK are not predicted to effect the same improvement type of a coordination instance, and therefore do not co-exist in any of our six models. There is moderately high correlation between CK types predetermined content, predetermined presentation, and predetermined method (between .52 and .69 for each pair combination). This is probably because many highly routinized and structured coordination mechanisms involve all three of these predetermined types of CK. Since all three of these types of CK are predicted to reduce cognitive effort (Model 4), multicollinearity is a concern (see Model 4 Results section for more details).

Table 18 shows a variety of recommended fit statistics for assessing the model fit of the 6 logistic regressions used to test our first set of propositions. The likelihood-ratio tests compare the fit of our hypothesized models with the corresponding null models (intercept only). If the test statistic is found to be significant, we can reject the null model in favor of the alternative (hypothesized) model as being a better fit (Aldrich and Nelson 1984). The likelihood ratio statistic is found to be significant at the p=.01 level in all of our models. A similar comparison of likelihood ratios is used in the comparison of -2 Log L Tests, which compare the hypothesized models with the corresponding full models (i.e., all 14 CK types regressed on the model's DV). An insignificant test statistic (at the p=.05 level), such as those found for model 1, model 2, model 3, and model 4, suggests that there is no significant difference between the two models, leaving us free to favor the more parsimonious, hypothesized models (Cohen et al. 2003). The comparison test statistic is significant at the p=.05 level for models 5 and 6. The Akaike information criterion (AIC) is a measure of relative quality of a statistical model, and can be used to compare different models (Akaike 1974). It also controls for model simplicity, and larger values are superior. The AIC value for the full model 5 is 395.165, which is only slightly higher than the hypothesized model (392.36). The higher AIC indicates that the full model (all CK types taken into account) may be superior to our proposed model (one CK, in model 5). In the case of model 6, the AIC of the full model is actually lower (288.026) than the hypothesized model (290.67). This comparison favors our more parsimonious hypothesized model.

Techniques that utilize OLS regression use the squared multiple correlation (R^2) as a measure of goodness of fit of the model, as it represents the proportion of total variation accounted for by a set of predictors. Logistic regression techniques utilize MLE techniques, and there is not a single agreed upon statistics equivalent to the squared multiple correlations. However, a set of indices exists that assess goodness of fit that are often referred to as pseudo R^2s. A common one is the Cox and Snell index, but a problem it has is it does not reach a maximum value of 1. In fact, if the proportion of cases is evenly split (.5) the Cox and Snell index reaches a maximum value of 0.75 (Cohen et al. 2003). In order to alleviate this issue, Nagelkerke (1991) proposed a modified index that modifies the Cox and Snell index in order to allow for a possible value of 1. We display both pseudo R^2s in Table 18. It is important to remember that these measures are not true “variance accounted for” as we are used to expecting in OLS regression.

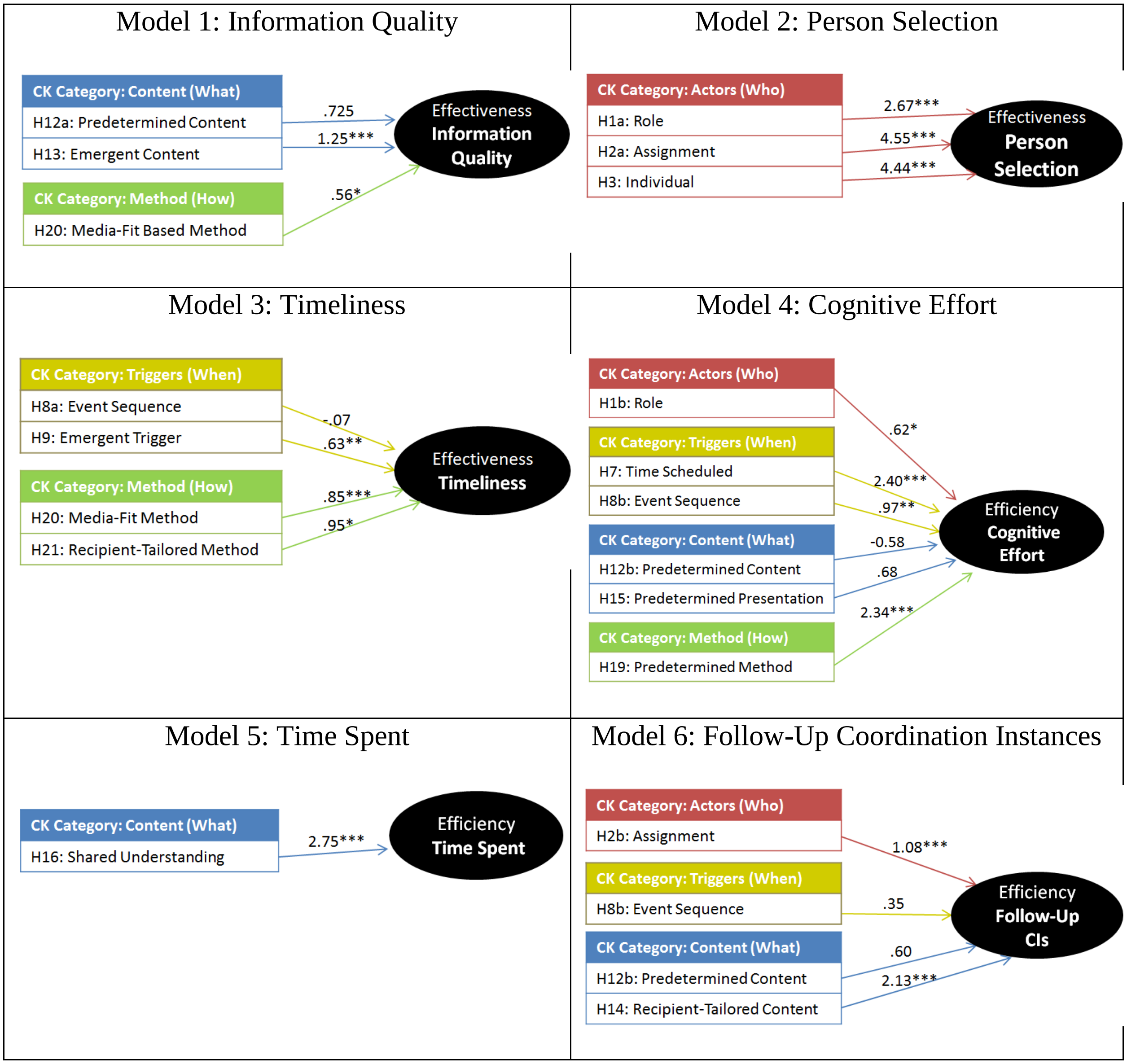
The nature of ordinal logistic regressions is to have multiple cut-points between proportional odds. Where binomial regression only studies the proportional odds between two values (e.g., 0 or 1) or one cut-point, ordinal logistic regression considers proportions between multiple sets (e.g., -1 or 0/1 and -1/0 or 1). An underlying assumption is that the proportional odds between these different cuts-points is the same (Brant 1990; Scott et al. 1997). The score test for proportional odds tests to see if two (or more) cut-points are behaving with similar proportional odds; significant values suggest that the assumption is not met (Cohen et al. 2003). Several of our models (2, 3, 4, and 5) fail this assumption test, which implies that the predictors affect the odds differently between -1 or 0/1 than between -1/0 or 1. Said another way, this suggests that the predictors in those four models are behaving differently around harmed coordination instances (coded as -1) than around improved coordination instances (coded as 1). We explore this possibility during our post-hoc analysis.

Table 18: Fit Statistics of Ordinal Logistic Regression Models

Ordinal Logistic Regression Model	Likelihood Ratio Test[1]	Comparison of -2 Log L Tests [df], (sig) (vs. Full Model)[2]	AIC	Cox & Snell Pseudo R^2	Nagelkerke Pseudo R^2	Score Test for Proportional Odds Assumption [df], (sig)
Model 1 DV: Information Quality	24.80 [3], (p=.002)	17.35[11], (p=.098)	339.42	0.05	0.07	5.59[3], (p=.1336)
Model 2 DV: Person Selection	173.45 [3], (p<.0001)	13.18[11], (p=.282)	315.19	0.45	0.56	83.83[3], (p<.0001)[3]
Model 3 DV: Timeliness	27.13 [4], (p<.0001)	14.33[10], (p=.158)	416.52	0.09	0.12	11.42[4], (p=.0223)[3]
Model 4 DV: Cognitive Effort	147.53 [6], (p<.0001)	8.48[7], (p=.292)	299.83	0.40	0.52	121.59[6], (p<.0001)[3]
Model 5 DV: Time Spent	55.93[1], (p<.0001)	23.20[12], (p=.026)	392.36	0.21	0.26	28.44[1], (p<.0001)[3]
Model 6 DV: Follow-Up CIs	23.50[4], (p=.0001)	22.64[10], (p=.009)	290.67	0.08	0.12	4.06[4], (p=.3974)

[1] Score and Wald Chi-Square Tests were also computed for each model. The results were very similar, therefore only the Likelihood Ratio Chi-Square test is shown.
[2] The full model refers to each of the CK predictors used for each DV. The complete results of these full models are available in Appendix E.
[3] Significant p values indicate that the proportional odds assumption was not met. Differences between the two levels of these DVs are explored in the post-hoc analysis section.

Figure 5 and Table 19 show the results of the six logistic regressions used to test our first set of propositions. Significance of the constructs is assessed in two ways: (1) the p-value of the Wald Chi-Square statistic and (2) the 95% Confidence Interval of the Odds Ratio. The Wald Chi-Square test statistic is used to test the null hypothesis, which predicts the parameter has zero effect. If the probability of Wald Chi-Square is significant then we reject the null hypothesis and find that the predictor made a significant contribution to the model (Boslaugh 2012). The proportional odds ratio, also known as the point estimate, can be interpreted as one unit of change in the predictor causes the odds of the cases in the DV to be one level higher to increase by the proportional odds (Cohen et al. 2003). For example, if we consider the first row of Table 19, we see that one increase in CK of predetermined content (i.e., it is found to be present) increases the odds of seeing an improvement in the information shared during the coordination instance by 2.064. Next we calculate a 95% confidence interval, which tells us we are 95% confidence that the "true" population proportional odds ratio lies between the lower and upper limit. If this interval does not span the value 1 (which would imply no effect on the odds ratio of the DV), we have additional evidence that the predictor plays a significant role in predicting the DV.



