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Interface changes causing accidents. An empirical study of negative transfer

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Abstract

When expert operators interact with a new device, they inevitably reuse former interaction modes and actions. This phenomenon is due to the human cognition seeking resources savings. Schemas support this strategy and are implemented in such a way that perfection is disregarded at the profit of an intuitive trade-off between performance and cognitive resources savings. As a consequence, humans have a strong inclination to fit well-known solution procedures into new problems. For this reason, changes in work environments can cause accidents when they allow operators to interact with a new device if the latter is erroneously perceived as familiar. This research issue originates from an industrial background. The suspected cause of a fatal error performed by an operator in a steelworks factory is replicated in an experiment. The results support the hypothesis according to which errors (and possible subsequent accidents) due to changes in the interface are more likely when the latter does not inhibit former modes of interaction modes. This main result is discussed under the angle of cognitive ergonomics and used as a basis to provide design guidelines.

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1. Introduction

The study of field situations from the standpoint of cognitive ergonomics aims at understanding cognitive acts within the context in which they happen. Humans, their tools, their reasoning processes and actions inside the environment are classical features of this kind of approach. The latter can be deliberately quantitative when research aims at isolating a particular parameter, e.g. the cause of an error. In this case, experimentation can be used to assess the effect of one or several factors on a given aspect of behaviour. This is the direction taken in this paper. A field study was conducted in a steelworks company where an accident occurred, which led to the death of an operator. This study was initiated in order to trace back the psychological causes of this accident. The latter will be treated as an error in the human–machine interaction.

We identify two wide classes of exception in human–machine interaction: (a) exceptions that occur after deployment for which designers have not conceived any procedure due to the unlikelihood of these events and (b) situations that are unexpectedly similar to others for which well-defined procedures and skills exist. Our paper deals with the second case and will try to highlight the risks associated with certain types of similarities at the interface level. The adopted angle sets the focus on the mental processes involved in interface changes. It follows that this paper is quite remote from raw performance metrics applied to interfaces (e.g. [Rauterberg, 1992](#)). Instead, an account of the mental processes involved in control tasks (as in [Woods et al., 1987](#)) and an analysis of the errors performed when interacting with changing interfaces will be presented.

1.1. Description of the accident

The following event occurred during a night shift in March 1990 at ASCOMETAL, a French steelworks factory employing some 500 people. An experienced operator was working on a thread drawing machine, a device that reduces the diameter of a metal thread by a series of tractions (see [Fig. 1](#)). Typically, the output thread is coiled onto a drum and kept in place by pressing wheels. Opening and closing the wheels is done by rotating a two-positions button. Because of the high tension of the thread, there are times in the process where opening the pressing wheels is extremely hazardous.

The operator used to work with eleven thread drawing machines. On the machine involved in the accident, the open and closed positions of the pressing wheels button were swapped as compared to the ten other machines. This swap was well-known but was not flagged or equipped with any kind of protection. Because of the swapped commands, the operator unintentionally opened the pressing wheels at a step of the process where this action is forbidden. The operator was violently hit by the thread uncoiling from the drum. This resulted in the death of the operator.

From a psychological point of view, the tools' characteristics were discrepant with respect to the routine control mode. Therefore, the skills implemented by the operator did not match the specific constraints imposed by this tool. In other words,

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