Situation Awareness Through social Collaboration Platforms In Distributed Work Environments

Completed Research Paper

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Abstract

In distributed work environments, collaborators often lack situation awareness, which can be described as knowledge about what is happening in an individual's work environment. Thus, information systems are needed to support situation awareness between distributed workers. However, despite its relevance, the concept lacks the clear theoretical understanding needed for a rigorous specification and evaluation of such systems. Based on an extensive literature review, we therefore develop a conceptual model to improve understanding of situation awareness in distributed collaboration. We demonstrate how the model may be utilized by evaluating an existing social collaboration platform regarding its ability to support situation awareness. Therefore, we develop an operationalization of the model and analyze the content of more than 15,000 enterprise microblogging messages obtained from an international financial institution. The results provide first evidence, that enterprise microblogging might be an appropriate solution to overcome the issue of situation awareness in distributed collaboration.

Keywords: Distributed Collaboration, Communication Technologies, Social Software, Enterprise 2.0

Introduction

Advances in technology have enabled and improved collaborative work between geographically distributed people (Hinds and Mortensen 2005; Riemer et al. 2007). Since companies are increasingly taking advantage of the economical benefits of such work settings, the number of mobile workers is exceeding one third of the world's workforce until 2013 (IDC 2010). On the other hand, as work becomes more global, distributed and non-collocated, it has proven to be difficult for workers to stay aware of all relevant information in their work environment (Gutwin and Greenberg 2002). Specifically it has been shown, that collaborators often lack what has been labeled situation awareness (SA) (Kaber and Endsley 1998). In brief, SA has been defined as an individual's knowledge about what is going around in its immediate environment (Endsley and Garland 2000). With respect to collaborative work, individuals need to know, e.g., about the emotional state of their colleagues or whom to ask regarding an issue in order to be able to work together efficiently. As prior research has shown, without or with an insufficient degree of SA, the collaborative goal may not be achieved successfully (Endsley and Jones 1997; Kaber and Endsley 1998).

While in traditional work settings SA is gained via face-to-face communication, information systems (IS) are needed to create and maintain SA between distributed people (Hinds and Bailey 2003; Kraut et al. 2002). As such systems have the potential to significantly increase work performance of distributed workers (Dabbish and Kraut 2008), SA has received growing attention from IS research and related domains (Gross et al. 2005; Liechti and Sumi 2002). However, most of the work from these domains is particularly focusing on the design of systems to support specific aspects of SA from a rather technical point of view, e.g., messages on office door displays (Cheverst et al. 2007) or computer visualization techniques such as fisheye views (Greenberg et al. 1996). According to the special purpose of these technical solutions, a plethora of different types of SA have been defined, even though these often only slightly differ, use different wording to describe similar ideas or look at the same phenomenon from different levels of granularity (Liechti and Sumi 2002; Omoronyia et al. 2010). Furthermore, due to the predominant technical orientation of this research, attention has shifted away from the original concept of SA as a cognitive process being rooted in social psychology (Dominguez 1994, Endsley 1995). As a result, it is not clear how IS support the creation and maintenance of SA at the level where the phenomenon naturally occurs: the individual. What is missing is a conceptual integration of the findings from technical-related research on SA with existing theory from the concept's original domain. Thus, despite the huge amount of work already published, the notion of SA has remained fuzzily specified (Cheverst et al. 2007; Omoronyia et al. 2010; Schmidt 2002). Moreover, the existing literature has been rarely investigated (Rittenbruch and McEwan 2009) in a structured way based on a rigorous methodology (Webster and Watson 2002). As a result, the concept of SA lacks the clear theoretical understanding needed for a systematic specification and evaluation of IS that support the creation of SA between non-collocated workers (Drury and Williams 2002).

Therefore, we synthesize the existing literature on SA and develop a general, process-oriented conceptual model to improve our understanding of SA, particularly in distributed collaboration. Our findings provide guidance for practitioners and scientists in the design and evaluation of IS that support the creation of SA. Since information is the foundation for the emergence of SA (Dominguez 1994) we particularly focus on the types of information needed to build and maintain SA. Moreover, we demonstrate how the model may be utilized by evaluating an existing social collaboration platform regarding its ability to support the creation of SA. Specifically we conduct a content analysis on a rich dataset of Enterprise Microblogging (EMB) data. Overall, our work makes the following contributions to research and practice. First, we conduct a systematic review (Webster and Watson, 2002) of the literature on SA and derive categories of awareness information needed to develop SA. Second, we propose and test an operationalization of awareness information for the evaluation of text-based IS. Third, we develop a process-oriented conceptual model which helps to understand how SA emerges at the individual level through processing of awareness information provided through IS. Finally, exploring an existing EMB platform with respect to SA, we contribute to the few research articles analyzing the value of social collaboration platforms (e.g., enterprise wikis or EMB) for business.

In the next section we provide a general definition of SA and describe how the concept has been adopted to research on collaboration and IS. Next we describe the methodology of our literature review and

discuss our findings in order to develop categories of awareness information. Then we synthesize existing theory on SA with the results of our review and develop a new process-oriented conceptual model of SA in distributed collaborative settings. Subsequently, we provide information regarding our empirical example, describe our research methodology and illustrate the results of our analysis. Finally, we discuss our findings and present limitations of our work as well as implications for further research.

Literature on Situation Awareness

Originally rooted in social psychology, the concept of SA has been defined basically as an individual's knowledge about what is going around in its immediate environment (Endsley and Garland 2000). Although SA might be important for anyone in almost any situation, the focus of this stream of research has been specifically on individuals engaged in some activity or task. Early investigations of the concept focused on high stress activities within military operations, such as air combats (Carroll 1992; Whitaker and Klein 1988). However, the notion of SA swiftly received attention from many other domains where people have to perform complex activities and make critical decisions (Endsley 1995). Common tasks such as driving in heavy traffic (Endsley and Garland 2000), or choosing a business strategy (Sambamurthy et al. 2003) also require awareness of the surrounding environment. Before choosing a suitable path of action, individuals need to understand the integrated meaning of their goals and tasks within their environmental context (Endsley 1995). In this regard, a more detailed definition of SA has been developed by Dominguez (1994) who argues that SA consists of four different pieces: extracting information from the environment, creating a mental picture of the situation by integration of this information with existing knowledge, directing further exploration by use of this picture and anticipation of events in the future. In other words, SA is defined as the result of a process which includes the extraction and integration of environmental information in its context to develop a mental picture of the situation as guidance for further action (Dominguez 1994). Subsequently, we will refer to this definition of SA, as it is the result of a systematic review of the literature und thus captures the concept's essence based on prior scientific work.

Situation Awareness and Collaboration

Although SA has been largely analyzed focusing on individuals, its importance and impact in collaborative settings has also gained significant attention (Endsley 1995; Gorman et al. 2006). In this regard, SA is needed to successfully achieve a specific, common goal which is typically the purpose of collaboration (Salas et al. 1995). On the one hand, each person needs to develop SA about the factors that have an impact on her individual tasks towards the common goal to be able to complete them successfully. The aggregation of this individual SA across all collaborators is referred to as team situation awareness (TSA) (Endsley 1995). On the other hand, depending on the specific goal and the structure of activities, it may be not sufficient to develop and maintain SA regarding the factors that influence each individual's tasks only (Salas et al. 1995). Rather, it might be necessary that each individual develops SA with respect to the activities of its co-workers, specifically when similar or interrelated activities are shared among more than one person. This is what has been labeled shared situation awareness (SSA). However, when collaborating towards a common goal, co-workers must develop and maintain TSA as well as SSA to act in a smooth and coordinated manner (Kaber and Endsley 1998). Without or with an insufficient degree of these concepts, the common goal may not be achieved successfully (Endsley and Jones 1997).

