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EPSRC Programme Grant EP/G059063/1

Public Paper no. 221

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Furniss, D., Blandford, A., & Mayer, A. (2014). The Wrong Trousers: Misattributing medical device issues to the wrong part of the sociotechnical system. Paper presented at the Workshop on 'HCI Research in Healthcare: Evidence to Practice' at CHI 2014, Toronto, Canada, April 2014.

PP release date: 9 May 2014

file: WP221.pdf

The Wrong Trousers: Misattributing medical device issues to the wrong part of the sociotechnical system

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Abstract
HCI does not have well developed theoretical underpinnings to capture how different parts of a sociotechnical system impact medical device design and use. We report an issue that was identified during an ethnographic study of infusion pump use on a haematology ward: the frequency of the alarms caused frustration to staff and patients. Staff understood this to be a device design problem outside their control – a manufacturing issue. It is actually configured this way by the hospital – a device management issue. This misattribution impacts corrective action, and the quality and safety of patient care. We highlight three theoretical areas that could provide leverage for understanding issues such as this.

Author Keywords
Medical device, reaching out, meso-ergonomics, distributed cognition.

Introduction
In Nick Park's 1993 animation, *The Wrong Trousers*, Wallace and Gromit are thrown into chaos as their techno-trousers are configured wrongly and the culprit behind this mess evades detection because he could not be correctly identified (i.e. the penguin was dressed as a chicken). During an ethnographic study of infusion pump design and use we also witnessed users stuck

with the wrong technology (i.e. alarm configuration issues), and the problem evaded corrective action because the root cause had not been properly identified (i.e. it is a management issue rather than a manufacturer issue).

This paper is not only about recognizing issues with devices, but also recognizing which part of the larger sociotechnical system is best placed to take corrective action. We highlight some areas that could provide theoretical underpinnings for such issues.

The Issue: The Nuisance of the Pre-Alarm

We investigated infusion pump design and use issues on a haematology ward. On the ward, each patient had their own room for infection control reasons. ,. Nurses would wash their hands, put on disposable gloves and an apron and even a mask on entering the patient's room, and wash their hands on leaving it, all depending on the patient's condition. So there is a relatively high cost in terms of time and effort for accessing patients' rooms.

Early on in the study, both patients and staff voiced concerns over the frequency of the infusion pumps' alarms. The pumps had a 10 minute pre-alarm, so 10 minutes before the end of the infusion the alarm would sound. This was intended to give the nurse warning to prepare for the end of the infusion. Generally, the pump would sound next to the patient: it would not be heard by the nurses outside the room so the patient would press their call button, the nurse would stop what they were doing to attend to the patient, the nurse would go through the cleaning procedures to enter the patient's room, and they would silence the alarm. They could not just wait there for 10 minutes so they would leave and come back when it started alarming again at the end of the infusion.

The patients were frustrated by this seemingly needless alarm, and it disrupted the nurses' work unnecessarily. On top of this we received reports that some patients would try to silence the alarms themselves which could cause problems if they did not know how to do it correctly; nurses discreetly advised some patients how to silence the alarms (this was against hospital policy and was only done for patients in whom the nurses had confidence); one patient even reported lying next to an alarming pump for the full 10 minutes because they did not want to disrupt the busy nurses.

The nurses reported to us that soon after the infusion pumps were installed they had raised the issue of the pre-alarm with the appropriate person but they were told that this was just how the pumps were designed. The nurses resigned themselves to putting up with the pre-alarm with patients affected and complaining.

Looking outside-in, as a usability researcher, further investigation found that this is a configurable setting on the pumps. Hospitals in the UK have been encouraged to standardize their devices (e.g. see Werth & Furniss, 2011) and in this hospital this included the device configuration. However, whereas a 10 minute pre-alarm might suit other wards, where accessing pumps has low costs in terms of time and effort, it is a nuisance for the staff and patients on the haematology ward. This situation has persisted because after their initial complaint the nurses understood that there was nothing that could be done.

Potential Theoretical Underpinning

This is not the first issue that we have heard of that has been misattributed to the wrong part of the sociotechnical system. For example, we've heard from a major infusion pump manufacturer that medical staff complained that their pumps alarmed too frequently because they were too sensitive to air bubbles in the line. It was not in fact the design of the pumps but how the hospital chose to configure them, i.e. this sensitivity was adjustable and hospital management have control over that feature.

