Chapter 3

Computer-supported Work

In this chapter, I will present the theoretical framework that I have used in my research. The theory and concepts I consider relevant are mainly used in research concerning the organization of work and cooperation between people at work. Furthermore, theory related to difficulties in using technology follows. I have used the theory as a starting point to guide me through the research — both in data collection, analysis, and discussion.

3.1 Work and the division of labor

The hospital and the division of labor within this organization are central to this thesis. Within the field of CSCW, there are several views on how the workplace is organized — common to them is the notion that it is the tasks within the organization that make up the *work*.

Strauss [67] uses the term *arc of work* to describe the totality of tasks in a project. This conceptualization can be used to analyze any division of labor, the work that is done and the workers who are doing it. Central to this conceptualization is the tasks that must be carried out, simultaneously and sequentially. The 'arc of work' that consists of all the tasks in a given project, can partly be planned or designed, but it is likely to be some unexpected contingencies that will affect the organization of tasks in some way. Because the tasks within the arc vary, there is a need for different divisions of workers, as the tasks may require different skill to execute. Thus the variety of work calls for different workers [67].

Building on Strauss [67], Gasser [21] uses the concept "production lattice" as a metaphor for how work is organized in an organization. The production lattice is built up by chains of tasks — including its dependencies and contingencies to the work situation and other tasks and

task chains. However, Gasser [21] focus on how workers adapt their work to badly designed systems and how they use systems in other ways than initially planned to make up for bad systems design.

3.1.1 Tasks and task chains

The tasks that constitute the arc of work is a central part of the analysis. Central questions about tasks include "[...] what, where, when, how, for how long, how complex, how well defined are their boundaries, how attainable are the under current working conditions, how precisely are they defined in their operational details, and what is the expected level of performance" [67, p. 6]. Tasks can thus be seen as separate entities, all which have some properties, including a goal to be achieved, execution and running time, and one or more responsible actors. Also of importance is how the tasks are linked to each other — in *task clusters* and in an *organization of tasks* [67, p. 4]. Gasser [21] views interlinked tasks as a *task chain*, as mentioned previously. Some tasks are dependent on other tasks or chains of tasks to be executed before initiated. Thus dependencies between tasks are often unavoidable.

All tasks are done by one or more actors, or, in some cases, they are automated by technologies. The distribution of tasks among actors can be done in several ways; "tasks can be imposed; they can be requested; also they can be assumed without request or command, but they can also be delegated or proffered and accepted or rejected. Often they are negotiated." [67, p. 6]. Tasks are distributed to actors; a person, a team, department or sub-division, for instance. The attributions of the actors can vary in several ways; based on "experience, skill, knowledge, training, occupation or other social world from which they come" [67, p. 6]. Thus, the distribution of various tasks among various actors is complex itself — which I will come back to in Section 3.4.

Related to this is the research by Gasser [21], on how users integrate computers as a resource into their work, and how they accommodate to make up for computer misfit. The organization and the work within it consist of people who do tasks. The tasks are ordered in task chains, and because of the interdependencies that can arise between task chains, the whole of the work is seen as a *production lattice*. The task is the "most basic unit of analysis", according to Gasser [21, p. 209]. All tasks are done by a person or group and it "presumes some agenda" — something that one wishes to accomplish by doing it. Also, each task "takes place over time and happens in some place" [21, pp. 208-209].

In an organization, all tasks are part of a larger system of tasks that often somehow are connected to or related to other tasks or task chains. In some cases, executing one task depends on the completion of another task, which can cause dependencies to arise between tasks and actors [21].

3.1.2 Workflow

Related to the concepts of distribution of work and chains of tasks are "workflow" — which is the ordering of work or tasks in a process. The term can be used to describe any process that involves some steps to be finished, and is often used paired with positive or negative adjectives — i.e., "good workflow" implies that the work one is doing is flowing well without interruptions.