Situation Awareness in IS

Within IS, the focus has been largely on SA in the sense of SSA, specifically in computer supported cooperative work (CSCW) and human computer interaction (HCI) research (Rittenbruch and McEwan 2009). Accordingly, a generally accepted and often cited definition of SA (Omoronyia et al. 2010) describes the concept as "... an understanding of the activities of others, which provides a context for your own activity" (Dourish and Bellotti 1992, p. 107). It is argued that context information is needed to ascertain the relevance of an individual's activities and contribution regarding a group's goals. This is close to what has been defined as TSA and SSA in the former section. However, also the distinction between SSA and TSA has been made, for both we will subsequently use the term SA since it is the broader concept. However, while individuals can easily develop and maintain SA when working together

face-to-face, it has been proven to be difficult when they are geographically distributed. Since IS are supposed to mediate communication and collaboration between non-collocated people (Hinds and Bailey 2003; Kraut et al. 2002), most of the work on SA has concentrated on the question of how to design software to support SA between individuals, working together in distributed settings (Gross et al. 2005).

Since SA is a rather broad concept, specific subtypes of SA have been defined describing different aspects about which people should be aware of when working together (Gutwin 1997). These are, e.g., availability awareness (Steinfield et al. 1999) which refers to knowledge whether another person is busy or available or rhythm awareness (Begole and Tang 2007) which has been defined as having a sense of temporal patterns within a workgroup. While many subtypes of SA have been defined in the IS domain, the framework of workspace awareness provided by Gutwin et al. (1996a) is most commonly cited within literature (Gross et al. 2005; Rittenbruch et al. 2007). Moreover, the authors explicitly derived their framework from SA's root domain; thus it is thoroughly grounded in theory. It consists of four subtypes of SA which overlap to some extent (Gutwin et al. 1996a): informal awareness, social awareness, group-structural awareness and workspace awareness. They define informal awareness as knowledge of who is around and who is doing what at work. Further, social awareness is information about others emotional state, their interest in some topic or their level of attention towards an issue. Moreover, group-structural awareness is a person's knowledge regarding other's roles, responsibilities or positions on specific issues. Finally, workspace awareness refers to a person's understanding of what is happening inside the boundaries of a shared workspace, which is a place where people can work together on artefacts (Gutwin and Greenberg 2002).

Conceptualization of a Model of SA in Distributed Collaboration

The first step in developing and maintaining SA or any of its subtypes is extracting information from the environment (Dominguez 1994). Specifically in the case of distributed work this means, people need to extract information about their co-workers in order to be able to work together effectively. Thus, if IS are considered to balance the lack of opportunities to gain SA face-to-face, they need to provide users with access to specific awareness information (Gutwin and Greenberg 2002). However, it is still not clear which specific kind of information systems should provide to support SA (Cooper and Haines 2008; Jang et al. 2000; Liechti and Sumi 2002). Therefore, we conducted a systematic review of the literature in order to identify categories of awareness information. As our initial analysis revealed, the focus of prior research had been almost on subtypes of SA instead of the kind of awareness information needed to maintain them. Thus, we decided to analyze and aggregate these subtypes to broader categories of SA, in order to derive corresponding information categories recursively. We then develop a process-oriented conceptual model which integrates our findings with theory from SA's root domain. Specifically, the model illustrates how SA emerges at the individual level as the outcome of the processing of specific awareness information.

Literature Review Methodology

We conducted a literature review following the approach of Webster and Watson (2002) to analyze, synthesize, and integrate the results of extant literature on what information is needed to develop SA. First, we created a list of literature relevant for our review. Since SA - with our focus on IS for distributed collaboration - has most often been studied in research on IS, HCI and CSCW (Dabbish and Kraut 2008; Rittenbruch and McEwan 2009), we started choosing the top ten journals from each of these streams of literature. In this regard, we considered the ranking provided by the Association for Information Systems to be most relevant for IS research. Since we could not find a similar ranking for HCI and CSCW, we followed the recommendations of Chen et al. (2005) and Zhang and Li (2005) for HCI as well as Holsapple and Luo (2003) for CSCW when selecting the most influential scientific sources. Altogether, we identified 27 journals[1] relevant for our analysis on SA. Subsequently, we chose papers related to SA from the selected literature sources. Therefore, we created an initial list of papers using the keyword

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[1] MISQ, ISR, CACM, MS, JMIS, AI, DSI, HBR, IEEETrans, AIMag, CAIS, ASQ, HCI, ACMTIS, INTFCS, IJHCS, IJMMS, OBHDP, CSCW, BIT, JPSP, IJHCI, IEEESMC, ACM, JPP, IWC, UMUAI

"awareness" to search for titles, abstracts, and keywords since 1985. The result was a huge list of more than 500 articles, since "awareness" is a general term which is commonly used in many contexts not related to SA. However, as the term awareness is often used in combination with different adjectives when referring to subtypes of SA (Schmidt 2002), this was the only way to examine our research in its entirety without excluding relevant work. To extract the more relevant publications, we then manually reviewed the content and selected only those publications which primarily deal with awareness in the sense of SA. In addition and to augment our scientific foundation, we reviewed the citations of the remaining publications to determine additional relevant work. Finally we conducted a second, more detailed content analysis on the entire set of selected papers leading to a final basket of 48 publications. In this selection process, we excluded publications which did not provide an explicit definition of SA or the subtypes used, did not refer to SA between individuals in collaboration, or did not discuss SA in a business context (e.g. military or hospitals). A list of the final set of publications is provided in the appendix.

Categories of SA and Awareness Information

In total, we identified 50 subtypes of SA during our literature review. In order to structure our approach our next step was to define categories of SA, to which similar subtypes could be assigned to. We did this through a deep analysis of the many subtypes of SA provided in the literature. As a baseline for categorizing, we took the 4 subtypes, offered in Gutwin et al.'s (1996a) framework. First, we discussed if and how it would be possible to assign the 50 subtypes found in our review to the four subtypes of this existing framework. Then, we elaborated to what extent these subtypes had to be generalized and augmented in order to derive broader categories of SA being able to cover all subtypes of SA. As a result we defined 4 broader categories of SA: category 1: activity awareness, category 2: structure awareness, category 3: social awareness and category 4: context awareness.

In the following we will illustrate how we developed the four categories of SA through aggregation and generalization of the subtypes of SA found in our literature review. Moreover, since the emergence of SA is based on the extraction of information from the environment (Dominguez 1994), we will discuss, which categories of awareness information are needed to develop and maintain each category of SA. On a more detailed level, we define specific facets of information each category of awareness information consists of. Finally, an overview of the categories, their assigned subtypes as well as corresponding categories of awareness information and facets will be presented.

