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Resilience through interpretive practice – A study of robotic surgery

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A B S T R A C T

The paper provides an ethnographic description of robotic surgery, along with task and work-domain analyses of it, with focus on surgeons' adaptation to situational demands. Thereby, the study conducted ties in with the discussions on resilience and interpretive practice, theoretical approaches that consider human capability and improvisation in activity as sources of safety. The study methods include observations of operations, video analyses, interviews and self-confrontation sessions (i.e., surgeons commenting on video samples of their own work). The results are summarised in a conceptual model encompassing the basic elements that enable robotic surgery as an activity: manual, perceptual, social, and cognitive aspects are covered at three hierarchical levels, from strategies and planning to routinised techniques. Uncertainties and complexities that render adaptation challenging are elaborated upon. Robotic surgery could be considered a complex form of navigation since where anticipatory interaction with the environment is needed – the surgeon creates the landscape where the operation takes place, and tissues are identified and separated by palpation, albeit without tactile feedback, and with careful consideration of the patient's health. In this challenging environment conflictual aims are to be addressed: minimal damage should be induced while one removes the cancer. The findings suggest that resilient activity is manifested in an interpretive human–environment connection wherein appropriate generic principles and aims guide more specific work actions; a hierarchy in adaptation to situational demands can therefore be identified as the specific actions, usually based on relatively fixed routines, vary and adapt in line with higher-level principles.

1. Introduction

Surgery is a safety-critical activity that involves adaptation to situational demands. There are differences between individual patients who have the same general conditions, and some details of the operation might not be known in advance. In a sense, the specifics of the patient's anatomy are uncovered as the operation progresses. Moreover, surgical work is, in essence, manual activity, which implies that there is always inherent variation in the surgical work produced by the movements of the surgeon's hands. Even in robotic surgery, which is mediated by a machine, the surgeon realises the operation with her or his own hand movements and not by precise predetermined procedures.

In the adaptation to situational demands that this entails, surgical work requires what is called 'resilience' in safety science terminology. One definition of resilience, offered by Hollnagel (2011, p. xxxvi), is 'the intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions'. Resilience, as a new way of thinking about safety, can be explained in terms of the Safety-I and Safety-II concepts (Hollnagel, 2014). Broadly speaking, the former understands safety in terms of identifiable failures or malfunctions. These may occur in a certain aspect of a system, such as a technology or human activity, and the latter is typically considered the prime source of hazard: the human element is more variable than technology, which, in principle, can be controlled and measured more precisely. With Safety-II, the professionals working in safety-critical domains are seen as providers of safety, since human actors are able to perform adjustments as needed in response to the variable demands and conditions. Safety-II thus steers the focus from mistakes to adaptation to situational demands. The literature (Hollnagel et al., 2013) argues that Safety-II thinking is of special relevance in health care, where adverse effects take place in unacceptable amounts.

What the existing resilience literature typically seems to lack, however, is understanding of how adaptation actually takes place within a certain work context. What are the principles and aims that guide adaptation? What uncertainties in work that necessitate workers'

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adaptation (without uncertainty, no adaptation would be needed)? Which complexities in the work make adaptation demanding? What kinds of information sources are used in decision-making that leaves room for adaptation? What types of actions does the adaptation comprise? This paper addresses questions of this kind in the context of robotic surgery for understanding adaptation in this work context. While we concentrate specifically on one type of operation, radical prostatectomy (which involves removal of the prostate gland), many of the findings are generalisable to any complex surgical operation.

We consider health care to be an especially challenging safety-critical domain in the sense that the object of work – the patient – is a source of uncertainties that bring about a need for adaptation. This adaptation is challenging and involves interpretation because human body is enormously complex. That said, not every aspect of surgeons' work varies. For example, certain medical principles are to be followed in virtually any situation. Accordingly, a certain 'hierarchy' can be identified in adaptation to situational demands – some parts of the work vary while others remain stable. Currently, the resilience literature seems to be relatively vague with regard to adaptation. By discussing hierarchy in activity, we can achieve conceptual precision: we propose that adaptation can take place at multiple 'hierarchical levels' of activity. The take-away message of our study for the safety science literature is that resilience manifests itself through interpretation that involves situational adaptation in accordance with the demands of the work, the aims for it, and the principles behind it.