Numbers above hypothesized relationship line are the estimates (ordered log-odds regression coefficients). Asterisks denote significance of the corresponding Wald Chi-Square Statistic. (* denotes significance <0.1, ** denotes significance <0.05, *** denotes significance<0.01)

Figure 5: Summary of Findings in 6 Ordinal Logistic Regression Models

Table 19: Results of Logistic Regression Models

Proposition #	DV: Effect of CI (6 Models)	IV: CK Present	Estimate	Standard Error	Wald Chi-Square	Odds Ratio	95% Confidence Interval of Odds Ratio 2.50%	97.50%
12a	Info Quality	Predetermined Content	0.72	0.48	2.236 (0.1349)	2.06	0.80	5.34
13	Info Quality	Emergent Content	1.25	0.47	7.109 (0.0077) ***	3.48	1.39	8.70
20 (part 1)	Info Quality	Media-Fit Based Method	0.56	0.33	2.898 (0.0887) *	1.75	0.92	3.34
1a	Person Selection	Role	2.67	0.48	30.747 (<.0001) ***	14.44	5.62	37.09
2a	Person Selection	Assignment	4.55	0.52	77.936 (<.0001) ***	94.44	34.41	259.22
3	Person Selection	Individual	4.44	0.67	43.532 (<.0001) ***	85.05	22.72	318.36
8a	Timeliness	Event Sequence Trigger	-0.07	0.31	0.045 (0.8329)	0.94	0.51	1.73
9	Timeliness	Emergent Trigger	0.63	0.30	4.275 (0.0387) **	1.87	1.03	3.39
20 (part 2)	Timeliness	Media-Fit Based Method	0.85	0.26	10.271 (0.0014) ***	2.33	1.39	3.92
21	Timeliness	Recipient-Tailored Method	0.95	0.54	3.1692 (0.075) *	2.59	0.91	7.41
1b	Cognitive Effort	Role	0.62	0.37	2.8168 (0.0933) *	1.86	0.90	3.83
7	Cognitive Effort	Time Schedule Trigger	2.40	0.55	19.427 (<.0001) ***	11.06	3.80	32.22
8b	Cognitive Effort	Event Sequence Trigger	0.97	0.41	5.618 (0.0178) **	2.65	1.18	5.94
12b	Cognitive Effort	Predetermined Content	-0.58	0.47	1.495 (0.2215)	0.56	0.22	1.42
15	Cognitive Effort	Predetermined Presentation	0.68	0.44	2.418 (0.1199)	1.98	0.84	4.69
19	Cognitive Effort	Predetermined Method	2.34	0.48	24.159 (<.0001) ***	10.42	4.09	26.53
16	Time Spent	Shared Understanding	2.75	0.39	49.897 (<.0001) ***	15.71	7.32	33.73
2b	Follow-Up CIs	Assignment	1.08	0.37	8.555 (0.0034) ***	2.95	1.43	6.10
8b	Follow-Up CIs	Event Sequence Trigger	0.35	0.42	0.701 (0.4026)	1.42	0.63	3.19
12b	Follow-Up CIs	Predetermined Content	0.60	0.43	1.944 (0.1632)	1.82	0.79	4.19
14	Follow-Up CIs	Recipient-Tailored Content	2.13	0.54	15.728(<.0001) ***	8.42	2.94	24.13

* denotes significance <0.1, ** denotes significance <0.05, *** denotes significance<0.01

The shading is meant to visually group the 6 distinct logistic regression models (separated by DV).

Model 1 Results (DV: Information Quality in the Coordination Instance)

We hypothesized that three types of CK would improve the effectiveness of the coordination instance by improving the quality of information, and these were tested via ordinal logistic regression in model 1. The relationship between the presence of CK about *predetermined content* and an improvement in the effectiveness of the coordination instance via the selection of better information is found to be non-significant and the confidence interval of the odds ratio includes 1. Thus, H12a is not supported. H13 is supported, as the relationship between CK about *emergent content* and CI improvements via better information is statistically significant (p=.0077) and the confidence level of the odds ratio does not include 1. The final type of CK that was hypothesized as affecting the selection of better information is CK about *media-fit based method selection* (H20). We find no evidence of this relationship, as the Wald chi-square statistic is not significant (p=.0887) and the confidence interval does span the value of 1.

Model 2 Results (DV: Person Selection (Actor) in the Coordination Instance)

We hypothesized that all three types of CK about actor selection would improve the effectiveness of the coordination instance by enhancing the selection of a better actor with whom to coordinate, and these were tested via ordinal logistic regression in model 2. The presence of CK about *role* (H1a), about *assignment* (H2a), and about the *individual* (H3) are all found to have a significant (p<.001) relationships with an improvement in the effectiveness of the coordination instance by enhancing the selection of a better actor. Further, 1 is not included within any of the confidence intervals of the odds ratio of these three variables. Thus, we find support for H1a, H2a, and H3.

Model 3 Results (DV: Timeliness of the Coordination Instance)

We hypothesized that four types of CK would improve the effectiveness of the coordination instance by improving its timing. The first two are CK types about the trigger of a CI. We hypothesized that the presence of CK about *event sequence triggers* (H8a) would improve the timing of the coordination instance, but this relationship was not supported (p=.8329 and 1 is within the confidence interval) in the ordinal logistic regression in model 3. However, CK about *emergent triggers* (H9) was shown to improve the timing of a CI (p=.0387 and 1 not within confidence interval).

The second two propositions tested in model 3 were related to CK about the method selection. CK about the *media-fit of a selection method* (H20) was found to have a significant effect on the timing of a coordination instance (p=.0014 and 1 not within the confidence interval). We found no evidence that CK about *recipient-tailored method* improves the timing of a coordination instance (H21), as the Wald chi-square statistic is not significant (p=.075), and the confidence interval does span the value of 1.

Model 4 Results (DV: Cognitive Effort Expended by Actors)

We expected several types of CK to improve the efficiency of a coordination instance by reducing the amount of cognitive effort expended by the actors involved. CK about *role* was expected to improve the efficiency in this way (H1b), but we found no evidence of this relationship; the Wald chi-square statistic is not significant (p=.0933), and the confidence interval includes the value of 1. The next two propositions tested in this ordinal logistic regression model were related to CK about triggers. Both CK about *time schedule* triggers (H7) and *event sequence triggers* (H8b) were shown to affect the cognitive effort expended by actors in the coordination instance ($p<.001$ and $p=.0178$, respectively). Neither confidence interval spanned the odds ratio value of 1.

The last three relationships tested in model 4 were CK about predetermined aspects of a coordination instance. No support was found for CK about *predetermined content* (H12b, $p=.2215$) nor *predetermined presentation* (H15, $p=.1199$) improving the efficiency by reducing cognitive effort of the actors. In addition to non-significant Wald chi-square statistics, both confidence intervals also spanned the value of 1. The model did support H20 ($p<.001$ and 1 not in confidence interval), which suggested that *predetermined method selection* will improve efficiency by reducing cognitive effort.

However, it should be noted that these three types of CK (predetermined) are highly correlated (see Appendix F), and multicollinearity may be suppressing some of the effects. In order to test this, we ran model 4 without CK about predetermined method selection as a predictor. In this alternative model, *predetermined presentation* became statistically significant (H15, $p<.0001$). Next, we ran another alternative model, dropping predetermined presentation and predetermined method. In this model, predetermined content selection became statistically significant (H7, $p=.048$). What this seems to suggest, is that predetermined method selection, predetermined content selection, and predetermined presentation all have effects on cognitive effort reduction but due to multicollinearity their individual effects cannot be disentangled.

Model 5 Results (DV: Time Spent by Actors)

We hypothesized that CK about *shared understanding* would improve the efficiency of a coordination instance by decreased the time actors spent on the coordination instance (H16).

Model 5 supports this proposition, as the Wald chi-square statistic is found to be significant (p<.001) and 1 is not within the 95% confidence interval.

Model 6 Results (DV: Follow-Up Coordination Instances)

Four types of CK were hypothesized to affect the efficiency of the coordination instance by reducing the number of subsequent coordination instances that were necessary. Sequential iteration of coordination instances is often expected and necessary (Smith and Eppinger 1997a), however we proposed that some types of coordinating knowledge might shape a coordination instance to avoid some unnecessary follow-up coordination instances. The presence of CK about *assignment* improving this coordination instance effect (H2b) was supported (p=.0034 and 1 not within confidence interval). However, the relationship between CK about *event sequence triggers* and this efficiency improvement (H8b) was not supported (p=.4026 and 1 within confidence interval).

The last two propositions tested in the ordinal logistic regression model 6 pertain to CK types about content selection reducing the number of follow-up coordination instances. The effect of CK about *predetermined content* (H12b) was not supported (p=.1632 and 1 in confidence interval), while the effect of CK about *recipient-based content selection* was supported (p<.001 and 1 not within confidence interval).

Testing Information System Related Propositions

In the previous section we used ordinal logistic regression to test propositions related to if the presence of certain types of CK, in a coordination instance, affected specific performance outcomes of the coordination instance. We created six models, one for each indicator of coordination instance performance, and considered all relevant (proposed to have an effect) coordinating knowledge types as predictors in each model. However, several of our propositions are about the presence of CK embedded in an information system, and, more specifically, about expected differences between situations where CK is embedded in an information system than when it is actively known and used by actors. In order to test this second set of propositions, we rely on comparisons of contingency tables. Specifically, for each proposition, we compare the phi coefficient of a contingency table that examines the relationship in the case of CK embedded in information systems with the phi coefficient of a contingency table that examines the relationship for when CK is actively known and used by the actors. A significant difference in the phi coefficients provides support for the proposition.

A contingency table (also known as a cross tabulation) examines frequency distributions between a set of variables in a table or matrix format (Boslaugh 2012). It is a common method when looking for correlation between two categorical or ordinal variables. This is relevant because it allows us to isolate and study the correlation between a specific type of coordinating knowledge with a trait (e.g., coordinating knowledge about assignment embedded in an information system) and the relationship is has to a specific indicator of performance in a coordination instance (e.g., cognitive effort of the involved actors as a measure of efficiency of a coordination instance). The simplest form is a 2x2 contingency table used when comparing two dichotomous variables; however, most of our contingency tables are 2x3, because our performance variables (types of efficiency and effectiveness) have three possible values.

For example, proposition 5 states: By managing coordinating knowledge about assignment, information systems reduces cognitive effort (i.e., improves cognitive effort efficiency), above and beyond the effect due to coordinating knowledge about assignment simply being present in a situation. Two steps are necessary to test this proposition. First, we need to compare the relationship between assignment CK embedded in an information system and cognitive effort. This step will test the "By managing coordinating knowledge about assignment, information systems reduces cognitive effort" clause. Second, if a relationship is found, we need to compare it to the relationship of CK about assignment not embedded in an information system (i.e., just being known and used by the actors without the help an information system) and cognitive effort. This second step will allow us to determine if "[the relationship observed in step one is] above and beyond the effect due to coordinating knowledge about assignment simply being present in the situation." In other words, if we find evidence of the expected relationship about assignment CK embedded in an information system and cognitive effort, we also want to know if it is a stronger relationship than "normal" assignment CK has with cognitive effort. In order to illustrate our process, we will detail the steps taken to test proposition 5.

Step 1 - Contingency table that examines the relationship in the case of CK embedded in information systems: In

Table 20, we have labeled each interior cell (A, B, C, D, E, and F) and placed the count of coordination instances that match the conditions of that row and column placement. For example, cell C has the frequency of coordination instances where CK about assignment embedded in an information system was not present and there was a reduction in cognitive effort (116 instances). Cell F is the frequency of coordination instances where CK about assignment embedded in an information system was present, and there was a reduction in cognitive effort (6 instances). If there is a strong relationship between CK about assignment embedded in information systems and a reduction of cognitive effort efficiency, we would expect there to be a significant difference between the proportions of the coordination instances found in cell C (assignment CK not embedded in IS) and cell F (assignment CK embedded in IS), as well as cell A (assignment CK not embedded in IS) and cell D (assignment CK embedded in IS). If there is no relationship between the two variables, then the pairs of cells (A, D and B, E and C, F) will have similarly proportioned frequencies.

Table 20: Example Contingency Table about Assignment CK Embedded in an IS

	CI Efficiency: Cognitive Effort, Observed as Harmed (coded as -1)	CI Efficiency: Cognitive Effort, No Change Observed (coded as 0)	CI Efficiency: Cognitive Effort, Observed as Improved (coded as 1)
CK about Assignment Embedded in an Information System Not Found*	**0** **[Cell A]**	**166** **[Cell B]**	**116** **[Cell C]**
CK about Assignment Embedded in an Information System Found	**0** **[Cell D]**	**1** **[Cell E]**	**6** **[Cell F]**

*This includes cases without any assignment CK present and when it is present but not embedded in an information system.

The difference between the proportioned frequencies can be assessed by a variety of statistical tests in order to determine if there is a significant relationship between the two variables. Two of the most common tests are Pearson's chi-squared test and Fisher's exact test. Pearson's chi-squared test (as well as related statistical tests using chi-square distributions) is known to have problems assessing sparse data samples (Kuss 2002). Sparse or asymptotic data occurs when expected counts in some of the cells are very small, which is common in "lop-sided" data or small sample sizes. Much of our data sets used in this set of analyses fall into this category. Table 14 shows the frequency of coordination instances where specific types of coordinating knowledge were observed as embedded in an information system, compared with coordination instances where the same type of coordinating knowledge was observed as being known and used by actors. In general, CK types observed embedded in an information system are small in number, so contingency tables using those variables are especially sensitive to chi-square tests. Fisher's Exact Test is a nonparametric test that is suggested for use in sparse data situations (Boslaugh 2012), so we use this test to determine if a statistically significant relationship between the variables is present. For Table 20, Fisher's Exact Test statistic (two-sided) is 0.045, suggesting that there is a significant relationship between the two variables, as $p<0.05$.