Category 1: Activity Awareness

Within the framework of workspace awareness, informal awareness refers to an individual's knowledge of who is around, what other persons are doing, and what they are going to do in a general sense (Gross et al. 2005; Gutwin 1997). On the other hand, workspace awareness has been defined quite similar as the understanding of another person's interaction with a shared workspace and as knowledge about who is in the shared workspace and is doing what, why and in which way (Gutwin and Greenberg 2002). The main difference between both types relies on the aspect, that workspace awareness is limited to the boundaries of some shared workspace, while informal awareness is not. From a conceptual and more abstract point of view, we argue that workspace awareness (Gutwin and Greenberg 2002) is the subordinate concept in that it is a special case of informal awareness (Gutwin 1997) while both types basically refer to tasks and activities of others. In a similar way, Carroll et al. (2003) define action awareness as knowledge about interactions of others with a shared resource and activity awareness as a sense for the long-term endeavours of others regarding project-related activities. Baecker et al. (1993) introduce collaborator awareness and general awareness and refer to it as knowing roughly what others are doing and having detailed knowledge of the activities of others. Further, chronological awareness, task-oriented awareness (Chen and Gaines 1997) and other awareness (Weisband 2002) all focus on knowing about the activities and tasks of others. Even though activities are at the center of the remaining 3 subtypes as well, task (Cooper and Haines 2008; Gutwin et al. 1996a), process (Steinfield et al. 1999; Weisband 2002), and concept awareness (Gutwin et al. 1995) put emphasis on an individual's understanding of the purpose and goals of activities, knowledge about the steps and how to perform a specific task.

From a more abstract point of view, all the above mentioned subtypes focus on activity related aspects which might help to improve collaborative work. We therefore decided to aggregate them into category 1:

activity awareness. Specifically, we define *category 1: activity awareness as consisting of all SA subtypes relating to activities which have to be performed in order to achieve a common goal.*

With respect to the kind of awareness information which has to be extracted from the environment to support activity awareness, several facets can be derived from the aforementioned subtypes. Individuals need information about the tasks and activities their co-workers are currently working on and about those they intend to start in the future to manage their shared tasks in an efficient manner (Carroll et al. 2003; Gutwin et al. 1996a). More general, information is needed about *what others are currently doing* and *what others intend to do in the future.* From a process view, collaborating people need to be aware of *what others need from them, how things have to be done* and what *is the purpose of their activities towards the overall goal* (Gutwin et al. 1996b; Steinfield et al. 1999). Thus, specific information from the environment needs to be provided accordingly. In the following we will refer to all of these aforementioned facets of information as *activity awareness information.*

Category 2: Structure Awareness

As group-structural awareness, Gutwin et al. (1996a) define an individual's knowledge about other's responsibilities and roles within a group as well as their positions on an issue. Similar to the latter aspects, Cooper and Haines (2008) describe behavior awareness as knowledge about who agrees and disagrees on an argument and who participates in which way in a discussion. In contrast, Omoronyia et al. (2010) put more emphasis on the resource aspect when they state that group-structural awareness basically consists of knowledge about the expertise of others. This view is also supported by Chen and Gaines (1997) who argue, that co-workers need resource awareness which enables them to locate specific knowledge and expertise within the group. Similar to the definition of group-structural awareness, Rittenbruch (2002) describe structural awareness as knowledge about organizational settings such as rules of interaction, status relationships and other's roles within the working process.

More general, all of the above mentioned subtypes refer to SA in the sense of an individual's knowledge about the existing informal or formal group structures in an organization. In this regard, we refer to informal work structures as the implicit roles in a group workers have been assigned to or have taken based on their opinions or positions on an issue. Moreover, knowledge about others' informal status, as opposed to their formal status according to an official hierarchy, can be derived as an important aspect of informal group structures. In contrast, formal group structures are referred to as other individuals' official responsibilities and roles as defined by, e.g., organizational charts. Thus we grouped all these subtypes under *category 2: structure awareness, which we define as an aggregation of all subtypes of SA related to knowledge about informal and formal group structures within collaborative work.*

In order to create structure awareness, collaborators need to know about the domain experts and other's official roles in order to work together efficiently (Chen and Gaines 1997; Omoronyia et al. 2010). That is, they need awareness information about *who is a contact person for what.* While this facet of information refers to SA about the formal work structure, collaborators need also specific information for building SA about the informal work structure within their work environment (Cooper and Haines 2008; Gutwin et al. 1996a; Omoronyia et al. 2009). In order to understand why co-workers are making decisions in a certain way, information is needed about the *positions of others on an issue* and *their status within their work environment.* Subsequently we will use the term *structural awareness information* when referring to the aforementioned facets of information.

Category 3: Social Awareness

Within Gutwin et al.'s (1996a) framework, social awareness has been defined as being aware about the emotional state of others, whether they are interested in an issue and are paying attention. Since such knowledge is typically gained within conversations through non-verbal communication, social awareness has been also referred to as conversational awareness (Rittenbruch 2002). In this regard, Vertegaal et al. (1997) argue to add knowledge about who is talking to whom to the concept of social awareness. This has been also stressed by Gutwin et al. (1995) referring to this point as social connections. With respect to non-verbal communication, the term "gaze awareness" has also been used by some authors (e.g., Ishii et al. 1994). Moreover, social awareness is suggested to include a person's knowledge about who can be

disturbed and who is available for interaction (Omoronyia et al. 2010; Tollmar et al. 1996). This has been also referred to as availability awareness (Jang et al. 2000; Steinfield et al. 1999; Weisband 2002) and presence awareness (Cooper and Haines 2008; Tee et al. 2006).

Generalizing from these subtypes of SA, all the aforementioned definitions put an emphasis on knowledge, which is needed to enable effective social interaction between individuals. In contrast to structural awareness as an important prerequisite for effective interaction, the focus here is on knowledge which helps to improve each specific interaction taking place between individuals. For example, while structural awareness enables individuals to determine an appropriate contact person for an issue, knowledge about the availability or emotional state of this person might provide guidance regarding the timing or appropriate style for interacting with that person. Moreover, it has been shown that awareness of the emotions of others may cause a reduction of conflicts between co-workers and higher team cohesion (Ayoko et al. 2008; Stevens and Campion 1994). We therefore *define category 3: social awareness as a broad class for all subtypes of SA relating to social interaction between collaborating individuals.*

For developing social awareness, several facets of awareness information are needed. In this regard, information about *who is interested in a specific is*sue as well as *the emotional state of other individuals* is crucial for effective collaboration (Greenberg et al. 1996; Omoronyia et al. 2009). Furthermore, when people are supposed to work together it is essential for them to know who is available for interaction, that is *who is busy and who is available* (Jang et al. 2000; Steinfield et al. 1999). In this regard, not only information whether somebody is busy is needed, but also information regarding the geographical location of others, especially in distributed settings (Espinosa et al. 2007). Finally, information about *who is talking to whom* is important to provide people with insights about social interactions between others in their work environment (Dourish and Bly 1992; Vertegaal et al. 1997). Since all these facets of information are needed to build social awareness we will subsume them with the term *social awareness information.*

Category 4: Context Awareness

With respect to the framework proposed by Gutwin et al. (1996a) some authors have suggested to add another subtype of SA, labeled as context awareness (Omoronyia et al. 2010, 2009). The notion of context awareness is based on the assumption that individuals have to be aware of the circumstances and facts that surround a particular event or situation to be able to fully understand what is happening. This is due to the fact that even simple activities can take very different meanings dependent on their particular context (Rittenbruch 2002). It is argued that context awareness emerges from the changing state of all other subtypes of SA over time. Similar, contextual awareness has been defined as giving individuals a broad sense of the context in which things are happening (Sonnenwald et al. 2004). Such knowledge might help, e.g., to understand why somebody did something and why something happened (Rittenbruch 2002). This has been also referred to as insight awareness by Cooper and Haines (2008). Moreover we argue that task-socio awareness, which is defined as knowledge about social and political dynamics (Chen and Gaines 1997) is related to context awareness as well. As the term dynamics implies, the focus of this subtype is on a time-related development of social and political aspects, e.g., others emotional state and their connections within a group or their roles and positions regarding an issue. That is, individuals might develop an understanding of the social and political context in their environment through the changing state of other subtypes within the categories structural and social awareness. The same logic applies to the subtype rhythm awareness, which has been defined as an individual's sense for recurring temporal patterns in their environment, e.g., the comings and goings of colleagues (Begole and Tang 2007).

