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# A Cognitive Assistant for the Emergency Department

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## Abstract

Work in an emergency department is challenging for clinicians and nurses. The fast pace and the large amounts of data captured make the ED an interesting application area for cognitive support. Data from electronic health records can be complemented with sensor data to capture the rich interactions between providers and patients. This data can be used to trigger and augment reflection in-action of providers to ultimately make better decisions. By capturing the personal experience of each individual and relating it to the planned or ongoing changes in care practices, every provider can participate in the ongoing improvement of care practices.

## Introduction

Reflection is a core process for improving work performance both on an individual [4] as well as collective level [5]. Building on the existing success of self-tracking tools, we see a potential that similar tools can empower employees at the workplace. Highly dynamic work environments like an emergency department (ED) are especially challenging and are a potential application domain for cognitive support. The work in an ED is characterized by a challenging combination: frequent interruptions and critical decisions. Sensors and mobile applications can continuously record the daily work while an employee, e.g. a nurse, can focus on the current task. Similar to

the private usage, the data can be used *"to reflect upon one's data, extract meaningful insights, and make positive changes.[3]"*

Our understanding of reflection builds on the work of Schön [13] who distinguishes between reflection in-action and reflection on-action. Reflection on-action refers to the retrospective analysis of experiences by looking at them from a new perspective. Reflection in-action is connected to an ongoing activity and is driven by new surprising "back talk" of a situation or problem. While time to reflect on-action is rare in an ED, many activities in the ED can be understood as reflection-in-action. For instance during a diagnosis, clinicians have to constantly re-evaluate their working diagnosis in the light of new evidence. Therefore, we see a potential to facilitate reflection in-action in the ED by using self-tracking technologies. According to Rivera-Pelayo et al. [14], self-tracking can (i) track cues, (ii) foster the initiation of reflective processes and (iii) support the recalling and revisiting and analysis of data to make sense of past. In other words, additional data can create more and richer "back talk" to facilitate reflection. Moreover, the task of tracking a specific item can be seen as an explicit trigger of reflection.

We have conducted initial observations in the ED to analyze the current workflow, technology usage and communication patterns. This position paper outlines our approach to facilitate reflection by self-tracking. The following section describes challenges for such a solution in the ED. The approach to design a cognitive assistant is presented and we outline related challenges for such an approach and lifelogging in general. We conclude by summarizing our contribution to the workshop.

## **The Emergency Department**

Healthcare providers in different roles were shadowed in overall 23 observations in two emergency departments. The two EDs differ but each of them is a complex socio-technical system [7]. The work in the ED is different each day as staff and patients are changing. The work is driven by ad-hoc requests and characterized by interruptions. Decisions have to be made under time pressure and with incomplete knowledge. The use of heuristics is common. Nurses, clinicians and other providers collaborate, share knowledge and last but not least guide the patients and their companions through this process. Work practices are defined by protocols but often realized in an ad-hoc manner.

The three main activities for providers in the ED are patient care, communication and documentation. The ratio of these activities varies according to the provider role and has changed with the introduction of technology. IT systems have replaced the large majority of paper based documentation. These systems deliver a higher data quality by enforcing structured data input and providing a central data repository. In consequence, clinicians spent the majority of their time in front of a computer to read and document their work. Other departments receive patients from the ED and built on its processes and the resulting data. All activities and decisions have to be documented to inform other providers in and outside of the hospital.

The ED has to implement medical advances in emergency care as soon as possible. This can be the use of a specific medication or a change in workflow. A current example is the transition to a new procedure to recognize and treat sepsis patients. Sepsis is "a life-

threatening condition that arises when the body's response to an infection injures its own tissues and organs." [16] Early recognition of sepsis is critical for a successful treatment. The new sepsis guidelines change the used criteria and involves multiple providers, e.g. triage nurse, charge nurse, nurse and attending in the ED.

### **Supporting Reflection in the Emergency Department**

Electronic health records (EHR) capture the majority of task related information in the ED. The EHR data describes the care activities in an objective manner. The crucial collaborative and communicative aspects of care are only partially, if at all, recorded. The subjective perspective of providers that might drive a change in tools and care practices is not present in this data. Wearable sensors and mobile applications can capture the collaborative aspects and the subjective experience of a provider. This data can empower the physician by: a) providing memory support to reconstruct critical situations, b) providing quantitative evidence to support employees in negotiations with other stakeholders and c) motivate change by constantly monitoring and visualizing progress.