The workflow within an organization can either be accomplished through "methods which are internal to the work" or by ordering work "[...] through methods *other* than those which the work itself provides" [4, p. 63] — like a workflow management system built on a formal model of the work. The former is explained as *workflow from within*, whereas the latter as *workflow from without* [4].

When introducing technologies that affect the workflow in organizations, all members often do not experience the benefits [26]. If an employee's experience with the technology is that it disrupts their workflow, accepting the technology might be difficult [4, 42]. If one has to adjust their workflow to the technology, additional work may be required, which is further explained in Section 3.4.

3.2 Cooperative work

Within the field of CSCW, defining what is cooperative work has been difficult. Since cooperation is a broad term that can be used to describe anything from two people working together on a task to groups of people or entire organizations, narrowing the scope while at the same time including all types of cooperation is difficult. However, Schmidt and Bannon [55] has established some criteria as to what can be characterized as cooperative work.

According to Schmidt and Bannon, the term *cooperative work* should be "taken as the general and neutral designation of multiple persons working together to produce a product or service" [55, p. 15]. They also argue that people who cooperate are somehow *mutually dependent* on each other; "[...] being mutually dependent in work means that A relies positively

on the quality and timeliness of B's work and vice versa and should primarily be conceived of as a positive, though by no means harmonious, interdependence" [55, p. 13]. Based on this, the three main criteria for work to be characterized as cooperative is (1) there are multiple actors working together, (2) these share a common goal, and (3) they are mutually dependent on each other.

Schmidt and Bannon also argue that the term *group* is often inappropriate to describe the people involved in cooperative work, as it implies that a work arrangement is "small, stable, egalitarian, homogeneous, and harmonious" [55, p. 15]. However, using the term *ensemble* appears suitable, as they can be large, unstable, changing, and distributed. Cooperative work is diverse and come about differently within the organizations in which it happens. Within CSCW, the term *cooperative work* goes beyond the everyday meaning, and stretch to include entire organizations where work is distributed among actors who are mutually dependent on each other's work to reach a goal.

The distinctions between collaborating, cooperating and coordinating have also been highlighted in the literature. Schmidt and Bannon [55] argues that cooperation is the most appropriate term for CSCW, as it includes both groups cooperating on one task, and also larger ensembles of people that are not necessarily cooperating on the same task, but share some common goal. Symon, Long, and Ellis [70], has a different point of view because the term *cooperation* may "[...] preclude consideration of conflict when people work together." The authors find the term *coordination* appropriate, as it "[...] allows consideration of both cooperation and conflict in the workplace" [70, p. 2].

I find it useful to view the hospitals in my case as *cooperative ensembles*. The overall goal of any hospital is treating patients. Of course, not all actors in a hospital cooperate directly, but their tasks are tangled into one another, all with the aim of providing patients with the best possible care.

3.3 Awareness

Awareness became a key term in CSCW as a result of ethnographic studies being used to do workplace studies. Awareness is a broad term that describes how collaborating actors adjust and integrate their activities with their colleagues without interrupting each other [54]. According to Schmidt, the term is ambiguous and used contradictory as a result of this [54]. Furthermore, he believes that the first thing to find out when talking

about awareness in CSCW is what the actors are *aware of*.

Drury, Scholtz, and Yanco [13] have researched *awareness* in HRI. They argue that CSCW and HRI awareness is different because CSCW awareness addresses more people working together, whereas, in HRI, it may involve single or multiple humans and single or multiple robots working together. Furthermore, they argue that more or less awareness is required depending on the autonomy of the robot and the roles that people have in the cooperation.

I have chosen to use Endsley's definition of *situation awareness* as described in Siino, Chung, and Hinds as a starting point in my research; "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" [57, p. 558]. This definition can, in my view, be used both to discuss the robot's awareness of its surroundings and the operator's awareness of the robot's surroundings.