All of the aforementioned subtypes of SA have in common, that they emerge from the other subtypes within the 3 categories of SA over time. Moreover, each of them helps an individual to put a specific event or situation in its environmental context. Thus we assigned all of these subtypes to *category 4: context awareness which we define as an aggregation of all subtypes emerging from the 3 categories of SA over time, thereby providing individuals with a general sense of the context in which things are happening.*

With respect to information requirements, context awareness differs from the aforementioned three types. The rationale for this is grounded in the specific characteristics of context awareness. Clearly, the emergence of context awareness is based on information as well. However, since context awareness is a

multi-dimensional formative construct of the changing state of activity, social, and structure awareness, there is no specific additional information to be provided. Rather context awareness is developed from the other three types of awareness information and their specific facets over time (Omoronyia et al. 2010).

Overview: Categories of SA, Subtypes and Awareness information

In the former sections we have developed four broader categories of SA based on the subtypes of SA we found in the literature. According to the goal of our investigation, we further derived categories of awareness information with specific facets, needed to maintain each category of SA. With respect to context awareness, we have discussed the special relationship of this category with all the other three categories and have argued why there is no specific type of awareness information for maintaining it. However, we expect activity, structural and social awareness to be interconnected and interrelated to some extent as well. For example, awareness about the current activities of others might help an individual to build structural awareness in an implicit way. In this regard, an individual might derive from the knowledge about others' current activities that these are appropriate contact persons to ask for assistance about similar tasks. Moreover knowing about the activities of others might implicitly update an individuals social awareness, e.g., with respect to their availability. Additionally and as argued before, structural awareness might be seen as a prerequisite for social awareness. While it is important to note that such relationships exist, for our research it was necessary to focus on explicit rather than implicit relationships between awareness categories, awareness information and specific facets in order to develop an initial framework. An overview of our findings is provided in Table 1.

Table 1. Categories and corresponding subtypes of SA with awareness information and specific facets	
Category 1: Activity Awareness	**Activity Awareness Information**
Informal Awareness, Workspace Awareness, Action Awareness, Activity Awareness, General Awareness, Collaborator Awareness, Chronological Awareness, Task-Oriented Awareness, Other Awareness, Concept Awareness, Process Awareness , Task Awareness	▪ What are others currently doing? ▪ What intend others to do in the future? ▪ What need others from me? ▪ How have activities to be done? ▪ What is the purpose or goal of an activity?
Category 2: Structure Awareness	**Structure Awareness Information**
Group-Structural Awareness, Behavior Awareness, Resource Awareness, Structural Awareness	▪ Who is a contact person for what? ▪ Who has which positions regarding an issue? ▪ Who has which status in the group?
Category 3: Social Awareness	**Social Awareness Information**
Social Awareness, Conversational Awareness, Gaze Awareness, Availability Awareness, Presence Awareness	▪ Who is interested in a specific issue? ▪ What is the emotional state of others? ▪ Who is busy or available? ▪ Who is talking to whom?
Category 4: Context Awareness	**No specific Information**
Context Awareness, Contextual Awareness, Insight Awareness, Task-Socio Awareness, Rhythm Awareness	Consists of the other three categories of awareness information and their specific facets

Although we identified 50 subtypes of SA during our review, so far we have considered only 26 subtypes to define the four categories of SA as depicted in table 1. The rationale for this is based on our approach of deriving categories of awareness information from the categories of SA and subtypes of SA, respectively. In this regard, all 26 subtypes of SA we assigned to the 4 awareness categories can be viewed as the result of the processing of specific information. That is, e.g., to develop and maintain presence awareness, individuals need information about whom of their co-workers is currently available and whom is busy (Espinosa et al. 2007). However, this is not the case for the remaining 24 subtypes we identified in our review. As our discussions revealed, these refer either to ways how SA is being produced, consumed or disseminated between people or to the level of detail on which SA is achieved. For example, by-product

and add-on awareness focus on the aspect, if there is some extra effort needed in order to create and consume awareness information to achieve SA or if it is generated as a by-product of other activities (Simone and Bandini 2002). Regarding the level of detail, e.g., deep awareness refers to detailed SA about some very special aspect, while global awareness is defined as the much more comprehensive SA which provides an individual with a sense of the whole (Chen and Gaines 1997). While these aspects are important for the design of IS, our work aims at the question which kind of awareness information has to be delivered rather than its production, consumption, dissemination or level of detail. Therefore, we will not elaborate on these subtypes any further.

An overview of all the 50 subtypes we found in our review is provided in the appendix. Moreover, the appendix contains information if the subtypes could be assigned 1) to one of the four categories or not, as they either referred to the production, consumption, dissemination 2) or level of detail of SA 3).

From Awareness Information to Situation Awareness

So far, SA its categories and subtypes, as well as the different categories of awareness information have been treated separately and from a rather static point of view. In this section we develop a process-oriented conceptual model which helps to explain how SA emerges through processing of awareness information over time. In general, process models take on a dynamic view in order to explain how the phenomenon under investigation evolves over time (Mohr 1982, Langley 1999, Van de Ven and Poole). Moreover, such models explain a certain outcome based on a recipe which strings together sufficient conditions occurring over time (Mohr 1982, Markus and Robey 1988).