We use Fisher's Exact Test as a preferred test of significance of the relationship within a single contingency table, in these situations of sparse data, but we must utilize the phi coefficient in order to compare two contingency tables. The phi coefficient describes the correlation between the two variables in our contingency tables and can be used to statistically compare correlation strength between tables (necessary in Step 2). This product moment correlation should be interpreted similarly to the more commonly seen Pearson correlation coefficient, as it is a simplification of the same calculation (Cohen et al. 2003). One key difference of note is that the range of the phi coefficient is dependent on the distribution of the two variables, and therefore almost always smaller than -1 to 1 (Davenport and El-Sanhurry 1991). Zero is still indicative of no relationship between the two variables. Effect sizes of the phi coefficient are usually accepted to be small=0.1, medium=0.3, and large=0.5 or greater (Cohen 1992; Volker 2006). For the contingency table show in Table 20 the phi coefficient is 0.138, which is considered a small effect size.

Step 2 – Comparison of Contingency Tables to Test Proposition: This contingency table and analysis completes the first step in testing proposition 5, but now we need to compare this detected relationship about assignment CK embedded in an information system and assignment

CK not embedded in an information system (i.e., the assignment CK known and used by actors without the aid of an information system). In order to do this, we create a second contingency table that excludes the cases where assignment CK is embedded in an information system. The resulting contingency table measures the relationship between the presence of assignment CK (held by actors and not embedded in an information system) and cognitive effort. This contingency table is shown in Table 21.

Table 21: Example Contingency Table about Assignment CK Known by Actors

	CI Efficiency: Cognitive Effort, Observed as Harmed (coded as -1)	CI Efficiency: Cognitive Effort, No Change Observed (coded as 0)	CI Efficiency: Cognitive Effort, Observed as Improved (coded as 1)
CK about Assignment Known by Actors Not Found*	**0** **[Cell A]**	**105** **[Cell B]**	**100** **[Cell C]**
CK about Assignment Known by Actors Found*	**0** **[Cell D]**	**58** **[Cell E]**	**22** **[Cell F]**

*Categories by CK being known by actors, and not being embedded in an information system.

The Fisher's Exact Test and the phi coefficient for Table 21 are 0.001 and -0.1933 respectively, indicating that there is a statistically significant relationship between the two variables, but that it is an inverse relationship of small effect size.

However, we need a way to statistically compare the two relationships (i.e., these two different contingency tables) in order to fully test our proposition. A higher phi coefficient indicates a stronger effect; and we calculate the z-test statistic to assess the significance of the difference between the two phi coefficients. The phi coefficient of the first contingency table is 0.138, and -0.1933 for the second. The z-test statistic between these two phi coefficients is 3.97

($p < .001$), so we find support for proposition 5. This result and our other information systems propositions are summarized below.

Contingency Table Results Related to CK about Actor Selection (WHO)

We hypothesized that CK related to role (H4) and assignment (H5) embedded in an information system would improve the efficiency of a coordination instance by reducing cognitive effort, to a greater effect than situations where the CK was present (known by actors) but not embedded in an information system. Unfortunately, only one coordination instance was observed to have CK about the role of an actor embedded in an information system, so we are unable to test H4. In order to test H5 we first examine the contingency table between the presence of CK about assignment embedded in an information system and observed performance improvements of reduced cognitive effort. The relationship is significant according to Fisher's Exact test ($p=.045$) and the phi coefficient is 0.138. Next we examine a similar contingency table; one between the presence of CK about assignment not embedded in an information system (i.e., present due to being known and utilized by the actors) and CI improvements of reduced cognitive effort. While the Fisher's Exact Test suggests a relationship between these two variables as well ($P=.001$), the relationship is in the opposite direction (phi coefficient is -.1933), indicating that CK about assignment not embedded in an information system may actually harm the efficiency of a coordination instance by demanding additional cognitive effort by the actors. These findings are summarized in Table 22, and we find support for H5.

Table 22: Contingency Table Results - Testing Proposition 5

Contingency Table Studied	P-Value of Fisher's Exact Test (two-sided)	Phi Coefficient	Z-test statistic between the two phi coefficients
Assignment CK Embedded in Information Systems x Reduction of Cognitive Effort (Efficiency)	.045	.138	3.97 (p < .001)
Assignment CK Present but not Embedded in Information Systems x Reduction of Cognitive Effort (Efficiency)	.001	-.1933	

H6 suggests that the presence of CK about role or assignment embedded in an information system will inhibit the use of CK about individuals. We do not have enough instances of CK about role embedded in an information system to test that part of the proposition, but we can partially test the proposition by considering the effects of CK about assignment embedded in an information system on the presence of CK about individuals. The results of this contingency table do not suggest a statistically statistical relationship between these two variables (Fisher's Exact Test not significant), so this proposition is not supported. However, it may be that the small occurrences of both the presence of CK about assignment embedded in an information system (7 cases) and the CK about individuals (35 cases) limited our ability to detect this relationship. H6 is not supported due to a failed Fisher's Exact Test, however for comparison we also show the contingency table results of CK about assignment not embedded in an information system and the presence of CK about individual. These results do not suffer from the severe sparse data problem as the embedded in an information system contingency table, and indicate that the negative relationship may exist even without the circumstance of being embedded in an information system.

Table 23: Contingency Table Results - Testing Proposition 6

Contingency Table Studied	P-Value of Fisher's Exact Test (two-sided)	Phi Coefficient	Z-test statistic between the two phi coefficients
Assignment CK Embedded in Information Systems x Individual CK (any form)	.603	-.06	1.82 (p < .069)
Assignment CK Present but not Embedded in Information Systems x Individual CK (any form)	<.001	-.21	

Contingency Table Results Related to CK about Triggers (WHEN)

We hypothesized that CK related to time schedule triggers (H10) and event sequence triggers (H11) embedded in an information system would improve the efficiency of a coordination instance by reducing cognitive effort and time spent on coordination instances, to a greater extent than situations where the CK was present (known by actors) but not embedded in an information system. Unfortunately, no coordination instances were observed to have CK about time schedule triggers embedded in the information systems, so we are unable to test H10. In order to test H11 we first examine the contingency table between the presence of CK about event sequence triggers embedded in an information system and observed performance improvements of (1) reduced cognitive effort and (2) reduced time spent. Both of these relationships are significant according to Fisher's Exact test (p=.0212 and p=.009, respectively) and the phi coefficients suggest small effect sizes are present (.1433 and .1695, respectively).

However, we only find partial support for H11 when we compare these results to contingency tables of the presence of CK about event sequence triggers not embedded in an information system versus these two efficiency gains. In the case of a reduction of cognitive effort, there is a larger correlation between the CK not embedded in an information system (opposite effect size direction than hypothesized) than when it is embedded in an information system (0.236 vs. 0.1433), although this difference is not found to be significantly different (z test statistic, p=.2543). In the case of efficiency gains reflected in less time spent on the coordination instance by actors, we find a non-significant correlation (Fisher's Exact Test Statistic p=.2281) with CK about event sequenced triggers not embedded in an information system. Therefore, we conclude that regarding efficiency gains related to a reduction in time spent on the coordination instance, a small effect exists when CK about event sequence triggers is embedded in an information system, but no association exists with CK about event sequence triggers not embedded in an information system.

Table 24: Contingency Table Results - Testing Proposition 11

<table>
<tr><td>Contingency Table Studied</td><td>P-Value of Fisher's Exact Test (two-sided)</td><td>Phi Coefficient</td><td>Z-test statistic between the two phi coefficients</td></tr>
<tr><td>Event sequence Trigger CK Embedded in Information Systems x Reduction of Cognitive Effort (Efficiency)</td><td>.0212</td><td>.1433</td><td rowspan="2">-1.14 (p=.2543)</td></tr>
<tr><td>Event sequence Trigger CK Present but not Embedded in Information Systems x Reduction of Cognitive Effort (Efficiency)</td><td><.001</td><td>.236</td></tr>
<tr><td>Event sequence Trigger CK Embedded in Information Systems x Reduction of Time Spent (Efficiency)</td><td>.009</td><td>.1695</td><td rowspan="2">N/A (second table fails Fisher's Exact Test)</td></tr>
<tr><td>Event sequence Trigger CK Present but not Embedded in Information Systems x Time Spent Effort (Efficiency)</td><td>.2281</td><td>.0985</td></tr>
</table>

Contingency Table Results Related to CK about Content (WHAT)

We expected CK about predetermined content selection to improve aspects of both efficiency and effectiveness when embedded in an information system. Specifically we first hypothesized (H17a) that this CK, when embedded in an information system, would enhance the effectiveness of a coordination instance by improving the information, and that this effect would be stronger than those of the CK being present but not embedded in an information system. However, the contingency tables that tested these associations failed to show statistically significant associations (see Table 25, failed Fisher's Exact Tests). Therefore H17a is not supported, but this is consistent with the failure to observe a relationship between CK about predetermined content (of any type) and an improvement in information quality (H12a).

Second, we hypothesized that predetermined content selection, when embedded in an information system, would improve efficiency by reducing the cognitive effort and time spent on a coordination instance, and that these effects would be stronger than when the CK type was not embedded in an information system. The related contingency tables (Table 25) show support for the association between CK about predetermined content selection and both types of efficiency improvements, regardless of whether or not the CK was embedded in an information system or not. The phi coefficients are slightly higher for the tables that study the CK embedded in an information system (0.3414 vs. 0.3192 and 0.1744 vs. 0.183), however the pairs of coefficients are not statistically different (see Z-test statistics). Therefore, while the relative sizes of the phi-coefficients align with H17b, we do not find statistical support.

Table 25: Contingency Table Results - Testing Proposition 17 (a&b)

Contingency Table Studied	P-Value of Fisher's Exact Test (two-sided)	Phi Coefficient	Z-test statistic between the two phi coefficients
Predetermined Content Selection CK Embedded in Information Systems x Better Info (Effectiveness)	.5233	.0682	N/A (both tables fail Fisher's Exact Test)
Predetermined Content Selection CK Present but not Embedded in Information Systems x Better Info (Effectiveness)	.4896	.0747	
Predetermined Content Selection CK Embedded in Information Systems x Reduction in Cognitive Effort (Efficiency)	<.001	.3417	0.3 (p=.7642)
Predetermined Content Selection CK Present but not Embedded in Information Systems x Reduction in Cognitive Effort (Efficiency)	<.001	.3192	
Predetermined Content Selection CK Embedded in Information Systems x Reduction in Time Spent (Efficiency)	.0155	.1744	-0.11 (p=.9124)
Predetermined Content Selection CK Present but not Embedded in Information Systems x Reduction in Time Spent (Efficiency)	.0085	.183	

Finally, we consider our information systems proposition surrounding predetermined content presentation. We hypothesized that if information systems embedded CK about predetermined content presentation it could improve the efficiency of the coordination instance by reducing the cognitive effort and time spent (H18). The association between CK about predetermined content presentation and a reduction in cognitive effort is supported, for both situations where the CK is embedded in an information system and not (Fisher's Exact Test, $p<.001$ in both cases), and both show medium effect sizes (phi coefficients of .3553 and .3212). Although the phi coefficient is larger for the situations where the CK is embedded in an information system, as hypothesized, the two values are not statistically significantly different (see Z-test statistic). When considering the association between CK about predetermined content presentation (embedded in an information system and not) and a reduction of time spent on the coordination instance, we see that neither contingency table is statistically significant (Fisher's Exact Test) at the $p<.05$ level. Therefore, we do not find support for H18.