3.4 Articulation work

> *"Articulation work is work to make work work. Or to be exact, articulation work is cooperative work to make cooperative work work."*
>
> – Schmidt [53, p. 19]

Schmidt [53] has recognized two types of articulation work. *First order* articulation work is "[...] the activities of mobilization and deployment — the very constitution and reconstruction of the cooperative work arrangement". These activities include the planning and coordinating of who is doing what, when and how. However, since typical cooperative work arrangements often are enduring or regular, this type of articulation work does not have to be reiterated. *Second order* articulation work is described as "[...] the activities through which the activities of the cooperative work arrangement, as already constituted, are coordinated and integrated." Thus, this type of articulation work is recurring, as long as there is a cooperative work arrangement with "[...] local issues, concerns, priorities, criteria, and so forth" that has to be articulated [53, pp. 27-28].

This corresponds well with how Strauss [66] used the concept, according to Gerson [22] — articulation work *in the first sense* "[...] is about making sure all the various resources needed to accomplish something are in place and functioning where and when they are needed to accomplish a task at a particular time and place" [22, p. 196]. Building on Strauss [66], Fjuk, Nurminen, and Smørdal also made this distinction, using the con-

cepts *explicit* and *implicit* articulation [17, p. 3]. The explicit articulation work is the "coordinating of certain aspects of cooperative functioning", and is thus viewed as the planning and coordinating of work. Implicit articulation work, on the other hand, is described as "invisible but invaluable" in situations where unexpected contingencies occur. Gerson [22] also built on Strauss' types of articulation work. He used the term *metawork* to describe the first — the work of organizing work, and *local articulation* about the latter — bringing together work locally to complete the task. In this thesis, I will use the terms *first order* and *second order* articulation work as Schmidt [53] to describe the two notions of articulation work.

Star and Strauss describes articulation work as "[...] work that gets things 'back on track' in the face of the unexpected, and modifies action to accommodate unanticipated contingencies" [64, p. 10]. Similar to Schmidt's [53] articulation work *of the second order*, Star and Strauss's [64] focus is on the situated aspect of articulation work — in contrast to the planned first order articulation work. This aspect underlines the fact that some articulation work can be expected — but what work it is may be impossible to know when designing technologies.

Carstensen and Sørensen [8] and Færgemann, Schilder-Knudsen, and Carstensen [16] has described the duality between formalized and ad hoc articulation work. As modern work situations become more complex and involve more actors with mutual dependencies, the need for coordination between them also grows to solve complex problems. Carstensen and Sørensen argue that "[...] when the number of mutual interdependent actors involved in a project exceeds the limit of a few, they need to examine the state of affairs in the field of work" [8, p. 387]. This is, however, impossible to do employing ad hoc modes of interaction only and a need for more formalized structures and procedures arise [8].

According to Bendifallah [3], articulation work can also become the primary work of some employees. If what is initially articulation work is recurring activities in someone's work, then the articulation work becomes part of that person's primary work.

3.5 Facilitation

When introducing new technologies into a workplace, some arranging and organizing to make the technology fit into the work practice is to be expected. Kristoffersen and Ljungberg [33] found that mobile technologies tend to demand that the users "make place" for the technology. They

equate the concept of "making place" with articulation work — additional work required to make the technology fit into the work practice.

To facilitate is to "make (an action or process) easy or easier" [12]. When facilitating a new technology in a workplace, one makes changes in the existing work practice or environment to ease the use of the technology. Though most technologies are expected to eliminate tasks and thus ease the workload, research has shown that work rather changes than disappears [21, 73]. The tasks that are supposed to be eliminated by the technology are, in fact, eliminated. But to make sure that these are executed as planned, the user has to *facilitate* for this to work properly.

Some facilitation can thus be understood as a *reaction* to technology that does not fit its context properly. Sokol [60] does not treat facilitation as a negative effect necessarily, but rather as a way of exploring how technologies can be easier to use by adapting, customizing and modifying them. Facilitation may be easy — making "small physical modifications to the configuration of technology" or more complex, like building additional infrastructure to accommodate the technology. [60, p. 295]

The tasks of facilitating a new technology may require a very different amount of effort, because some may be required repeatedly, while others are only needed occasionally. Hence, some facilitation tasks may be preferred over to others.