Based on Dominguez's (1994) definition of SA, the process-oriented conceptual model depicted in Figure 1 is aligned with the four subsequent phases 1) information extraction, 2) information integration, and based upon, 3) development of a mental picture to guide 4) further action. As is common in process-related literature the dynamic, time-oriented nature of the model is thus established through a linear sequence of phases (Langley 1999). Moreover, the model conceptualizes SA as the outcome of two necessary but not sufficient conditions which are sequentially stringed together: availability of awareness information and context awareness. Finally, the model illustrates the specific role of IS as bridging the gap between an individual and others in physically distributed settings.
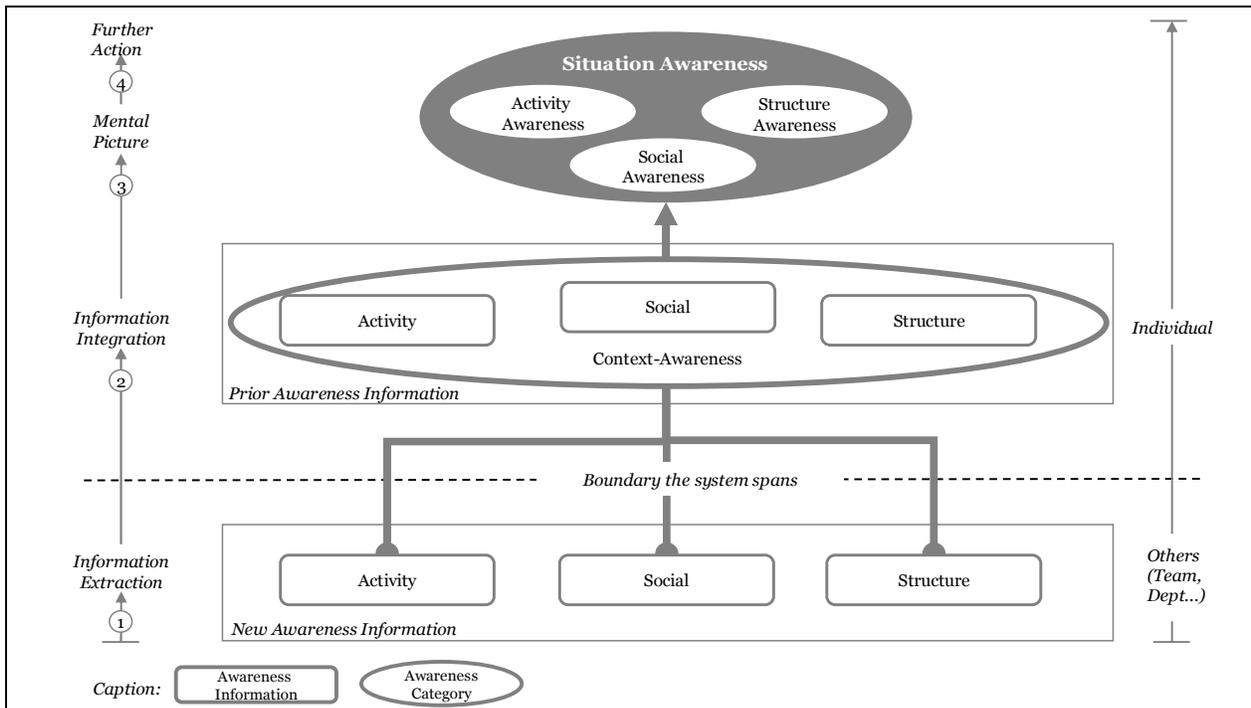

Figure 1. A process-oriented conceptual model of SA in distributed collaboration

As discussed in the former sections, awareness information is a necessary condition for the creation and maintenance of SA. Therefore, the process starts with the *information extraction* phase (Dominguez 1994). As soon as new activity, social, or structure awareness information from others in the environment is available, individuals should be able to extract these in a timely manner. Since this is typically hard to achieve in physically distributed work, IS are needed to span the boundary between these non-collocated people (Hinds and Bailey 2003; Kraut et al. 2002). Most simply, such a system can be seen as an input/output-system which receives awareness information from the environment, and provides it as output to an individual at some other place (Ballou and Pazer 1985). Receiving this output from the system, the *information integration* phase begins at the individual level. In order to make sense out of this new incoming awareness information provided by the system, the individual needs to integrate it in its specific context (Dominguez 1994). In other words, since information holds little value without context, context awareness as a necessary condition for interpreting new incoming awareness information is needed (Omoronyia et al. 2010). As figure 1 depicts, context awareness and all its assigned subtypes accordingly, emerge as an aggregation of prior awareness information the individual has received over time. Moreover, it is maintained through each piece of new awareness information the system provides on the output-side. Finally, SA emerges as a *mental picture* of the situation (Dominguez 1994). Specifically, one of the subtypes within the categories of SA is developed or maintained dependent on the specific type of awareness information provided to the individual. As an aggregation of all subtypes, SA may then provide guidance regarding an individual's *further actions*. From a distributed collaboration view, this may lead to more effective interaction between individuals when working together (Endsley and Jones 1997).

An Application of the Conceptual Model to Enterprise Microblogging

In the following we will use the conceptual model to evaluate an existing social collaboration platform in a real-world case regarding its ability to support SA. Specifically, we analyze the content of a huge dataset of EMB messages to measure to what extent the system provides awareness information to its users. Therefore, we develop a coding scheme which operationalizes each of the three awareness information categories and their specific facets. While this operationalization helps to make our analysis more transparent, it might be a valuable source for future investigation of social collaboration systems with respect to SA.

Although there might be other technologies worth to be analyzed with our conceptual model (see e.g., Gross et al. (2005)), EMB is considered one of the most pervasive forms of electronic communication (Riemer et al. 2010) and as such is a promising way to support SA in distributed work environments within organizations (Meyer and Dibbern 2010; Zhao and Rosson 2009). Moreover, since private microblogging (e.g., Twitter) has gained momentum, enterprises now investigate how to exploit the potential of this technology for corporate communications. However, it remains unclear if EMB leads to improvements in team communication (Riemer et al. 2010).

Content Analysis Methodology

Our analytical approach is based on a manual content analysis, as this is a technique to make systematic, replicable and valid inferences from data to the context (Krippendorff 2004a). Typically, content analysis is used to classify many words of text into specific categories based on an explicit coding scheme (Morris 1994; Weber 1990). As a positivist research method it has been extensively used in social science as well as in decision sciences and IS research (Qu et al. 2008). Dependent on the specific question under research, Hsieh and Shannon (2005) define three distinct approaches: conventional, summative, and directed. Within the first approach, researchers allow the categories and names of categories to emerge from the data, instead of using predefined ones. Similarly, the focus of a summative content analysis is on investigating, identifying and quantifying the use of words or content, but rather to infer usage instead of meaning. Both of these approaches have in common that new theoretical knowledge is derived in an inductive and exploratory way. In contrast, directed content analysis follows a deductive approach as existing theory is utilized to define categories and a coding scheme prior to investigating the data. Typically, the scheme is then applied to the data, to validate or extend an existing model or framework. As

the purpose of the last approach fits exactly the goal of our analysis we will conduct a directed content analysis on EMB data based on the three categories of awareness information.

Case Description and Data Collection

The EMB data is gathered from a financial institution with around 100,000 employees worldwide. In order to enable collaboration beyond departments, countries, and time zones effective communication technologies were needed. Therefore the EMB platform was developed during the first half of 2010. Since its going live in June 2010 it is extensively used by 690 employees from all internal corporate divisions (e.g. IT, HR). The platform can be accessed via a web front end, a desktop application as well as mobile devices. Similar to Twitter, users post short messages that appear in a chronological stream on a user's associated EMB page. Furthermore, incoming message streams can be customized by a "follower" feature. Since participation is non-anonymous each person's name as well as a profile picture are visible as part of the message header. The maximum length of each message is restricted to 300 characters.

We obtained a large data sample consisting of more than 15,000 messages posted via the EMB platform since the going live until December 2010. We cut off the first 3 months of data to ensure that the initial stage of assimilation, which is often characterized by use lags and unstable utilization (Fichman and Kemerer 1999) has no influence on our results. Moreover we utilized the last month of our observations for pilot and coder training purposes (Lombard et al. 2002). As a result we obtained a dataset of 7,852 messages from September 2010 until November 2010 (14 weeks). Of these, 54% were posted within conversations, while 46% were single messages without any reply. On average, each of the 690 active users posted 10.2 messages in this period. According to information gathered in an expert interview with one of the responsible IT managers, approximately 80% of the users are working in the IT department, which is one of the largest internal departments of the financial institution. Moreover, participants range from university hires to managing directors across all age groups.