Thoughtful interpretation seems to be essential in performing the specific surgical procedure we studied, because radical prostatectomy entails some contradictions. The surgeons address two conflictual aims simultaneously: a cancerous prostate gland is to be removed in such a manner that enough of the surrounding tissue is cut away to remove the cancer completely, but at the same time enough of the surrounding nerves should be preserved to retain erectile function. In modern robotically assisted radical prostatectomy, the outcome in 15% of operations has been that there were cancer cells found along the edges of the removed tissue compromising (while not fully negating) complete cancer removal. Whether these 'positive surgical margins' exist is determined after the operation via examination of tissue samples from the removed prostate gland, and the likelihood is strongly influenced by the surgeon's experience (Yossepowitch et al., 2014).

2. Theoretical framework

2.1. Resilience in activity: The interpretive practice approach and core-task analysis

Our study can be seen as a continuation of a line of study examining interpretive practice (Klemola and Norros, 2001; Norros et al., 2015). In this stream of work (Savioja et al., 2014), it was found that even in highly regulated and proceduralised nuclear power plant operation work, the operators' actual work practices vary considerably. In actualisation of the strictly defined procedures, some work shifts were observed to employ additional work practices, elements not directly dictated by the guidelines but that presumably contribute to the system's resilience. 'Interpretive practice' was a label given to these behaviours to highlight operators' interpretation of the situation in questioning of the observed phenomena, dialogue within the team, anticipation of system state, and use of various information sources. In their analysis of work practices, Norros (2004, 2014, 2017) and colleagues (Savioja et al., 2014; Wahlström et al., 2013) human actors connect themselves to the possibilities of the environment by continuous action–perception cycles. Differences in types of work practices reflect differences in human–environment connection in the analytical model developed by Norros (2004): some activities echo the internal reflection of the operators (as in the above-mentioned interpretive practice) while other activities are seen as predominantly guided by the pre-defined rules (behaviours of this kind have been called 'confirmative practice') or by features of the environment (in 'reactive practice').

In Norros's (2004) thinking, however, not just any kind of activity that entails drawing from workers' active reflection can be seen as a manifestation of 'interpretive practice' and as providing resilience in safety-critical work: the activities have to make sense in view of the tasks and demands of the work assignment in question. According to her, to delineate which activities these are, one can use the core-task analysis method, which utilises a theoretical model of human–environment interconnection (Norros, 2017). The model assumes that safety-critical work activity entails generic control demands related to (1) dynamism (i.e., temporal demands, such as a need to make quick decisions), (2) uncertainty (i.e., unexpectedness of events, or insufficient or imprecise information), and (3) complexity (i.e., multiple, reciprocally connected influencing elements, such as patient anatomy, technology, and human behaviour). Three basic features of work activity, in turn, can be seen as resources with which these control demands are addressed: (1) skill, (2) collaboration, and (3) knowledge. Work activity can be analysed through exploration of how these control demands and resources connect with each other, in which the connections found are called core-task demands of the relevant work domain. Overall, then, the interpretive human–environment connection is manifested as the workers use their skills and knowledge (i.e., not only procedures and obvious environmental cues) to mitigate and overcome the complexities and demands associated with their work assignments in a manner that is meaningful in a specific situation.

Our approach is consistent with these thoughts expressed by Norros (2004, 2017) about what kind of worker activity supports system resilience – the concept of interpretive practice encapsulates this. Our data are analysed accordingly in consideration of the conceptual elements of core-task analysis and action–perception-cycles.

2.2. Adaptation in view of Leontev's activity hierarchy

To carry the discussion of adaptation to situational demands forward, we apply Leontev's (1978) theory on activity. In Leontev's view, three levels can be identified, these being (1) activity, (2) action, and (3) operation (see Table 1). 'Activity' is the highest level in this

Table 1
An interpretation of adaptation to situational demands through Leontev's (1978) activity hierarchy.

Level in the hierarchy	Simple example	Content/contributors	Adaptation to situational demands
Activity	Building a house	• Principles (e.g., scientific or practical) • A model encompassing chains of actions • A general motive	• Variation through entailing different kinds of 'actions', in varying order
Action	Raising the roof	• Sub-elements of the activity • An immediate and well-defined conscious goal	• Variation through entailing different kinds of 'operations', in varying order
Operation	Hammering	• Actualisations of actions • Usually routine, non-conscious items • Occurring in conjunction with the immediate conditions and the tools used	• Inherent variation as operations are actualised in conjunction with the situational conditions