Technological advances in the analysis of work in dangerous environments: Tree felling and rural fire fighting

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1. Introduction

Dangerous work situations, by their very nature, are worthy of attention from ergonomists as it is important that we work to understand and reduce the risks inherent in physically demanding work situations. These work environments are typically difficult to study comprehensively, especially as the presence of the ergonomist in the field is likely to impede work and even exacerbate already precarious work situations. Thus, for their own and the safety of others, and because they can collect data in a controlled environment, ergonomists turn to their laboratories as a proxy - sometimes focusing on only a few variables of interest, and sometimes designing complex and challenging experiments in attempts to replicate the complexities of the actual work environment. However, no laboratory can hope to capture all conditions of the field.

2. Research Objectives

The objective of this study was to explore the use of new technologies to facilitate the field study of people engaged in dangerous work situations without disrupting the work or adding to the danger. This was achieved through the investigation of work activity in dangerous environments: tree felling and rural fire fighting.

3. Methodology

An innovative suite of equipment was developed for the study, enabling data collection that did not disturb or inhibit the individual working in dangerous, and sometimes extreme, conditions. Forest workers and fire fighters wore helmet and body mounted video cameras during their normal work. The video was subsequently used for task analysis using the software package Observer XT. The qualitative component of the study consisted of a semi-structured interview (Singleton and Straits, 2010) comprised of several open-ended questions, which encouraged the participants to use their own words to describe their experiences and perceptions of hazards in tree felling and hazards, workload and productivity in rural fire fighting. The participant viewed video and audio from their work (fire) or another’s work (felling) and commented on what they saw. The interviews were audio recorded onto a concurrently playing video file of the helmet camera recording using the computer software program Camtasia. This ensured that participants’ responses could be heard and their corresponding helmet mounted camera video images be seen on the screen.

The two case studies formed the basis for an investigation into three aspects of work: first, to record, measure and understand the work (including physiological workload) of people engaged in dangerous occupations; second, to understand how hazards were identified and dealt with by individuals working in extreme conditions and third, to gain insight into hazardous work environments for the purpose of enhancing training for personnel working in dangerous conditions.

4. Results

The forest worker sample was eight full time professional loggers working in Pinus radiata harvesting operations in the Central North Island of New Zealand. Three experienced tree fallers had an average of 8.3 ± 1.5 years (± SD) tree falling experience. The five novice tree fallers had 1.1 ± 0.8 years (± SD) tree falling experience. The three experienced tree fallers were significantly more productive felling an average of 34 trees / hour compared with the five novices who felled an average of 17 trees / hour. Experienced fallers tended to take a greater proportion of their time preparing the top scarf which is the first felling cut from which all other cuts follow. Experienced fallers looked up 6 times per tree which was significantly less frequently than novice fallers who looked up 15 times per tree. This study did not provide data on exactly what they looked for or at in the aerial scene – but it is possible that because of their greater experience they were able to identify potential hazards more quickly and had a more efficient visual scanning process.
Data from fire fighters were collected at two fires in the Bay of Plenty region of the North Island of New Zealand. Fire 1 was in young pine trees (Pinus radiata) on steep terrain in Kaingaroa Forest and Fire 2 was in gorse, broom, black berry and eucalyptus undergrowth on flat terrain in Rotorua City. The fire fighter at Fire 1 was observed for a total of 110 minutes and 47 seconds. He spent 35% of the study period engaged in face to face conversation with other fire fighters. Almost all conversations were related to obtaining and relaying information related to fire suppression and the welfare of fire fighters in his crew. He was stopped, not talking or engaged in other activity for 28% of the observation period. In contrast, the fire fighter at Fire 2 applied water for 46% of the observation period and tended the hose for 27% of the observation period. He engaged in little conversation; only 6% of the observation period. This reflects the difference in the roles of the two fire fighters and the detailed information that can be gathered about their work from a helmet mounted camera. Fire fighting is a physically demanding job. At Fire 1, on steep terrain, the fire fighter had a maximum heart rate of 185 beats per minute. At Fire 2, on flat terrain the fire fighter had a maximum heart rate of 144 beats per minute. Expressed as a proportion of their estimated maximum heart rate (220 beats per minutes – age) they were operating at peaks reaching 96% and 79% of their maximum heart rate which is extremely high.

Tree felling is a completely different type of task and allo-confrontation was used where an expert looks at video of someone else’s work. In contrast to fire fighting, tree felling is apparently very orderly and repetitive. The same cycle of tasks are performed in the same order for each tree. However the work can descend into chaos but still appear orderly and repetitive.

Fire fighter ‘auto-confrontation’ reflective interview provides an investigator with the potential for greater depth of understanding of the task. The participant did not describe the execution of physical activity, such as walking, carrying a hose or talking, probably because these activities were self-evident from the video record. Rather, the participant described the higher level organisational issues such as who was at the fire, the chain of command, why particular communications were taking place and his feelings at the time.

5. Discussion
The study has shown that, through triangulation of novel combinations of recording instrumentation and video-cued reflective interview, we can gain rich interpretative insights into the working world of the tree faller and rural fire fighter and understand how they manage the hazards they confront in their work. This in turn enables us to develop practices designed to minimise or avoid physical risk to the worker. Furthermore, the annotated video collected in the forests and at fires can be utilised as an authentic resource for training of both workers and trainers. The study has highlighted the value of, and need for, research that is situated in real work environments, and that captures the multidimensionality of workers’ activities without impeding or altering their behaviour.

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Reference