Content Analysis Procedure

Despite its popularity and widespread use in research, content analysis has been often criticized for its subjectivity (Harwood and Garry 2003). Therefore, all relevant actions and decisions during analysis should be guided by established principles, heuristics, and rules to make the analytical approach transparent and to assure reliability and validity of the results and measures used. Thus, we followed closely the 5-step process for manual content analysis suggested by Morris (1994). Accordingly, we first had to decide on the unit of analysis, which determines the segments the data is broken down for the coding process (Rourke et al. 2001). Within literature, single messages are often used as a unit of analysis (Harwood and Garry 2003; Rourke et al. 2001), as these are objectively identifiable by independent coders. Another advantage of this approach is that analysis is conducted on the original unit as determined by the author (Rourke et al. 2001). Therefore, we decided to choose each post as our unit of analysis.

In a second step, we then developed a coding scheme (Krippendorff 2004a; Morris 1994), based on the three categories of awareness information and their specific facets. Whenever possible, we adapted existing measures from prior empirical studies to our research context. To ensure validity, we conducted intense discussions and asked a panel of one practitioner and two academics to review our measures. Moreover, the coding scheme has been subject to several revisions as a part of the process until the final version was created. Operationalizations of each category and facet of awareness information as well as examples from our data sample used to code the EMB data are illustrated in Table 2.

Next, two authors and one research assistant were provided a training sample of 200 messages for sample coding (Lombard et al. 2002). Since training enhances a coder's familiarity with the scheme this is an important activity to ascertain the objectivity of the judges (Kolbe and Burnett 1991). The results were discussed afterwards and the coding scheme was revised accordingly.
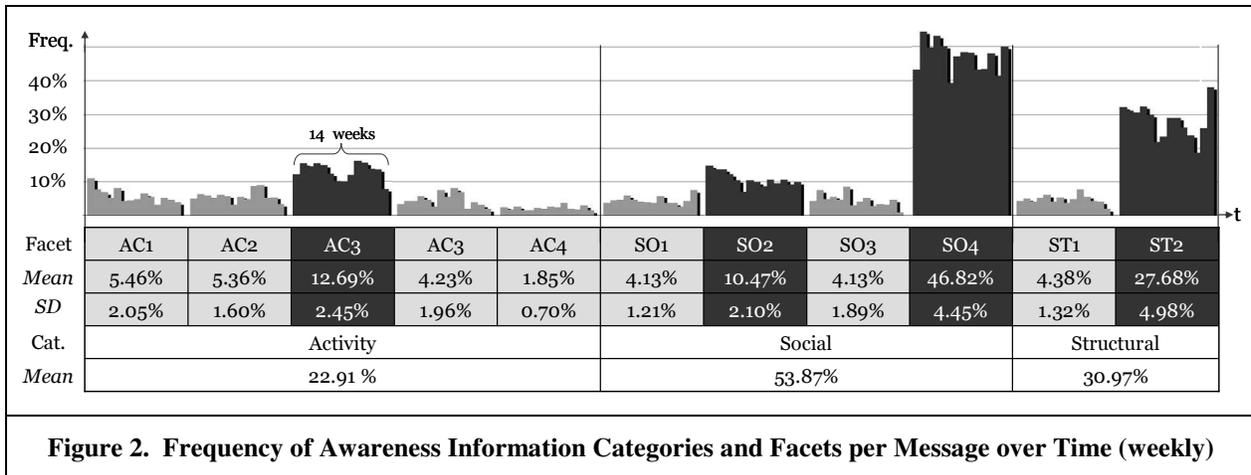
Table 2. Coding Scheme		
Category / Facet	**Operationalization**	**Example from the data sample**
Activity Awareness Information — **AC1:** What are others currently doing?	▪ Statements about activities or tasks others are currently working on (Land et al. 2008)	"Working on reporting for the Summer Sales Campaign"
AC2: What intend others to do in the future?	▪ Statements about activities or tasks others plan to perform in the future (Land et al. 2008)	"We will deploy the new release of the project likely this weekend. So expect some irregularities. Will be up again on Monday."
AC3: What need others from me?	▪ Direct statements about what a person is supposed to do (Weisband 2002) ▪ Expressions for assistance (Zhang 2010)	"@NN I would like to become a NN tester. Please let me join in..." "What's the URL for the NN portal?"
AC4: How have activities to be done?	▪ Direct Statements about how work and activities have to be performed ▪ Statements about how activities should not be done, use of negative imperatives, e.g., „don´t", never (Linden and Di Eugenio 1996)	"@NN yeah... mailbox flooded! it's amazing to note how many people don't know how to use emails properly! The sender should have used bcc instead of To and also to include PLEASE DO NOT REPLY ALL"
AC5: What is the purpose or goal of an activity?	▪ Descriptions of an activity's purpose or goal, e.g. use of purpose clauses and action descriptions (Di Eugenio 1992)	"The cut-off is dictated to us. In order to comply with Federal banking regulations we must finalize the payroll a certain # of days prior to pay day."
Social Awareness Information — **SO1:** Who is interested in a specific issue?	▪ Direct feedback regarding the interestingness of an issue ▪ Indirect feedback, e.g. questions for elaboration (Chen et al. 2010)	"Interesting, I'm not sure if we have a similar policy in the US." "Very interesting idea. Can you expand on that thought a little more, please?"
SO2: What is the emotional state of others?	▪ Paralinguistic cues (Harris and Paradice 2007; Riordan and Kreuz 2010),e.g., vocal spelling, lexical surrogates, spatial arrays	"I am trying EMB for the first time. Yuppee!!!" "Hurray!!!!! Got first XX this time :o)"
SO3: Who is busy or available?	▪ Explicit availability statements (Weisband 2002) ▪ Direct statements about geographical location, place references (Manov et al. 2003)	"He's extremely busy atm and won't be available before September". "I'll be in NN next week, if anyone wants to meet for a coffee, etc."
SO4: Who is talking to whom?	▪ Direct statements about who is talking to whom, has talked to whom (Fu et al. 2008) ▪ Directed communication, replies (Abbasi and Chen 2008; Honeycutt and Herring 2009)	"talking with NN to see what we can do." "@NN Nice blog post! Just talked with NN about re-launching blogs this Fall"
Structure Awareness Information — **ST1:** Who is a contact person for what?	▪ Direct statements about official roles, profession, expertise, experience or appropriateness of others as a contact person for help (Campbell et al. 2003)	"I follow NN as he is an expert on Y and always a good source on new technology." "NN, you can ask NN in Regional Mgmt - she will probably know who it is"
ST2: Who has which positions regarding an issue?	▪ Direct position statements in discussions, e.g. suggestions and opinions regarding an issue (Abbasi and Chen 2008) ▪ Judgemental feedback (Pang et al. 2002)	"I agree with NN... I also would suggest *not* calling it NN as that may confuse people working" "@NN Excellent. Nice work!"
ST3: Who has which status in the group?	▪ Visual, syntactical and grammatical style (Panteli 2002) ▪ Language style, e.g. semantic contagion, verbal mimicry (Kleinnijenhuis et al. 2010)	"Glad to hear that K'bd works"