Table 26: Contingency Table Results - Testing Proposition 18

Contingency Table Studied	P-Value of Fisher's Exact Test (two-sided)	Phi Coefficient	Z-test statistic between the two phi coefficients
CK10T (content presentation CK embedded in tech) x EN4 (Reduction in Cog Effort)	<.001	.3553	.46 (p=.6455)
CK10NT (content presentation CK known by actors) x EN4 (Reduction in Cog Effort)	<.001	.3212	
CK10T (content presentation CK embedded in tech) x EN5 (Less Time Spent)	.0909	.131	N/A (both tables fail Fisher's Exact Tests)
CK10NT (content presentation CK known by actors) x EN5 (Less Time Spent)	.1941	.1156	

Post-Hoc Analyses

Separation of Models Based on the Score Test for the Proportional Odds Assumption - We created six ordinal logistic regression models in order to test our propositions related to the presence of a type of CK contributing to performance improvements. The dependent variable in each of these models was a specific type of efficiency or effectiveness improvement. Each coordination instance was coded along each of the six possible DVs as having either: an improvement in that aspect of performance (coded as 1), no obvious improvement regarding that aspect of performance (coded as 0), or a reduction of performance in that aspect of performance (coded as -1). Although observations that identified a reduction in performance were much rarer than the other two situations, we included these coordination instances in the ordinal logistic regression to explore our proposed relationships. This decision carries with it the assumption that the relationship between the predictors (i.e., presence of the CK types) and the DV (i.e., performance change) is the same across the different level changes (also known as cut-points) (Brant 1990; Scott et al. 1997). Said plainly, we assumed that if the presence of a CK type caused a performance gain, it was just as likely to neutralize a bad situation (the cut-point between -1 and 0 codes) as improve a neutral situation (the cut-point between 0 and 1 codes).

In order to verify this is the case, we conducted the score test for proportional odds tests to see if these two cut-points are behaving with similar proportional odds. In four of our models (2, 3, 4, and 5) this test was significant, which suggests the assumption is not met (Cohen et al. 2003). Not meeting this assumption implies there may be two fundamentally different binomial logistic regression models for these performance improvement types, one at each cut-point. In other words, the *presence of certain CK types* might make a specific aspect of a coordination instance worse (more likely to be coded as -1 than a 0); and this set might differ from the set of *CK types whose presence improves* a specific aspect of a coordination instance (more likely to be coded as a 1 than a 0).

For example, model 2 is an ordinal logistic regression testing the hypothesized effects of three types of CK (role, assignment, and individual) on the effectiveness of a coordination instance via selecting a better person with whom to coordinate. These original results are shown in column one of Table 27. In order to explore the underlying set of binomial logistic regression models, all of the coordination instances that had the better person effect coded as -1 or 0 were pulled out and a binomial logistic regression model was run with this data set on the dichotomous DV (better person: -1 or 0). This model explores if the presence of these types of

CK (role, assignment, and individual) affect the chances of a coordination instance having a reduction in this type of performance (i.e., the coordination instance was harmed by having a worse person selected) or a neutral state (no reduction or improvement was observed regarding the selection of a person). These results are shown in column two, and we see that none of these types of CK have a significant effect on the odds of a coordination instance having harmed performance regarding person selection versus a neutral one. Next, we separated the coordination instances that had the better person effect coded as a 0 or 1 and ran a binomial logistic regression model on that data set, with the DV being the alternative dichotomous set. This explores the effect these three types of CK have on improving the selection of a person (coded as 1) versus a neutral observation regarding the selection of a person (coded as a 0). We see in column three that all three types of CK significantly improve the odds of an improvement over a neutral performance observation regarding selection of the actor with whom to coordinate. These findings further suggest that, in the case of our original model 2, our results are likely due to the strong effect that the CK has in improving performance (0->1 value) and hides the non-significant effects that the CK has regarding the reduction (or lack of reduction) of performance (-1->0).

Model 3 explores the effects that CK about event sequence triggers, emergent triggers, media-fit based method selection, and recipient-tailored method selection might improve a coordination instance by improving the timing of the instance. Column 1 in Table 27 shows the original results of the model, where we found support that the latter three of this set of CK types improves the timing of a coordination instance (H6, H13, and H14). However, when we explore the two binomial regression models in the same manner as described above, we see that only CK about emergent triggers is relevant when considering negative or harmed results regarding timing of a coordination instance. Further, the relationship is *reversed,* and if CK about emergent triggers is present there are increased odds that a coordination instance is less effective due to harmed or worsened timing. In the third model column, H6 reveals that the hypothesized relationship is supported in the data set focusing on improved coordination instances, and that the duality of the relationship behavior between the two cut-points was masked in our original ordinal regression model.

Model 4 looks at CK types suspected of improving the efficiency of a coordination instance by decreasing the cognitive effort of actors involved in the instance. The additional binomial regression models in columns 2 and 3 show an interesting insight into the relationship that CK about predetermined presentation affects this type efficiency. Like H6 discussed above, this post-hoc analysis around H10 shows a very different relationship of the CK when considering the differences between harmed and neutral coordination instances than between neutral and improved coordination instances. The presence of CK about predetermined presentation increases the likelihood of a harmed coordination instance (negative estimate shown in column 2) and the likelihood of an improved one (positive estimate shown in column 3). Further, the complex duality of this relationship confounded our findings in the original ordinal regression model, which suggested no relationships between this CK and an improvement of efficiency due to reduced cognitive effort.

Table 27: Results of Splitting Models into Two Binomial Logistic Regressions

			Original Ordinal Regression Model Results: All data, treated as ordinal data (-1, 0, 1 codes)				Binomial Regression Model Results (Exploring Harmed CIs): Only using data with relevant DV coded as -1 or 0				Binomial Regression Model Results (Exploring Improved CIs): Only using data with relevant DV coded as 0 or 1			
Hyp #	DV	IV	Estimate	Wald Chi-Square	Pr > Chi-Square		Estimate	Wald Chi-Square	Pr > Chi-Square		Estimate	Wald Chi-Square	Pr > Chi-Square	
1	Right Person	Role	2.6697	30.7465	<.0001	***	12.2737	0.0025	0.9604		3.1283	24.4187	<.0001	***
2	Right Person	Assignment	4.548	77.9362	<.0001	***	-0.6174	0.5298	0.4667		5.2114	61.5187	<.0001	***
3	Right Person	Individual	4.4433	43.5322	<.0001	***	-1.3106	1.1688	0.2796		5.2447	38.8616	<.0001	***
5	Right Time	Event Sequence Trigger	-0.0664	0.0445	0.8329		0.6157	0.4383	0.508		-0.0738	0.0504	0.8224	
6	Right Time	Emergent Trigger	0.6261	4.2754	0.0387	**	-1.7528	3.6084	0.0575	*	0.8185	6.8498	0.0089	***
13	Right Time	Media-Fit Based Method	0.8472	10.2705	0.0014	***	12.8501	0.0037	0.9516		0.672	6.1138	0.0134	**
14	Right Time	Recipient-Tailored Method	0.9532	3.1692	0.075	*	11.7141	0.0005	0.9818		0.9096	2.8515	0.0913	*
1	Cog Effort	Role	0.6198	2.8168	0.0933	*	9.1409	0.0033	0.9542		0.6284	2.517	0.1126	
4	Cog Effort	Time Schedule Trigger	2.4037	19.4274	<.0001	***	-2.1416	1.5728	0.2098		2.6604	20.4553	<.0001	***
5	Cog Effort	Event Sequence Trigger	0.9749	5.6175	0.0178	**	1.9369	1.3819	0.2398		0.9279	4.3858	0.0362	**
7	Cog Effort	Predetermined Content	-0.5796	1.4946	0.2215		-1.2212	0.4684	0.4937		-0.5182	0.9868	0.3205	
10	Cog Effort	Predetermined Presentation	0.6833	2.4181	0.1199		-4.8206	7.1088	0.0077	***	1.0615	5.3253	0.021	**
12	Cog Effort	Predetermined Method	2.3436	24.1587	<.0001	***	2.2889	1.6427	0.2		2.2935	20.8735	<.0001	***
11	Time Spent	Shared Understanding	2.7541	49.8965	<.0001	***	-1.8036	4.2042	0.0403	**	3.0325	48.8701	<.0001	***

Exploratory Factor Analysis - The relationships between CK types and effects on coordination instances were theorized about independently. In order to test these propositions, we created logistic regression models and contingency tables to explore these relationships. However, it is likely that there are common combinations of CK types present (i.e., portfolios of CK types) and that interactions between them occur. In order to start to explore these possibilities we use exploratory factor analysis in order to identify these common combinations of CK types and look for trends in how they affect coordination instances[5].

Common factor analysis is a technique commonly used to describe variability among measured variables in terms of a lower number of unobserved variables, or latent factors. It is often used in scale development and testing to lend credibility that like items are measuring the intended underlying constructs (Netemeyer et al. 2003), but it is also an appropriate technique for finding latent factors in a set of data (Velicer and Jackson 1990). In order to determine the correct number of factors to consider, we examined the eigenvalues of the correlation matrix and scree plot. Using an eigenvalue cut-off point of 1 (Kaiser 1960), five factors emerged from the 14 CK type items.

We utilized Harris-Kaiser independent cluster rotation technique in order to achieve optimally simple factor results. This is an oblique rotation technique that uses a combination of the pattern and the weights matrix of the individual components (Harris and Kaiser 1964). A benefit of the technique is that it yields both a simple pattern and a simple weights matrix, so that the interpretation on the basis of the pattern coincides with the interpretation on the basis of the weights matrix (Kiers and Tenberge 1994). For oblique factor solutions, such as the Harris-

[5] There is a bit of a debate about whether it is appropriate to use principal component analysis techniques on binary data sets. A commonly stated concern is that binary data will produce too many factors. However, we believe there is face validity to the five factors that emerge from our data set through traditional cut-off techniques. Therefore, we agree with Jolliffe (2002) that when PCA is used as a descriptive technique, binary data can be used without undue concern.

Kaiser independent cluster rotation technique, the factor structure correlation results (Table 28) allow us to examine the correlations between the variables and the factors.

Table 28: Factor Structure Results

Factor Structure (Correlations) Using Harris-Kaiser Rotation					
Coordinating Knowledge About…	**Factor1**	**Factor2**	**Factor3**	**Factor4**	**Factor5**
Predetermined Method	-0.87	0.47	0	0.39	-0.29
Predetermined Presentation	-0.77	0.49	0.07	0.13	-0.2
Predetermined Content	-0.69	0.78	-0.1	0.27	-0.21
Time Scheduled Triggers	-0.34	-0.17	0.09	0.77	0.05
Event Sequence Triggers	-0.34	0.88	-0.13	-0.03	-0.05
Shared Understanding	0.01	0.12	-0.01	0.77	-0.09
Recipient-Tailored Method	0.11	0.09	0.21	-0.06	0.76
Recipient-Tailored Content	0.14	-0.24	-0.16	0	0.73
Individual	0.2	-0.2	-0.57	-0.04	0.17
Assignment	0.23	-0.26	0.84	-0.01	0.16
Role	0.35	0.19	-0.61	-0.06	0.09
Emergent Triggers	0.39	-0.64	0.13	-0.46	-0.04
Emergent Content	0.6	-0.66	0.15	0.11	0.05
Media-Fit-based Selection	0.78	-0.34	0.19	-0.01	0.03

Note: Correlation values smaller than -0.30 have been highlighted in red and correlation values greater than 0.30 have been highlighted in green in order to visually enhance the pattern.

Each column of correlations under the five factors can be examined to see how the presence of the 14 CK types is related to each factor. As this is an exploratory exercise, we want to be inclusive in the relationships we explore. We selected a correlation value of +/- 0.30 as a cut-off point of correlations to consider in our discussion, as this has been associated with medium effect size in social science research (Cohen 1992).

Factor 1 is associated with coordination instances that have CK about roles, emergent triggers, emergent content selection, and media-fit based selection. Further, there is a notable absence (negative correlation) of CK about time scheduled or event sequenced triggers and predetermined content selection, content presentation, or method selection. We refer to factor 1 as “*Emergent CK Group*.”