3.5.1 The Robot Facilitation Framework

To understand how the introduction and use of mobile autonomous robots can alter existing tasks and add new ones, Soma et al. [61] have developed the *robot facilitation framework*. The framework consists of three components; *pre-*, *peri-* and *post*-facilitation.

Pre-facilitation is explained as necessary changes the user makes "[...] for the robot to start, as well as the alterations they think will merit the robot's operations," before the robot starts carrying out its tasks. This includes the installation and physical placement of equipment, such as placing the docking station for a vacuum cleaning robot, as well as small changes in the environment that the user assumes will better accommodate the robot, such as moving cables or carpets that the robot might get stuck in. This type of facilitation can vary greatly since different types of robots require different types of and different levels of facilitation. Small, simple operations to facilitate a vacuum cleaner are as much pre-facilitation as the planning and construction of a new hospital that is going to implement robot couriers for transporting tasks. [61, p. 4]

Peri-facilitation is described as the work needed to "[...] facilitate a smooth operation period for the robots." [61, p. 4] Because of today's technological abilities, robots require an uncluttered operating area. Alterations and preparations made during pre-facilitation are rarely entirely sufficient. Thus, to facilitate a smooth operating time for the robot, humans need to continuously tidy or in other ways aid the robot. These tasks might come as a surprise to the user, as the anticipated changes were made during pre-facilitation. Within the scope of peri-facilitation is also maintenance included, as this is seen as tasks needed to maintain the smooth operation [61]. What I emphasize most about peri-facilitation in relation to the other types is that this type of facilitation is recurring. One has to do the same or similar operations, again and again, to make it possible for the robot to run optimally.

Post-facilitation is bigger changes that the user makes in the robot's environment. These changes are based on the experience the user acquires during peri-facilitation. Some recurring patterns of peri-facilitation can be reduced by making permanent changes and thus avoid some tasks in the future. Typical post-facilitation are changes in infrastructure — buildings where the robot work. However, the authors question whether post-facilitation only should be identified as large, irreversible changes [61]. I find it useful not to limit post-facilitation to this, as it becomes difficult to separate from peri-facilitation. Post-facilitation is in my view *more* permanent changes than peri, but does not have to be large or irreversible. Neither are the tasks recurring — at least for some time.

3.6 Difficult-to-use systems and artifacts

A central focus of this thesis is breakdown situations related to robots in workplaces. Breakdown situations can happen because the system is difficult to use or does not work properly within its planned use context. With most consumer technologies, the user is free to refrain from using an artifact if he finds it too difficult to use. However, this may not be the case in workplaces, and the user will have to find ways to use the system anyway, e.g., by *working around* or *augmenting* the system [21]. Another argument is that "artifacts built on a planning model of human action confuse *plans* and *situated action*" [68, p. 3]. If an artifact is designed to work in some specific way, but does not take into account the *ad hoc* activities in situations in the *real world*, it may become difficult to use.

Some technologies may be well designed to fill a need for potential

users, but other factors can affect the experience to make it seem difficult to use, like "the special needs of individuals, the environment surrounding implementation, inconsistency of the new technology with previous procedures for performing similar task activities" [60, p. 283].

Bratteteig and Verne [5] investigated the reasons why people refrain to use technological artifacts and found three main reasons why artifacts are difficult to use; badly designed systems and artifacts, the artifact in its use context and other people's activities. *Badly designed systems and artifacts* is a critique on the artifact itself — for instance, its physical design or interaction — that makes it difficult to use. *The artifact in its use context* refers to difficulties using an artifact because it is not customized to the environment in which the artifact is supposed to work. *Other people's activities* are recognized as problems caused by factors outside the user's control, like the fact that the system is part of a larger, complex system [5]. Thus, difficulties using technologies may be the result of a number of disparate factors.

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