Following Morris' (1994) content analysis procedure we then started an iterative process of sample coding on a larger reliability sample and revisions of the coding until all reliability measures reached an acceptable level. In accordance with findings from prior research (Lombard et al. 2002) the size of each reliability sample was set to 500 messages which were not part of the sample for our final research. Then, each coder independently assigned all posts in the sample to the categories of our coding scheme. Next we computed Krippendorff's alpha and Fleiss' kappa to assess the reliability of the coding scheme and to ensure the validity of the analysis (Dewever et al. 2006; Lombard et al. 2002). As suggested in the literature, for both measures we considered a value of more than .80 as evidence for the reliability of our measures (Krippendorff 2004b; Neuendorf 2002). Then, discrepancies between the coders were discussed, and the coding scheme was subsequently revised. The whole process was repeated twice until an acceptable level of intercoder agreement was reached for all categories (Morris 1994).

Finally, after reliability of the coding scheme was approved, one of the co-authors processed all 7,852 posts in our research dataset [2]. While intercoder reliability is sometimes computed on the coding results of the whole sample as well, it is a common approach to rely on a census of the data in case of large datasets (D'Aveni and MacMillan 1990; Lombard et al. 2002).

Data Analysis and Results

The results of our analysis show that the messages exchanged via the EMB platform are a rich source of awareness information. Of the 7.852 posts we analyzed, 72% contained at least one of the three categories of awareness information. Specifically, more than 50% of the messages support the users with social awareness information about their colleagues. However, with a share of more than 30% for structural and 22% for activity awareness information the other two types are well represented in the messages, too. On a more detailed level, figure 2 sheds light on how the specific facets of each of the three types of awareness information lead to these results. For each facet, we computed its average frequency within all the messages in our data sample. Moreover, we aggregated the occurrence of each facet in the data on a weekly basis (14 weeks), in order to analyze if there are significant up- and downturns over time.

Facet	AC1	AC2	AC3	AC3	AC4	SO1	SO2	SO3	SO4	ST1	ST2
Mean	5.46%	5.36%	12.69%	4.23%	1.85%	4.13%	10.47%	4.13%	46.82%	4.38%	27.68%
SD	2.05%	1.60%	2.45%	1.96%	0.70%	1.21%	2.10%	1.89%	4.45%	1.32%	4.98%
Cat.	Activity					Social				Structural	
Mean	22.91 %					53.87%				30.97%	

Figure 2. Frequency of Awareness Information Categories and Facets per Message over Time (weekly)

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[2] As a consequence of the specific settings of our research approach, we did not code the data for facet "ST3" (see table 2) for two reasons. First, due to the character limit, users typically have little regard for the proper use of punctuation, capitalization, abbreviations and spelling when using microblogging tools (Dan et al. 2011). Second, an analysis of semantic contagion and verbal mimicry is based on text mining techniques and thus is not feasible within our manual research approach (Kleinnijenhuis et al. 2010). Moreover, the method relies on availability of information regarding a user's position within the company and our data sample did not contain such detailed information on user level.

As figure 2 illustrates, AC3, SO2, SO4 and ST2 occur with highest frequency among all 11 facets of awareness information. Specifically, with an average frequency of 46% the system supports its users with information about who of their colleagues is talking to whom (SO4). Thus, reading the posts on the platform, employees can learn a lot about the interactions and networks of their co-workers. Furthermore, almost every third message contains information about the positions and opinions of the users (ST2). This is especially due to the fact that the platform is used for intense discussions and feedback regarding many different topics. With more than 10% the tool provides information about what the employees need from each other (AC3) to do their work. Another facet which is well represented in the messages is information about the emotional state of the users (SO2). Although it has been suggested that such information is hard to obtain through computer mediated communication (Derks et al. 2008), we found a great amount of the EMB messages contain emotional information. The remaining 7 facets are all well below 10% regarding their frequency of occurrence in the user's posts. Specifically, we did not find much information about the purposes and goals of activities (AC4). Regarding the temporal aspect, visual inspection of figure 2 shows that all facets remain comparably stable during the 3 months of our analysis. This is also statistically confirmed by the fact that all variations from the mean frequency of occurrence (SD) are below 5% for all facets. Thus, it seems that the financial institution's EMB platform was fully adopted by its users during our sample period (Fichman and Kemerer 1999).

Discussion and Conclusion

In this paper, we have developed a process-oriented conceptual model to improve our understanding of SA in distributed collaboration. Integrating findings from IS research and related domains with existing theory on SA from the social sciences, the model explains how SA emerges from the extraction and processing of awareness information at the individual level. Moreover it illustrates the important role of IS for bridging the gap between geographically distributed workers. Further, we developed a broad categorization of different subtypes of SA and derived categories and facets of awareness information needed to maintain them. All constructs being used are grounded in existing theory or have been developed from prior research based on a comprehensive and systematic literature review. Moreover we conducted a sample application of the model to a social collaboration platform and demonstrated how our findings might be used for data analysis purposes. Therefore we developed an operationalization of awareness information to analyze text-based communication and conducted a content analysis on a large dataset of EMB messages.

Theoretical Contribution

The first theoretical contribution of this work is our systematic review of the existing literature on SA. Researchers from IS and related domains have asked for a more parsimonious specification of SA and its subtypes (Liechti and Sumi 2002; Omoronyia et al. 2010) to reduce the ambiguity and fuzziness of the concept (Cheverst et al. 2007; Omoronyia et al. 2010; Schmidt 2002). To the best of our knowledge, we are the first who systematically group the many subtypes of awareness into generalized categories of SA.

Our second theoretical contribution is based upon these general categories of SA, specifically on the information which is needed to maintain them. Since each category of SA is based on the extraction of awareness information from the environment (Dominguez 1994), the three categories of awareness information and their specific facets help to further foster the theoretical understanding of SA. Moreover, since only few measures of SA have been suggested in prior literature (Rittenbruch and McEwan 2009) the developed categories and facets of awareness information are a starting point for conceptualizing a construct to measure SA. In particular, our operationalization of awareness information might be utilized in future empirical studies on SA. In this regard, the developed categories of awareness information and their specific facets offer a flexible framework for other research objects as well, beyond our specific research case of a text-based social collaboration platform.

The third research contribution is the process-oriented conceptual model which illustrates how SA emerges from the extraction and processing of awareness information. While existing research on SA in IS, HCI and CSCW domains has investigated SA preliminary from a technical point of view, the developed conceptual model integrates these findings with theory from the social sciences. As a result, the model

helps to understand why IS are important for the creation and maintenance of SA especially in distributed settings and how they support the emergence of SA on an individual level. Along the four phases as defined by Dominguez (1994), the model depicts how IS help to extract awareness information from the environment and support the development of SA as a mental picture and guidance for future actions. Moreover, it highlights the specific role of context awareness as a necessary integrator for new incoming awareness information.

Finally, we contribute to the few studies on social collaboration platforms, particularly EMB and their usefulness and value for business. In recent times there have been several calls for more dedicated research on the use of social collaboration platforms in enterprises (e.g., Richter et al. 2011). To the best of our knowledge we are the first to analyze the value of social collaboration platforms for SA based on real archival data.