Factor 2 is associated with CK about event sequence triggers and predetermined content selection, content presentation, and method selection, while being negatively associated with emergent CK about triggers and content or media-fit-based selection. We refer to factor 2 as "*Routinized CK Group*."

Factor 3 seems exclusively categorized by relationships regarding CK about actor selection, specifically highly correlated with CK about assignment while being negatively correlated to the other two types. We refer to factor 3 as "*Assignment CK*."

Factor 4 is associated with CK about time scheduled triggers, shared understanding, and predetermined method selection, while being negatively associated with CK about emergent triggers. We will expound on this in Chapter 6, but we suspect this portfolio of CKs is especially common in routinely occurring meetings, and refer to this factor as "*Meeting CK Group*."

Finally, factor 5 is associated with CK about recipient-tailored content selection and recipient-tailored method selection. We refer to this as the "*Tailored to Recipient CK Group*"

In order to study the relationship between these 5 factors, or sets of CK, and the performance effects of the coordination instances, we performed a correlation analysis between the factor values and the six possible performance improvements. This calculation is seen in Table 29.

Table 29: Correlations between Latent Factors and CI Effects

Pearson Correlation Coefficients Between Factors and CI Effects						
Factors…	**Info Quality**	**Person Selection**	**Timeliness**	**Cognitive Effort**	**Time Spent**	**Follow-Up CIs**
Emergent CK Group	0.128**	0.370***	0.265***	-0.539***	-0.090	0.036
Routinized CK Group	-0.088	-0.179***	-0.149**	0.323***	0.148**	0.016
Assignment CK	0.006	0.130**	0.150**	-0.015	-0.063	0.061
Meeting CK Group	0.128**	0.048	-0.085	0.333***	0.412***	0.132**
Tailored to Recipient CK Group	-0.007	0.185***	-0.003	-0.097	-0.060	0.269***

Note: ***denotes significance at the 0.01 level or less; ** denotes significance at the 0.05 level or less

The Emergent CK Group is associated with all three types of effectiveness improvements (better info selected, better actor with whom to coordinate selected, and better timing of the instance), but using an increased amount of cognitive effort needed by the involved actors. The Routinized CK Group had nearly opposite effects, as it was associated with two efficiency gains (less cognitive effort and less time spent on the coordination instance), but a decrease in the quality of actor being selected and of the timing of the instance. The third factor, which was associated with CK about assignment, was correlated with improvements to actor selection and timing. The Meeting CK Group is associated with all three types of efficiency gains (less cognitive effort spent, less time spent, and fewer follow-up instances needed), as well as an improvement of information quality. Finally, the Tailored to Recipient CK Group is correlated with better actor selection and fewer follow-up instances needed.

In the next section, we discuss the broader implications of these data analyses and results, expound on the limitations of the study, and explore future research and implications of the work.

CHAPTER 6: CONCLUSIONS AND FUTURE RESEARCH

Many modern organizations rely heavily on their employees coordinating information among each other in order to accomplish their goals (Argote 1982; Malhotra et al. 2005; Malone and Crowston 1994; Okhuysen and Bechky 2009; Rico et al. 2008; Willem et al. 2006), and this is especially true in the healthcare arena (Faraj and Xiao 2006; Gittell 2002). Information systems play a key role in how people coordinate (Argyres 1999; Goh et al. 2011). This dissertation extends work in the coordination area by explaining how people coordinate, by using the newly developed coordinating knowledge framework. In order to address previous gaps in the literature, we first recognized that coordination is a series of coordination instances. Next, we developed a framework around the meta-knowledge necessary in order to perform a coordination instance, called *coordinating knowledge*. Through a literature review, we recognized four sources of coordinating knowledge, which individuals drew upon in order to develop this meta-knowledge. We identified 14 specific types of coordinating knowledge, and theorized about the effects they each had on the performance of a coordination instance. Further, we used this new framework to better understand how information systems could affect coordination by embedding or enhancing coordinating knowledge in the information system. Through qualitative data gathering and quantitative data analysis methods, we found preliminary evidence of our coordinating knowledge ideas.

Limitations

Like all studies, this dissertation is not without limitations. Our introduction of the coordinating knowledge framework and our micro-level study of a coordination instance is novel and we believe opens many doors to coordination research. Like many nascent ideas, it is difficult to study. Our data collection and statistical analysis gives us preliminary evidence that coordinating knowledge is an important facet of coordination and most of our proposed propositions found some support in our coded data set.

We chose to investigate coordinating knowledge in a hospital context, specifically ICU and ED areas, because the environment is fast-paced and dynamic. Coordination is not only fundamental to providing healthcare to patients as diverse teams of experts weave in and out of patient cases and pass information back and forth, but it is relatively visible to an outsider observing the situation and it happens constantly, allowing a researcher to note many coordination instances per hour, in a variety of circumstances. However, one limitation of our work is that the data collection is limited to one industry, and more specifically one hospital located in the United States. How well our findings and ideas generalize to other arenas will need to be explored by future work.

The nature of coordinating knowledge means that our study often examines how people know to do what they do. This is a challenging notion to decipher, capture, and quantify. Field studies are especially well suited for nascent ideas, such as this (Edmondson and McManus 2007), but present challenges regarding their ability to isolate the cause of specific behaviors (McGrath 1981). We used a variety of methods during our field study, which included observation, examination of documents and technology outputs, and talking to healthcare professionals directly after a coordination instance occurred. We believe, in general, this yielded convincing initial evidence of coordinating knowledge and how it affects the performance of coordination instances. However, as often people may not even be fully aware of why they do what they do (and how they know to do it), we recognize the limitations inherent in our methodology choices. Further, the data set analyzed in this dissertation was coded by the author and major professor, both of whom had knowledge of the propositions developed a priori. Although every precaution was taken to faithfully code the data instances seen during the data collection, there remains a possibility that the coding decisions were made with unconscious bias of confirming the propositions. The data will be independently coded by a third-party, blind to the propositions, in order to rule-out any bias.

We will discuss how the nuances of the hospital environment may have affected our observations of individual types of coordinating knowledge in the following discussion section. However, it is worth discussing the very small frequencies of observations around recipient-tailored content and recipient-tailored method, as seen in Table 14. Both of these types of coordinating knowledge are related to knowing and anticipating coordination needs due to being familiar with a team member's behaviors and preferences. Due to the nature of this implicit and often unspoken nature of these types of coordinating knowledge, we believe a limitation of our study is the ability to detect these types of coordinating knowledge. While we have several instances that provide us with some evidence that they exist and are important in certain coordination circumstances, future research may need to study these pieces of the puzzle in a different manner.

The role of information systems is very complex in the coordination processes of healthcare. Government regulations (e.g., HIPPA) guide documentation behaviors and information system uses. Hospitals invest a lot of time and money in electronic medical record solutions, and the switching costs are very high. These electronic medical record solutions represent a large percentage of the information systems used in a hospital setting, and there is little variation between instances involving a component. By limiting this study to one hospital, we also limited our exposure to many different types and designs of electronic medical records. There were, primarily, two electronic medical record solutions involved in our study (the ICU department used a different system than the ED). Future work would benefit from exploring a variety of information systems solutions, to increase variation in the way CK is embedded in an information system.

Finally, our decision to study coordination at the micro-level carries with it limitations. We chose to study the effectiveness and efficiency impacts of individual coordination instances, instead of broader performance variables (e.g., patient outcome). We did this purposely in order to better understand our novel unit of analysis, the coordination instance. We believe there are two related limitations involved in our selection and coding of indicators of efficiency or effectiveness of a coordination instance. One difficult challenge is identifying performance improvements of these coordination instances when studied in isolation. It is a challenge to identify if there is an improvement or harming effect regarding an indicator of efficiency or effectiveness (e.g., recognizing that there has been an improvement in the quality of information or a decrease in the amount of cognitive effort the actors spent). To address this, we relied on observer opinion and discussions with the healthcare professionals after the events took place, but since this is a field study it is impossible to have an objective baseline to compare each coordination instance. In the end, the coding of our DVs was a subjective matter, and one that should be considered a limitation. The second limitation is that we do not address the link between the performance of individual coordination instances and holistic coordination process outcomes. Future research would benefit from exploring this relationship in a multi-level study.

Discussion

During our theoretical development of coordinating knowledge, we introduced a framework of 14 specific types of coordinating knowledge. Our analysis of the 289 coordinating incidents provides support for the existence of all 14 types of coordinating knowledge. Via qualitative analysis, pattern matching, and statistical analysis we tested the propositions we developed in the study about the relationship of the various CK types and effectiveness or efficiency of a coordination instance. Although we did not find statistical support for all of them, and some combinations of coordinating knowledge were not observed in our context, we found no evidence that contradicts our coordinating knowledge framework.

We proposed three types of coordinating knowledge related to actor selection: role, assignment, and individual. Our research found evidence that all three existed in the hospital context, and our proposed affects about improvements to the coordination instances were generally supported. There were very few instances recorded where coordinating knowledge about assignment or role were embedded in an information system, which limited our ability to test our proposed propositions and likely made it difficult to detect relationships.

We proposed three types of coordinating knowledge related to knowing when to engage in (trigger) a coordination instance. While support was found for most of the relationships theorized around these types of coordinating knowledge, we found no support for the two parts of proposition 8, specifically that event sequence triggers would increase the effectiveness of the coordination instance by delivering the information in a timelier manner and would increase the efficiency by reducing the number of sequential, follow-up coordination instances. We did not take into consideration poorly designed business processes that trigger coordination instances, so it is possible that our data contains event sequence triggers being used that do not occur at an ideal time in the sequence of events. It is also possible that our data collection methods were unable to detect improvements in the timing of coordination instances. When considering our information system propositions we were only able to test the one related to event sequence triggers. We did not observe any cases where information systems assumed coordinating knowledge about time scheduled triggers. We found partial support for our expected efficiency improvements when embedding event sequence triggers inside information systems.

There were five types of coordinating knowledge related to content selection and presentation proposed, and support was found for the relationships involving emergent content selection, recipient-tailored content selection, and shared understanding around the presentation of content. However, no support was found for the theorized relationships around predetermined content selection and predetermined content presentation. Situations that involve these two types of coordination often involve information systems, specifically electronic medical records. Many of these observed coordination instances were actors interacting with the electronic medical record software, as it prompted for predetermined content or delivered predetermined content and presentation. In fact, it was very common for the software to provide a very structured coordination mechanism that involved predetermined content, presentation, and method selection all at the same time. Therefore, we find that these three variables were highly correlated (see Appendix E) and there is evidence that multicollinearity may have caused the suppression of statistically significant relationships of predetermined content and presentation (see Model 4 Results for more detail). Another possible explanation that emerged from many conversations with healthcare professionals is that the electronic medical record software was flawed and difficult to use. Therefore, the lack of support of those propositions may also be related to poorly designed information systems, perhaps involving incorporation of flawed coordinating knowledge. To simplify the scope of the study, we made the assumption that all coordinating knowledge was correct, but this is likely evidence that is not the case and should be considered when studying coordinating knowledge, especially those embedded in an information system.

We identified three types of coordinating knowledge that informs the method selection of a coordination instance. All three were supported in our analyses. No additional information systems propositions were developed, as the method selection, by its nature, may involve technologies in the coordination instance.

Tables 16 and 17 show us the supported relationships from our tested propositions, in order to consider patterns of our theorizing and data findings. Two types of coordinating knowledge that had no impact on the indicators of coordination instance performance were predetermined content selection and predetermined content presentation. We believe that the theorized relationships are still likely to exist, but that these types of coordinating knowledge are also likely to be embedded in an information system solutions. Our experience indicates that this is a complex relationship, and that flawed coordinating knowledge and poorly designed information systems can harm coordination instance performance. We discuss some ideas of how to address this in the future research section, but a pattern of our results is that in our limited research context, we did not find the effects of these predetermined types of coordinating knowledge.