The development and introduction of the new sepsis protocol is a first use case. The early recognition of sepsis will be supported by visualizing the probability of sepsis for the given chief complaint and vital signs. The collaboration between providers will be tracked by the EHR and wearable sensors. The new protocol will change communication patterns and the timing of treatments. The clinical documentation can show the impact of the new procedure but lacks qualitative data about the process. Sensors can capture the details of

specific sepsis cases so that employees can reflect on the introduction. For instance, changes in communication patterns could point to undesired shifts in workload or the need for additional means of communication. While these changes may sound trivial, these are the small steps that lead to an ongoing and substantial improvement of care.

A critical question for such a solution is the integration of the data presentation into the daily workflow. Providers have to reflect on the data and appropriate the defined processes to the needs of their ED. Studies in healthcare environments [9], [10][13] indicated that reflection on-action required a facilitator or a group meeting to review the data. However, physicians do not have the time to take part in frequent workshops. In contrast, users in the same studies frequently demonstrated reflection in-action for example when collecting data on processes or when discussing a problem. The short interruption to note down an event can trigger reflection in-action and new insights as demonstrated by the collected notes. Hence, a good time to present data is the moment when more data on the same topic is captured.

Analyzing the ED on the basis of distributed cognition theory [6] can help to identify suitable integration options. Distributed cognition postulates that cognition can be off-loaded in the environment. Tools and other persons can support various tasks and shape these cognitive activities. Cognition is understood as a collaborative, distributed activity. This description matches the collaboration in the ED. Providers collaborate and use their environment to support cognitive tasks. We are looking at existing knowledge acquisition points and analyze the existing cognitive

support mechanisms to extend them with recorded data. For instance, some physicians use small sheets of papers to keep track of their patients when they are not in front of the computer. Augmenting these notes with current digital information is one of the currently discussed implementation options.

### **Design Challenges**

A cognitive assistant for a work environment and especially for highly regulated environments like an ED has to deliver on a variety of requirements beyond the technical challenges. Legal constraints, implications of hierarchies, employee motivation, collaborative usage patterns, and implementation challenges have to be taken into account to be successful.

Lifelogging tools have to provide a clear short-term benefit to motivate their usage. For example, the envisioned tools for the ED might help to uncover new problems, if applied regularly. However, the reward for this effort is unclear during the initial usage and does not provide an obvious benefit in the short term. By connecting the monitoring application to an ongoing transformation, the lifelogging can be built on a common goal. Providers may use the tool to complain about the change or use the data to drive it. In both cases the monitoring helps them to immediately articulate their needs.

The ED already generates a wide variety of data for clinical documentation and billing purposes. Clinicians have to document all their work for each patient. The majority of this data resides in the electronic health record and is bound to a patient. However this data is protected by privacy laws; in case of the US the meaningful use [2] and HIPAA guidelines [18]. While

the ED is already a highly monitored environment the subjective and collaborative nature of the captured data raises new questions. For instance, recorded data might be used against a clinician, if malpractice is suspected. These challenges are specific to this use case but similar legal challenges can be expected for most lifelogging applications in a workplace.

Hierarchies are present in many workplaces and do not only aggravate the legal challenges but might lead to undesired side effects. Managers could turn self-tracking into an employee monitoring to enforce desired behaviors [16]. Employees who suspect such usage could cease to use such tool or find ways to generate fake data. The abuse of such a system is difficult to prevent as the creation of shared knowledge is the goal.

Data in the workplace will often not only relate to an individual but to a team. Personal data of several individuals has to be shared to form a common artifact. Existing self-tracking applications already implement sharing functionality but Rooksby et al. [15] argue that these features are mainly used to announce achievements to friends or compete with other users. This kind of sharing typically serves to increase user motivation via competition or peer recognition [8] rather than to support team and communication processes, as it is necessary in work settings. A shared representation is required that supports the co-construction of meaning with the ED and may act as a boundary object to other departments.

The complexity of the healthcare environment and the dependencies between systems make this a DesignX problem [11]. Therefore, a solution can only be found

in small incremental steps that are conducted in close cooperation with the user. Healthcare design means designing a service as part of a complex system. While devices and IT artefacts may play a role, they ultimately are only means to realize the desired service: providing the best care possible. Healthcare providers already have values and behavioral patterns. It is crucial to change the mind of those involved by sharing and iteratively broaden their perspective. Data can be an important argument in this process. The technology has to be embedded not only in a design process but a cultural change [12]. Otherwise the impact of solutions will wane and small achievements will be reverted to the well-known manner of handling or ignoring these challenges [1].

### **Conclusion**

Self-tracking can play a decisive role in empowering employees as a cognitive support. IT systems and sensors are already collecting data for clinical, management and billing purposes. Sensors and monitoring applications can complement the data. The combination of cognitive support and culture change could spur innovation and care quality in healthcare.

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