Practical Contribution

The practical implications of our work are twofold. First our framework of SA and particularly our conceptualization of awareness information might help to form the basis for a rigorous specification and evaluation technique of IS designed to support SA (Drury and Williams 2002). On the one hand, the framework might be used to measure to what extent an organization's existing systems already support SA. On the other hand, our framework might be used as a guideline for the design of new systems for supporting SA and their evaluation after implementation. In the empirical part of this article we provide operationalizations of all three awareness information categories and illustrate how these might be applied for evaluating an existing system.

Second, our results provide first evidence that the implementation of social collaboration platforms in enterprises such as EMB might be a valuable investment for organizations. So far, many firms still struggle when it comes to implementing such tools in their communication infrastructure since the positive impact of such platforms on performance is difficult to measure (Richter et al. 2011). However, SA is an important prerequisite for successful collaboration (Endsley and Jones 1997; Kaber and Endsley 1998). Based on our results we thus conclude that EMB can play a crucial role to generate business value from improved SA among employees. Therefore, we suggest organizations to implement those platforms into their communication infrastructure for improving collaboration between distributed people.

Limitations and Future Research

A potential limitation of our research is that there might be more subtypes of SA than those we identified in our literature review. As a result, we can not rule out the possibility that the facets of awareness information are incomplete. However, our literature was guided by a well accepted, systematic methodology in order to reduce the possibility of missing important articles (Webster and Watson 2002). Moreover, the model is flexible enough and can be further supplemented if additional aspects emerge as a result of future research. However, there are many avenues for future research on SA and how IS might help to bridge the physical gap between distributed working employees in collaborative settings. Subsequently, we will highlight two avenues, which seem to be most rewarding. The first avenue is to empirically validate our conceptual model. Future theoretical development may be advanced by empirically validating and testing the impact of the four categories and their facets of awareness information on the emergence of SA. With respect to our model we propose to utilize awareness information as well as its categories and facets as an exogenous variable which loads on the latent construct SA. Since SA is not directly measureable itself, future research will first have to develop an appropriate measure for SA in the sense of an endogenous variable. In this regard, operationalizing work related outcome measures might be a promising approach, since our model suggests SA has a positive influence on work performance (Dabbish and Kraut 2008; Kaber and Endsley 1998). With respect to text-based IS as in our empirical example, e.g., message quality, quantity or response time might be appropriate measures (see, e.g., McLure-Wasko and Faraj (2005)). A second promising avenue of research is to apply the model to other tools and platforms beyond our specific example on EMB. On the one hand it should be analyzed which technologies are appropriate for providing which kind of awareness information. On the other hand, it might be worth investigating to what extent different industries or cultures have an impact on the appropriateness of technologies for providing awareness information.

Acknowledgement

Appendix

Table 3. Articles from literature review and corresponding subtypes of SA	
Authors	**Subtypes of SA (~ awareness)**
Baecker et al. 1993	Collaborator~[1], general~[1], peripheral~[3]
Begole and Tang 2007	Rhythm~[1]
Beranek et al. 2005	Activity~[1], availability~[1], process~[1], social~[1]
Berlage and Sohlenkamp 1999	Peripheral~[3]
Cadiz et al. 2001	Peripheral~[3]
Carroll et al. 2003	Action~[1], activity~[1], social~[1]
Chen and Gaines 1997	Chronological~[1], collective~[3], community~[3], deep~[3], global~[3], group~[3], peripheral~[1], resource~[1], task-socio~[1],
Cockburn and Weir 1999	Group-structural~[1], informal~[1], social~[1], workspace~[1]
Cooper and Haines 2008	Behavior~[1], insight~[1], presence~[1]
Dourish 1997	Asynchronous~[2], synchronous~[2]
Dourish and Bellotti 1992	Passive~[2]
Drury and Williams 2002	Asmmetrical~[2], complete~[2], partial~[2], symmetrical~[2]
Erickson et al. 1999	Group~[3],
Espinosa et al. 2007	Presence~[1], task~[1], team~[3]
Fussell et al. 1998	Passive~[2]
Greenberg et al. 1996	Group~[3], group-structural~[1], informal~[1], social~[1], workspace~[1]
Gross et al. 2005	Informal~[1], social~[1], group-structural~[1], workspace~[1]
Gutwin 1997	Conversational~[1], informal~[1], structural~[1], workspace~[1]
Gutwin and Greenberg 1995	Group~[1]
Gutwin and Greenberg 1998a	Workspace~[1]
Gutwin and Greenberg 1998b	Workspace~[1]
Gutwin and Greenberg 2002	Workspace~[1]
Gutwin and Greenberg 2004	Group~[1]
Gutwin et al. 1996a	Group-structural~[1], informal~[1], social~[1], workspace~[1]
Gutwin et al. 2004	Workspace~[1]
Gutwin et al. 1996b	Workspace~[1]
Gutwin et al. 1995	Concept~[1], social~[1], task~[1], workspace~[1]
Ishii et al. 1994	Gaze~[1]
Jang et al. 2000	Activity~[1], availability~[1], process~[1]
Jang et al. 2002	Activity~[1], availability~[1], process~[1]
[1] assigned; [2] not assigned: level of detail; [3] not assigned: production, consumption, dissemination of SA	

Table 3. Articles from literature review and corresponding subtypes of SA	
Authors	**Subtypes of SA (~ awareness)**
Liechti and Sumi 2002	Contextual~[1], group~[1], peripheral~[1], workspace~[1]
Neale et al. 2004	Activity~[1]
Nomura et al. 1998	Activity~[1], asynchronous~[2], synchronous~[2], workspace~[1]
Omoronyia et al. 2009	Context~[1], group-structural~[1], informal~[1], social~[1], workspace~[1]
Omoronyia et al. 2010	Context~[1], group-structural~[1], informal~[1], social~[1], workspace~[1]
Paul and Beyer 2002	Functional~[3], organizational~[3], personal~[3]
Prinz 1999	Task-oriented~[1], social~[1]
(Rittenbruch 2002)	Asynchronous~[2], contextual~[1], conversational~[1], group-structural~[1], peripheral~[3], structural~[1], workspace~[1]
(Rittenbruch et al. 2007)	Intentionally-enriched~[2], passive~[2]
(Rittenbruch and McEwan 2009)	Event-Based~[2], group-structural~[1], informal~[1], social~[1], workspace~[1]
(Schlichter et al. 1998)	Group~[3], group-structural~[1], informal~[1], social~[1], workspace~[1]
(Simone and Bandini 2002)	Add-on~[2], by-product~[2]
(Sohlenkamp and Chwelos 1994)	Asynchronous~[2], synchronous~[2]
(Sonnenwald et al. 2004)	Workspace~[1]
(Steinfield et al. 1999)	Activity~[1], availability~[1], environmental~[3], process~[1]
(Tollmar et al. 1996)	Peripheral~[3], social~[1]
(Vertegaal et al. 1997)	Conversational~[1], micro~[3], macro~[3], workspace~[1]
(Weisband 2002)	Activity~[1], availability[1], group~[3], process~[1], social~[1], other~[1]
[1] assigned; [2] not assigned: level of detail; [3] not assigned: production, Consumption, dissemination of SA	

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