Another pattern that emerges is that it is rare for a specific type of coordinating knowledge to improve both an indicator of effectiveness and one of efficiency. Previous work in coordination has noted the complicated relationship between effectiveness of coordination and uncertainty in the environment (Argote 1982). It stands to reason that coordinating knowledge that leads to efficiency often exists in standardized situations (e.g., predetermined content or time-scheduled triggers derived from routinized coordination mechanisms), and that these are different types of coordinating knowledge than those that lead to effectiveness in emergent and unpredicted (i.e., uncertain) situations. The exception to this pattern was found within the types of coordinating knowledge that guide the selection of an actor, specifically role and assignment. So, in general, coordinating knowledge that guides selection of an actor has the potential to improve the effectiveness of a coordination instance (selecting a more appropriate person), but also improving efficiency. However, all other types of coordinating knowledge saw improvements to usually only one indicator, but always to one category of indicators (improvements to effectiveness or improvements to efficiency). We see further evidence of a possible tension between effectiveness and efficiency improvements in our post-hoc analysis discussed in the next section.

Finally, few of our information systems propositions were fully supported. We often found evidence of relationships between the presence of a particular type of coordinating knowledge embedded in an information system and a performance indicator, but differences between this relationship and the relationship of the coordinating knowledge present but not embedded in an information system were often not significant. This is likely a result of our sparse data, where few instances of coordinating knowledge embedded in an information system were found for most types of coordinating knowledge. However, more work and perhaps a different methodology are needed in order to better explore these relationships.

Table 30: Relationships that were Hypothesized and Supported in the Data Analysis

	Coordination Instance Performance Indicator					
	Related to Effectiveness			Related to Efficiency		
Coordinating Knowledge Types Involved…	Information Quality	Person Selection	Timeliness	Cognitive Effort	Time Spent	Follow-Up CIs
Role		X		X		
Assignment		X		X		X
Individual		X				
Time schedule Triggers				X		
Event sequence Triggers				X		
Emergent Triggers			X			
Predetermined Content Selection						
Emergent Content Selection	X					
Recipient-Tailored Content Selection						X
Predetermined Content Presentation						
Shared Understanding					X	
Predetermined Method Selection				X		
Media-Fit Method Selection	X		X			
Recipient-Tailored Method Selection			X			

Note: Underlined X indicates this relationship only hypothesized and tested for CK embedded in an information system.

Post-Hoc Analyses (Splitting Models into Two Binomial Logistic Regressions) - After noticing that several of our models failed the Score Test for Proportional Odds Assumption, we split the data sets for these models into different groups and ran two binomial logistic regressions for each (detailed in Chapter 5). The results of these pairs of binomial logistic regression suggest that types of coordinating knowledge behave differently between our two cut-points. These classifications were coded when we had reason to believe the coordination instance was harmed regarding this indicator (-1), had no evidence or indication that the coordination instance was altered regarding this indicator (0), or had reason to believe the coordination instance was improved regarding this indicator (1).

Generally speaking, our data set contains relatively few -1 codes across the six indicators of coordination instance performance. This is likely due to a combination of reasons. First, healthcare professionals are unlikely to want to point out places where poor coordination performance occurred. The healthcare context is especially sensitive to liabilities that occur when any mistakes are made, and the researcher did not attempt to push actors into uncomfortable situations where they would be asked to classify an action as inefficient or ineffective. The more natural framing of the conversation (and sufficient for our initial research goals) was to try to understand when coordination instances were especially efficient or effective. However, some observation data made it clear that there had been significant problems in one of the coordination instance performance indicators, and these were coded as -1. Often these were fairly extreme situations where the coordination instance failed completely and had to be repeated in a different manner.

Understanding that many of these situations were not simply a degradation of performance along a spectrum, but actual failures, casts these findings in a different light. It may be that the coordinating knowledge necessary to have a functional coordination instance (cut-point -1/0), is a different set than the ones that yield extra performance improvements (cut-point 0/1). Said another way, certain coordinating knowledge types may be necessary to avoid failure, while other ones may enhance performance of a functional coordination instance. For example, when considering proposition 13 (original model 3), we see that the presence of *media-fit based method selection* is a statistically significant predictor of timeliness, using data around cut-point 0/1 (difference between a neutral and improved coordination instance regarding the indicator timeliness). However, it is not a predictor for the difference between a poorly timed coordination instance and a neutral one. One interpretation of this might be that *media-fit based method* *selection* is not necessary to form a functional and reasonable coordination instance in most situations (cut-point -1/0). However, the addition of it when shaping a coordination instance may yield improvements to the timing of the coordination instance (cut-point 0/1).

Another possibility we believe these findings may suggest is evidence of the presence of flawed coordinating knowledge. In our ordinal logistic regression model (model 4), we did not find support for proposition 10, which proposed that the presence of coordinating knowledge about *predetermined presentation* would reduce the cognitive effort burden of the actors. However, the pair of related binomial logistic regression models suggests that its presence *increases* the likelihood of a harmed coordination instance (significant negative estimate regarding cut-point -1/0) and that it also increases the likelihood of an improved coordination instance (significant positive estimate regarding cut-point 0/1). These opposite relationships negated each other when we considered the data set as a whole, such that we found no significant effects for propositions 10. One explanation of this is that in some situations the coordinating knowledge predetermined presentation is not a good fit for the situation, but is still shaping the coordination instance (e.g., a rigid presentation solution in an electronic medical record). In these cases, the presence of this type of coordinating knowledge is harming the coordination instance. In other cases (surrounding cut-point 0/1) the coordinating knowledge is useful and therefore improving the coordination instance efficiency. Table 27 summarizes all of the results of this post-hoc analysis.

Post-Hoc Analyses (Exploratory Factor Analysis) – In our second post-hoc analysis, we used exploratory factor analysis techniques to identify five latent factors that helped explain underlying patterns in our 14 types of coordinating knowledge. We summarize these findings in

Table 31. The first column has the names we gave to describe the five latent factors (see Chapter 5), the next two columns detail what types of coordinating knowledge is associated with the factor (second column) and disassociated with the factor (third column). In other words, coordination instances with coordinating knowledge patterns that closely align with a particular factor will have the coordinating knowledge types present that are shown in the second column, but also have the coordinating knowledge types absent that are shown in the third column. The next pair of columns list coordination instance performance indicators that have a medium-effect size (0.30) correlation with the latent factor (more details can be seen in Table 29). Each latent factor has a positive correlation with the indicators in the fourth column, but a negative correlation with the indicators in the fifth column.

During our theoretical development of coordinating knowledge, we discussed four previously identified antecedents to coordination: coordination mechanisms, domain expertise, team familiarity, and team awareness. We suggested that these were actually sources of coordinating knowledge, and we summarized our beliefs about which types of coordinating knowledge are derived from which sources in Table 4. Returning to our exploratory factor analysis results and examining the types of coordinating knowledge present in each latent factor (second column of

Table 31) we realized that in nearly all cases the latent factors represented groups of coordinating knowledge *derived from the same source*. This dominant source of the coordinating knowledge types is showing in the sixth and final column of the table.

We deemed the first latent factor the "Emergent CK Group," because this set of coordinating knowledge types seemed to loosely represent coordinating knowledge that knowledge workers use in dynamic, unpredictable, emergent situations. The pattern tends to have coordinating knowledge about role, emergent triggers, emergent content selection, and media-fit based method. The dominant source of that combination of coordinating knowledge is domain expertise. The second latent factor we call the “Routinized CK Group,” as it represents coordinating knowledge that would be useful in predictable and routinized situations. Not surprisingly the dominant source of coordinating knowledge of this set is coordination mechanism. The third latent factor was some bit surprising, because it is only comprised of one type of coordinating knowledge, that of assignment. However, assignment is one of only three types of coordinating knowledge we expected to be sourced from team awareness, and it is the only of the three to be sourced exclusively from team awareness. We believe, especially in our research context, it stands out as the most salient use of team awareness in the coordinating knowledge set. The fourth latent factor is comprised of coordinating knowledge about time scheduled triggers, shared understanding, and predetermined method. This is the only group that does not clearly show a dominant source of coordinating knowledge. However, upon further reflection, we believe this is a very common combination of coordinating knowledge types in planned, routine meetings. We discussed how coordination mechanisms often are partial blueprints of a coordination instance, which explains how they may have some routinized, ostensive aspects, but some open-ended aspects which vary depending on the performance of the routine. Meetings have often been described as a type of coordination mechanism (Okhuysen and Bechky 2009), and are likely to have routinized methods and timing (time scheduled trigger and predetermined method), but the content discussed varies instance to instance and shared understanding often develops. We have called the final latent factor “Tailored to Recipient CK group,” and it contains two types of coordinating knowledge derived from team familiarity

Table 31: Summary of Latent Factors Found in Exploratory Factor Analysis and Dominant Source of Coordinating Knowledge

Factor Description	Categorized by CKs Present (positive correlation)	Categorized by CKs Absent (negative correlation)	Improved CI Effects (positive)	Harmed CI Effects (negative)	Dominant Source of Present Coordinating Knowledge
Emergent CK Group	Role Emergent Triggers Emergent Content Media-Fit Based Method	Time-Scheduled Triggers Event-Sequenced Triggers Predetermined Content Predetermined Presentation Predetermined Method	Info Quality Person Selection Timeliness	Cognitive Effort	Domain Expertise
Routinized CK Group	Event-Sequenced Trigger Predetermined Content Predetermined Presentation Predetermined Method	Emergent Triggers Emergent Content Media-Fit Based Method	Cognitive Effort Time Spent	Person Selection Timeliness	Coordination Mechanism (Routinization)
Assignment CK	Assignment	Role Individual	Person Selection Timeliness		Team Awareness
Meeting CK Group	Time-Scheduled Shared Understanding Predetermined Methods	Emergent Trigger	Info Quality Cognitive Effort Follow-Up CIs		Coordination Mechanism & Domain Expertise (Meetings!)
Tailored to Recipient CK Group	Recipient-based Content Recipient-based Method		Person Selection Follow-Up CIs		Team Familiarity

Implications for Theory

Contributions to coordination literature - First, we define a coordination instance as a single episode in which the actors engage in actions necessary to manage the dependencies of their tasks in order to reach their shared goal, and we demonstrate the benefits of considering coordination at this micro-level. Previous work has recognized the importance of coordination (Argote 1982; Faraj and Xiao 2006; Okhuysen and Bechky 2009; Weick 1979), but the broad and sometimes vague explanation of exactly what coordination entails has left a gap in our theoretical understanding. Recognizing that coordination is a result of a series of coordination instances, and that improvements to coordination instances will eventually lead to improvements in outcomes dependent on coordination, we are able to focus on these instances and gain new understanding about coordination. Specifically, this understanding involves coordinating knowledge and the specific effects on the efficiency and effectiveness of coordination instances. We believe the identification and level of analysis creates a pathway into new studies of coordination.

Second, we introduce the framework of coordinating knowledge. By developing this set of meta-knowledge involved in shaping coordination instances, we explain *how* people know how to coordinate. Understanding the forces at work that shape each coordination instance is important in order for us to understand how and why coordination is affected when environmental factors are changed. This provides a new lens and gives a tangible structure to coordination for future studies interested in studying coordination.

Finally, we demonstrate how coordinating knowledge explains the benefits previously observed of other key coordination antecedents (coordination mechanisms, domain expertise, team familiarity, and team awareness). We do not mean to imply that the list of four coordinating knowledge sources is complete, and future work may yield insights into additional sources.