Part of the broader issue here is that until the problem is attributed to the correct part of the sociotechnical system, appropriate corrective action cannot be identified. They are stuck in the wrong trousers and they do not know the right culprit to chase.

We are not aware of well-developed theory in HCI that focus on investigating how the design and use of medical devices are affected multiple sociotechnical levels, and how effects might be misattributed to the wrong part of the sociotechnical system. We review three areas below that could provide a theoretical underpinning for these sorts of issues.

First Area: Distributed Cognition

Distributed Cognition (DCog) looks at how cognition is coordinated in the environment (Hutchins, 1995). It delimits the locus of cognition (i.e. it can happen outside of the head – e.g., a diary is an example of distributed memory), and delimits what can be involved in cognitive processes (i.e. cognition is not restricted to thought processes alone but can include Post-It notes, tools, maps, etc.) (Hollan et al. 2000). Hutchins (1995) uses examples from ship navigation to show how cognition is shaped and influenced by the more immediate use of tools and representations in the environment, but also the development of tools over a longer period of time. This latter feature shows how technological and cultural developments impact the coordination of cognition, e.g. the advent of the computer has dramatically changed how information is processed at work.

We have used DCog as framework to guide our ethnographic data gathering and analysis. More specifically we have used DiCoT (Furniss & Blandford, 2006), which encourages the analyst to develop five models of the system in DCog terms. However, reference to different levels within a system is only implicit in DCog. For example, there are methodological choices about whether to focus the analysis at an individual, desk or room level, but there is no explicit advice on, for example, recognizing if design configuration decisions by hospital management impact performance on the ward. It seems there is potential theoretical underpinning in DCog but it currently lacks the explicit support we are looking for.

Second Area: Reaching Out

Grudin (1990) uses the concept of 'reaching out' to describe how problems with computer systems have advanced from hardware issues (1950's), to software issues (1960-70's), to perceptual-motor interface issues (1970-90's), to more advanced interactions with the computer as a dialogue (1980's +), to group working issues (1990's +). At each level new problems bring with them new forms of expertise needed to address them, e.g. from electronic engineers, computer scientists, HCI researchers and ethnographers.

Grudin's term is rooted in the historical development of computer systems and the focus of its research over many years. 'Reaching out' has not been operationalized as a concept for analysis, but its focus on technological development and evaluation and its emphasis on how expanding levels of a system can impact the technology show promise. For example, perhaps a medical device can be considered to 'reach out' to different levels of a system, so we can explicitly consider whether we have attended to the correct level in the evaluation of a device's performance, e.g. to the management's pre-alarm configuration decision rather than the device manufacturer.

Third Area: Meso-Ergonomics
Karsh et al. (2014) define an area of meso-ergonomics, which focuses on the causal relationships between at least two different levels in a sociotechnical system. This contrasts with approaches to ergonomics that look at organizational aspects (macro-) and approaches that focus more on physical and cognitive elements of a system (micro-). They describe a process for defining hypotheses between different levels to investigate causal mechanisms and influences between levels. Meso-ergonomics seems relevant to the problem at hand. However, there is still work to be done in terms of developing models for recognizing and describing these issues in relation to the design and use of medical devices (quite different to hypothesis testing).

Conclusion
There is a need for HCI to develop concepts, models and tools that can more readily capture how the interactions at different levels of a socoiotechnical system impact on the performance of technology. This is pertinent to the 10 minute infusion pump pre-alarm issue we have raised, and relates to ongoing evaluations we are conducting on an inpatient blood glucose meter. Medical staff and patients may be suffering because they are stuck in the wrong trousers and they do not know the right culprit to chase (e.g. hospital management rather than the device manufacturer). To our knowledge HCI does not have a well-developed theoretical underpinning for dealing with these issues. We highlight three areas that could be developed and appropriated for this purpose.

Acknowledgements
We thank all the staff and patients that took part in the study. Dr Paolo Masci contributed to early discussions about whether the nuisance alarm was a configuration issue. This work is supported by the UK Engineering and Physical Sciences Research Council [EP/G059063/1].

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