Contributions to information systems coordination research – Previous work has shown that information systems are important to coordination performance (Argyres 1999; Dabbish and Kraut 2008; Kudaravalli and Faraj 2008; Levina and Vaast 2006). We believe this dissertation provides two new paths for theoretical development in information systems literature. First, is the contribution that information systems may act as repositories where coordinating knowledge is stored and accessed. Many of our illustrative examples show an actor possessing coordinating knowledge as part of his or her internal knowledge. However, information systems and other artifacts may have coordinating knowledge embedded in them (e.g., a form usually has pre-determined content selection embedded in its design). We identified some circumstances where this may have occurred and developed initial propositions about how it could affect coordination instances, but we have barely scratched the surface of understanding the ramifications information systems have on coordination. Coordinating knowledge gives us a new framework with which to explore this landscape and a new lens to examine how information systems can influence coordination by embodying various types of coordinating knowledge.

Second, information systems literature has developed a rich understanding of the power of modularity and decoupling as design principles (Schilling 2000; Sullivan et al. 2005; Tiwana 2008). Modularity is the degree to which a system's components may be separated and recombined. This principle allows process design to minimize the types of coupling that occur between components (Beck and Diehl 2011). For example, in the software engineering context, designers consider data coupling (modules share data through defined parameters), control coupling (one module controls the work flow of another module), and content coupling (one module modifies and relies on the internal workings of another module) (Press and Constantine 1979). We believe that this rich body of literature and design patterns can help us understand coordination processes, particularly with the new coordinating knowledge framework. Applying these core concepts to the coordinating knowledge framework at the coordination instance level will likely yield insights about (1) how to better design business processes surrounding coordination and (2) how to better design information system artifacts to support and improve coordination. Embedding coordinating knowledge inside information systems may allow design to loosely couple a coordination situation, where experts are not as dependent on remembering all components of CK in order to engage in coordination to complete their tasks.

Implications for Practice

The coordinating knowledge framework allows organizations insight into *how* experts know how to enact a coordination instance to manage dependencies. Organizations can influence coordinating knowledge by considering its sources and providing or encouraging cultivation of specific types of coordinating knowledge. In our post-hoc analysis we conducted exploratory factor analysis and identified five underlying factors that provide insight into common combinations of coordinating knowledge types and their relationship with our indicators of coordination instance performance. One unexpected finding was how salient coordinating knowledge sources (coordination mechanisms, domain expertise, team familiarity, and team awareness) were within the latent factors. In fact, they appear to be the defining focus within the latent factors.

Table 31 summarizes these latent findings, and we see that the first factor, *emergent CK group*, is related to patterns using the coordinating knowledge types: role, emergent triggers, emergent content, and media-fit based method, while excluding the coordinating knowledge types commonly used in predetermined and routinized coordination instances. Of all of these present types of coordinating knowledge, domain expertise is the most prevalent and common source according to our theorizing (summarized in Table 4). Further, this latent factor is associated with increases in effectiveness (at the cost of efficiency indicator cognitive effort). So, if an organization was concerned with increasing the efficacy of their coordination processes, increasing domain expertise (via additional training or hiring specialists) is likely to increase those types of coordinating knowledge and increase effectiveness. Similarly, the coordination mechanism source is the underlying dominant source of all of the types of coordinating knowledge found in the *routinized CK group*. Implementing coordination mechanisms that routinize coordination instances is likely to improve efficiency, but perhaps at the cost of some indicators of effectiveness. This underlines the practical implication that the easiest levers to manipulate in order to affect coordination performance may be these underlying sources.

By describing particular ways that coordinating knowledge influences efficiency and effectiveness of a coordination instance, we suggest ways in which organizations have the potential to improve specific aspects of coordination instances to meet their needs and strategic goals. However, the same post-hoc analysis that identified five latent factors representing common coordinating knowledge combinations also yields evidence that there is a tension between efficiency and effectiveness of a coordination instance. One type of coordinating knowledge, or a set of related types, may be associated with an increase in efficiency and a decrease in effectiveness, or vice versa (see "Emergent CK Group" and "Routinized CK Group" in

Table 31, as examples). Administrators attempting to alter coordination instance performance will do well to not only focus on the appropriate types of coordinating knowledge (or sources of that coordinating knowledge) to guide the desired performance change, but remember the performance improvement may come at a cost in another area.

Finally, we believe that even at this nascent stage our research yields practical appreciation about how changing a business process or a information systems artifact has rippling effects on coordination performance. Changing team member assignment, adding a new piece of software, or altering policies can disrupt or alter coordinating knowledge, which will in turn affect performance outcomes dependent on coordination.

Future Research Areas

Reconsidering Previous Coordination Contingency Studies - Previous work in coordination often considered variations in the nature of coordination and variations in the environment to better understand group-level performance. When considering the nature of coordination prevalent in the literature, we see a history of coordination being characterized along a series of dimensions that has resulted in classifying coordination efforts into bimodal grouping, such as programmed vs. unprogrammed (Argote 1982; March and Simon 1958; Van de Ven et al. 1976; Willem et al. 2006), standardized vs. mutual adjustment/feedback (Adler 1995; Malone and Crowston 1994; Orlikowski 1996; Thompson 1967), formal vs. informal (Brown 1999; Sherif et al. 2006; Tsai 2002), and mechanistic vs. organic (Andres and Zmud 2001). We believe the distinction between these pairs is similar; one side favors a structured plan of coordination while the other favors an unstructured, somewhat impromptu coordination style. However, the various empirical studies utilizing these bimodal groupings of coordination have yielded conflicting results. One possible reason for the conflicting results may be that some components of a coordination instance (i.e., who? when? what? how?) can be structured, while other components may be unstructured. Coordinating knowledge is a new lens that gives as a tangible structure to coordination, and allows for a finer grained description and analysis of which components of coordination are structured and how, which should to useful to future studies theorizing about coordination.

Past contingency theories that involve coordination provide one source of possible future studies that would benefit from using coordinating knowledge to define and understand the nature of coordination instances. Previous work has considered how performance might change when task uncertainty was present (Gittell 2002; Okhuysen and Bechky 2009; Ren et al. 2006; Van de Ven et al. 1976; Weinberg et al. 2007), when tasks had varying levels of interdependencies (Mohr 1971; Rico et al. 2008; Thompson 1967; Van de Ven et al. 1976; Weinberg et al. 2007), when team structure or group size varied (Crawford and Lepine 2013; Espinosa et al. 2007a; Kirkman and Mathieu 2005; Ren et al. 2006; Weinberg et al. 2007), or when the type of task was fundamentally different (Adler 1995; Espinosa et al. 2007a; Lewis and Herndon 2011; Straus and McGrath 1994; Watson-Manheim and Bélanger 2007). The coordinating knowledge framework allows us a more precise tool to understand the nature of coordination instances and make better predictions about how and why coordination is affected when these environmental and situational factors differ. We suggest that reexamining these research questions, while using the coordinating knowledge framework, may create new understanding about the coordination and generate practical suggestions about how to maximize performance by attending to meta-data that informs the coordination process.

Multi-level studies examining aggregated coordination instances - We have assumed that improved coordination instances lead to better coordination and, ultimately, improved group performance. While this assumption seems to have strong face validity, multi-level research is needed to understand how coordination instances "roll-up" to provide overall coordination. Using an engineering lens, complex design processes have been explained as a series of iterations (Smith and Eppinger 1997a, 1997b), and this logic could be applied to coordination instances as the building-blocks to complex problems that require on-going coordination. Questions should be posed and studied related to the necessary sequence and accumulation of coordination instances, which is likely to vary depending on the nature of the tasks being completed. The importance of the timing and the series of coordination instances through a project is known to impact success (Lowry et al. 2009). For example, some situations may create redundant coordination instances. In heavily regulated industries, like healthcare, procedures and policies may provide coordinating knowledge that guides coordination in a particular and heavily regulated way. Actors may leverage this coordinating knowledge and conduct a coordination instance that satisfies the procedure, but then also use different coordinating knowledge and enact a redundant coordination instance in order to efficiently and effectively coordinate with the other actor. For example, a procedure may be in place that specifies a nurse is to record notes about a patient in an electronic medical record each shift to make it available to team members. A nurse may document the information in the electronic medical record, yet may also verbally communicate the same information with team members in order to make sure the information has been received. In fact, there is partial evidence that verbal coordination often facilitate rather than replace written coordination in the healthcare context (Broekhuis and van Donk 2011). In our example, two coordination instances occurred, even though the content was the same or similar. More research is needed to understand the causes, the benefits, and the costs of these redundant coordination instance occurrences. There may also be tradeoffs between optimizing the performance of a given coordination instance to the detriment of overall coordination. The conditions under which these tradeoffs occur and how they can be prevented is worthy of closer investigation.

In contrast to the concern of redundant coordination instances, is the concern that there are missed coordination instances. When considering specific types of coordinating knowledge, like those about emergent triggers and emergent content, we noted that without the presence of this coordinating knowledge the coordination instances simply might not occur. In groups of experts, when coordination instances fails to occur, coordination breaks down and performance may be severely impacted (Ren et al. 2008; Van de Ven 1976). Knowledge is lost because it fails to be passed from one expert to another, and is not present for ideal task completion. We refer to this phenomenon as *knowledge decay*, and believe coordination instances and the coordinating knowledge framework may yield insights into how to prevent it.

Coordinating Knowledge Embedded in Information Systems - Coordinating knowledge may be stored and even enacted upon, via external artifacts. Information systems are involved in many coordination instances (e-mail, ERP systems, specialized industry software such as electronic health records, cell phones, etc.). Various types of health information technologies have been shown to change routines (Goh et al. 2011) and collaborative software tools improve performance (Banker et al. 2006). We developed several propositions about how we expected coordinating knowledge types embedded or enhanced by information systems to affect the coordination instance performance. Our findings were mixed, and several propositions were not tested due to lack of relevant coordination instances (i.e., we did not observe all types of coordinating knowledge embedded in an information system). Further research is needed in order to better understand and test this phenomenon of embedded coordinating knowledge within various types of information systems.

Furthermore, the CK framework can be used to inform design of information systems that facilitates coordination. We have already discussed using modularity and decoupling principles to understand how and when to embed coordinating knowledge in information systems to enhance the effectiveness and efficiency of coordination instances. For example, information systems can be used to decouple two actors that need to coordinate by serving as switchboards that route the needed information to the right person at the right time in the right format without the sender needing to have CK knowledge about the actors, timing, or presentation of the information. Understanding which CK types should be embedded in an information system in this manner and under what conditions is an important future research direction. Furthermore, from a design standpoint, we have accumulated much knowledge on how to design information systems to reduce coupling. For example, object-oriented software design relies on objects collaborating to carry out system functionality. This is not unlike human coordination to perform a task. Best practices in this area have been encoded in a number of design patterns (e.g., the controller design pattern, the adaptor design pattern) (Gamma et al. 1994). Using these design patterns to inform the design of information systems to facilitate coordination among humans is a promising direction for future design research. For example, the system acting as a switchboard between two actors needing to coordinate in the example above mimics the controller design pattern in software engineering.

Portfolios of Coordinating Knowledge – This work develops coordinating knowledge types, and considers their individual impacts on the performance of coordination instances. However, future research would benefit from considering the effects of combinations of coordination instances. Our post-hoc analysis involving exploratory factor analysis yields some insight into common patterns of combinations of coordinating knowledge that are prevalent. Further, the various types of coordinating knowledge may have substitutive or complementary effects when considered in combination.

Tension between Efficiency and Effectiveness - **We considered how each type of coordinating knowledge might affect the efficiency or effectiveness of a coordination instance. However, there is often tension between efficiency and effectiveness gains in a coordination instance. Our second post-hoc analysis involving exploratory factor analysis lends evidence of this situation. One factor that we describe as the "Emergent CK Group" is made-up of specific types of coordinating knowledge commonly used in dynamic, emerging situations where coordination needs cannot easily be anticipated. This Emergent CK Group is associated with improvements in effectiveness (all three indicators), but negatively associated with the efficiency indicator of cognitive effort expended by the involved actors. In other words, these types of coordinating knowledge are used to influence much more effective coordination instances, but at the cost of using more cognitive effort. Another factor, called the "Routinized CK Group" shows us the other side of the coin. These specific types of coordinating knowledge are ones common in predictable, routinized coordination. The**

Routinized CK Group is associated with efficiency gains (less cognitive effort and time spent by the actors involved), but at the cost of efficacy. See

Table 31 for details. Further research is needed to better understand this tension and how to mitigate the negative performance changes when adding additional types of coordinating knowledge to situations.

Negative Effects of Coordination - When considering the ways in which coordinating knowledge can affect the efficiency and effectiveness of coordination instances we have assumed that all coordination instances are beneficial. However, coordination inherently has costs associated with it (most notably time and effort) (Evans and Davis 2005). If coordination instances are enacted that are not beneficial, then they waste resources and have harmful effects to overall performance. In the healthcare arena, we can easily imagine situations where actors might spend time engaged in coordination instances instead of attending to other duties necessary for optimal patient care. One coordination instance between two actors may also preclude a coordination instance between a different combination of actors. If the same type of coordinating knowledge is always used to make a decision, it might limit the actors that are involved in coordination instances and cause the formation of sub-groups within a larger group. Sub-groups have been shown to harm overall performance of a larger group (O'Leary and Mortensen 2010). Future research is needed to understand situations suffering from too much coordination, or the wrong coordination instances, what coordinating knowledge types are involved and how these develop over time. Additional studies are also needed to understand what might occur with incorrect or bad coordinating knowledge. In other words, what happens when actors possess and utilize coordinating knowledge that is wrong?

Conclusion - The major thrust of this dissertation was to develop the idea of the coordinating knowledge framework, and to gain insight into the coordination process by studying it at the micro-level of a single coordination instance. By doing so, we believe we added an important tool to the toolbox which we can continue to use to understand how information systems effects coordination. By not viewing coordinating knowledge monolithically, but rather at the more granular CK component level, we can understand how information systems facilitates coordination by embodying (or not) various CK components. In many ways, the healthcare arena proved to be an ideal situation in which to study coordination, as coordination instances are visible and frequent. However, we believe the coordinating knowledge framework will be a useful lens to study coordination in a variety of different environments.

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APPENDICES

Appendix A: Definitions of Coordination

Authors	Definition
(Thompson 1967)	"Coordination concerns the combination of interdependent parts to achieve the most effective or harmonious results"
(Argote 1982 p. 423)	"Coordination involves fitting together the activities of organization members, and the need for it arises from the interdependent nature of the activities that organization members perform"
(Malone and Crowston 1994 p. 90)	"the management of interdependencies among tasks"
(Gittell and Weiss 2004 p. 132)	"coordination [is] an activity that is fundamentally about the connections among interdependent actors who must transfer information and other resources to achieve outcomes"
(Quinn and Dutton 2005 p. 36)	"the process through which people arrange actions in ways that they believe will enable them to accomplish their goals"
(Faraj and Xiao 2006 p. 1157) (Okhuysen and Bechky 2009)	"a temporally unfolding and contextualized process of input regulation and interaction articulation to realize a collective performance"
(Broekhuis and van Donk 2011 p. 253)	"the combination of interdependent parts to achieve the most effective or harmonious results"

Appendix B: Example Interview Guide

Reiterate the purpose of the research project and this interview.
Deliver IRB Information Letter.
Request permission to audio-record the interview.

- **It would be helpful if you could describe the typical consultation process. What does a typical consultation that you're involved in look like?**

- What types of patients do you see?
  - What are some of more common case types (chronic, one time)?
  - **How are other medical professionals involved in these cases?**
    - **Ask about his/her involvement with doctors, methods of communication, quantity of communication, follow-through, etc.**
  - **How do you coordinate care across these various professionals? What are some common coordination/communication issues? What are some common solutions to these?**
  - Is it common (important?) that other medical professionals know anything about your specialized field?

- **Please describe how your area's EMR software operates and how it interacts with your business processes.**

- I understand you're going to be participating in a telemedicine project at Hugh Chatham; can you tell me what you know about that?
  - **What do you think your role will be? (i.e.…walk me through the process…see if I can tease out the role of other medical professionals)**
  - **How is your work time divided now? (i.e., X% doing this, Y% doing that) How do you think it will look after this implementation?**

- **What do you see as the biggest benefits to telemedicine? Specifically from your point of view?**

- **What are the biggest drawbacks? Do you have any hesitations or concerns about places that telemedicine might limit your ability to deliver care?**

Appendix C: Two Example Documents Collected from Hospital

Example 1: Notes about an Emergency Department patient. Report summary from the electronic health record software, showing both nurse and physician notes.

Nurse's Notes [redacted] *Hospital*

[redacted]

Arrival Date: 05/04/2012 **Time:** 09:26
Bed T 4

[redacted]

Private MD: [redacted]

Presentation:

05/04 09:32 Presenting complaint: Patient states: chain saw laceration to the left lower anterior leg. Complicating Factors: There are no complicating factors for this patient. Last Known well n/a. Transition of care: patient was not received from another setting of care. paw

09:32 Acuity: Urgent. paw

09:32 Method Of Arrival: W/C. paw

Triage Assessment:

09:35 **General:** Appears in no apparent distress, Behavior is appropriate for age, cooperative. **Pain:** Complains of pain in left shin. **Neuro:** Level of Consciousness is awake, alert, obeys commands. **Respiratory:** Airway is patent Respiratory effort is even, unlabored. **Injury Description:** Laceration sustained to left shin is jagged, 7.6 to 20 cm long, not bleeding, was sustained 30-60 minutes ago. is bleeding a small amount. paw

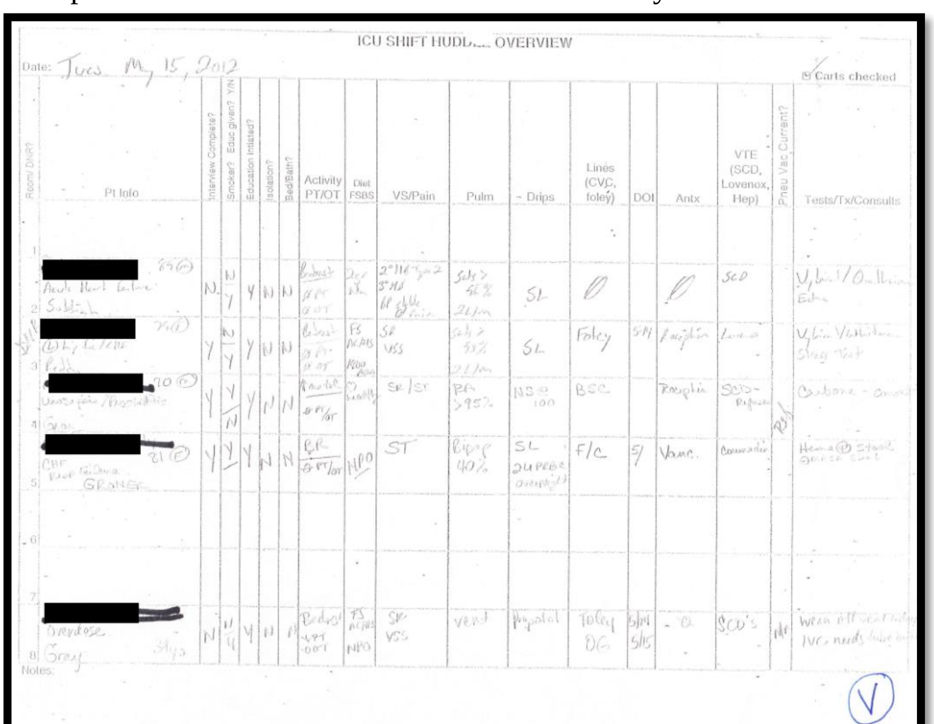
Historical:

- **Allergies:** No known drug Allergies;
- **Home Meds:**
  1. *MEDICATION SOURCE verbalized by patient
  2. Lisinopril Oral daily
- **PMHx:** Hypertension
- **PSHx:** Knee surgery
- **Immunization history:** Last tetanus immunization: up to date..
- **Family history::** Not pertinent. No immediate family members are acutely ill,.
- **Social history:** Smoking status: Patient/guardian denies using tobacco, The patient lives with family, No

Screening:

09:37 **Abuse Screen:** paw
Denies threats or abuse.
Nutritional screening:
No deficits noted.
Tuberculosis screening:
No symptoms or risk identified.
Fall Risk:
None identified.
Helpless/Hopeless:
denies feelings of helplessness or hopelessness.

Example 2: ICU Shift Huddle Overview – Summary of Patients



Appendix D: Methods of Observed Coordination Instances

Value	Frequency Count	Percent of Total Frequency
In-Person Conversation	132	46%
Phone Call	55	19%
EMR	43	15%
Paper Form	24	8%
Posted Notice	14	5%
In-Person, Shared Technology View	8	3%
Page (via paging system)	4	1%
Hospital Intercom	2	1%
Unknown or Unclear Combination	3	1%
Fax	1	<1%
Implicit	1	<1%
Voice Recording	1	<1%
Written Note (free form, handwritten)	1	<1%

Appendix E: Correlation Matrix

	CK1	CK2	CK3	CK4	CK5	CK6	CK7	CK8	CK9	CK10	CK11	CK12	CK13	CK14	E1	E2	E3	E4	E5	E6
1 Role	1.00																			
2 Assignment	-0.41	1.00																		
3 Individual	0.05	-0.22	1.00																	
4 Time Scheduled Triggers	-0.15	0.00	-0.11	1.00																
5 Event Sequence Triggers	0.10	-0.21	-0.10	-0.28	1.00															
6 Emergent Triggers	0.00	0.12	-0.01	-0.24	-0.54	1.00														
7 Predetermined Content	-0.03	-0.22	-0.15	0.15	0.54	-0.50	1.00													
8 Emergent Content	0.01	0.21	0.07	0.05	-0.43	0.28	-0.69	1.00												
9 Recipient-Tailored Content	0.09	0.05	0.14	0.02	-0.12	0.07	-0.22	0.08	1.00											
10 Predetermined Presentation	-0.20	-0.13	-0.19	0.13	0.38	-0.22	0.53	-0.48	-0.15	1.00										
11 Shared Understanding	0.01	0.00	0.03	0.28	0.05	-0.16	0.16	0.08	0.00	0.10	1.00									
12 Predetermined Method	-0.21	-0.21	-0.27	0.37	0.36	-0.40	0.62	-0.39	-0.18	0.64	0.15	1.00								
13 Media-Fit-based Selection	0.14	0.28	0.06	-0.09	-0.28	0.29	-0.40	0.37	0.07	-0.45	0.06	-0.63	1.00							
14 Recipient-Tailored Method	0.05	0.14	-0.04	0.02	0.05	0.00	-0.07	0.00	0.17	-0.05	-0.04	-0.17	0.01	1.00						
E1: Effective (Right Info)	0.03	0.04	0.05	0.04	-0.03	0.04	-0.10	0.19	0.06	-0.07	0.13	0.00	0.17	-0.04	1.00					
E2: Effective (Right Person)	0.09	0.45	0.28	-0.05	-0.12	0.01	-0.22	0.25	0.09	-0.28	0.08	-0.28	0.27	0.08	0.24	1.00				
E3: Effective (Right Time)	0.05	0.15	-0.06	-0.04	-0.14	0.20	-0.18	0.14	-0.11	-0.18	-0.04	-0.24	0.25	0.10	0.20	0.18	1.00			
E4: Efficient (Cog Effort)	-0.05	-0.11	-0.15	0.38	0.27	-0.33	0.37	-0.26	-0.09	0.41	0.10	0.60	-0.37	-0.04	0.11	-0.14	-0.06	1.00		
E5: Efficient (Time Spent on)	0.08	-0.02	0.04	0.23	0.12	-0.14	0.16	-0.05	-0.04	0.08	0.44	0.20	-0.05	-0.03	0.19	0.10	0.06	0.32	1.00	
E6: Efficient (Follow-Up CI)	0.04	0.15	0.01	0.11	0.05	-0.04	0.04	0.04	0.22	-0.08	0.09	0.02	0.03	0.19	0.20	0.27	0.12	0.09	0.14	1.00