Interruptions in the computer aided office work: implications to user interface design

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1. Introduction

With recent trends in labour requirements moving from manual labour to cognitive oriented tasks, the need for understanding of the factors that influence skilled cognitive task performance has never been greater. One of such factors are interruptions during performing computer aided mental tasks.

We have chosen interruptions as a topic for study for a number of reasons. First, due to the fact that computerised mental work places high demands on the cognitive system, it is likely that this type of work is very sensible to interruptions. Second, interruptions appear to be typical for the working conditions of many occupations in which computerised mental work predominates, which makes it interesting to find out how people deal with them while carrying out their duties. Third, interruptions may negatively affect the person's performance, thereby exerting an influence on workers' productivity. The ultimate goal of the study was to propose cognitive engineering solutions to the user interface of computer systems aimed at preventing negative consequences of interruptions.

There is no uniform paradigm for the study of interruptions during work processes. In the past, interruptions have been studied in various ways and with diverging objectives. The research on the effects of interruptions on the mental work dates from classic Zeigarnik experiments. However, up to now there exist only several studies with heterogeneous theoretical background that reveal particular aspects of the influence of interruptions on performing *computerised* mental tasks.

In the conceptual model of the study presented in this paper, developed in the context of a broader research programme (WORC, 1992), three sets of variables are taken into account:

(1) variables that refer to determinants of work activity, i. e. various situational working conditions, interruptions, task characteristics, motivation, and personal characteristics.

(2) variables that relate to activity, i. e. strategic activity and work activity.

(3) variables that relate to the outcomes of work activity, i. e. strategic performance, work performance, and subjective work experience.

Regarding activity, a distinction was made between work activity *per se* and strategic activity. We assume that people carry out certain activities that do not directly result in the completion of work tasks, but are conductive to work activity by creating and/or maintaining the necessary conditions for it. Neutralising interruptions or other disturbances, ensuring the supply of work material or information, can be mentioned as examples of strategic activity. Work activity and strategic activity are supposed to imply the use of the same functional systems. Their distinction refers exclusively to the goal of the activity, i. e. either the performance of tasks, or the creation of appropriate conditions for task performance.

2. Research questions

The conceptual model presented above leads to the formulation of several hypotheses:

(1) interruptions affect task performance depending on the nature of interruption (duration and complexity): (a) when interruptions occur more time is needed for completing the task; (b) these effects are stronger for complex interruptions than for simple interruptions.

(2) interruptions may invoke additional compensatory activities (*strategic activities*), directed at either *immunisation* (taking away the influence of the disturbance) or *recovery* (facilitating the resumption of the work activity).

3. Experiment

31 subjects performed a computer-assisted task bearing high similarity to real-life office tasks. The experimental task was to make corrections in a computer file, based on a hard-copy version of a text containing hand-written corrections. During the experimental sessions subject's work activity was disturbed by a number of interruptions (phone calls). During the phone call the subject was told to perform another task, referred to as "interruptive task". Interruptions were made according to a certain scheme which has been designed in such a way that the effects of the presence and complexity of interruptions could be ascertained. Interruptions affected three types of editing operations: (a) regular editing (making simple corrections) – *regular*; (b) typing in new text – *new*; (c) moving a block of text to a new location – *move*.

The independent variables were the presence/absence of interruption and the complexity of interruption. An example of simple interruptive task was to find the telephone number in the telephone book. Complex interruptive task was to correct all the typing faults in a short article. The dependent variable was editing latency.

The experimental study has been conducted in parallel by HCI Laboratory, Moscow State University (Russia) and Work and Organization Research Centre, Tilburg University (The Netherlands). Here we report results obtained by Russian team.

4. Results

Statistical analyses revealed the significant effects of both presence/absence of interruptions ($F(1,93)=9.91$, $p=0.0022$) and interruption complexity ($F(2,93)=5.24$, $p=0.007$) on the editing latencies for cognitively complex editing operations (e.g. moving a paragraph to a new location), while the performance indices for cognitively simple editing actions (e.g. typing in a new paragraph) were not affected by interruptions. A probable explanation to this fact may be that operation *new* is the simplest operation in text editing. It involve neither search and location of some point in the text (as for *regular*) nor include complex sequences of actions and additional mental load caused by the necessity to track the contents of the clipboard (as for *move*). Operation *move* is an example of a "functional thread", i. e. a series of commands or actions, and effects of interruptions on this class of operations were more dramatic.

Further analysis showed that an additional orientation activity, that appears after completing the secondary task, is mainly responsible for increase in net operation time if operation is interrupted.

Based on the analysis of videotaped subjects' behaviour, an empirical classification of interruption handling strategies (for text editing tasks) has been proposed.

Strategy [0]: no attempts to continue the main task. This is the case when subjects fully switch to the secondary task immediately after the phone ring.

Strategy [1]: attempts to *complete* the current operation. Three different types of this strategy were observed: attempts to complete the current operation [1A] before picking up the phone, [1B] during the secondary task, or [1C] in parallel with secondary task.

Strategy [2]: activity on *memorising* the current state of the main task. Two types of this strategy were observed: [2A] solely visual memorisation, when subject's visual attention is focused on the computer screen during receiving instructions from the experimenter, and [2B] use of software or hardware tools for memorisation, e.g. subject positions and keeps his finger on a keyboard in order to memorise the action he should do next.

Strategy [3]: activity on *preventing* possible errors by avoiding potential error-prone situations, e.g. subjects might paste the contents of the clipboard into inappropriate place, returning the block of text from clipboard to the screen in order to avoid possible loss of that block.

5. Implications to user interface design

In our opinion, many contemporary office software systems do not provide users with sufficient support of interrupted work. This is why users have to invent a variety of different interruption handling strategies which help them in performing interrupted tasks. Based on the analysis of interruption handling strategies, we have developed some recommendations for the user interface design for frequently interrupted work conditions.

1. Interface should give the possibility to instantaneously "freeze" the current state of the system in order to prevent occasional damages of the information while working on the interruptive tasks.

2. Interface should implement complex operations (functional threads) as a single operation and provide efficient on-line assistance to the user in performing complex operations. For example, "Select – Cut – Find new position – Paste", the sequential group of actions for moving a paragraph to a new location should be organised as a single command *Move paragraph* invoking an appropriate "wizard" which guides the user in performing necessary steps.

3. Many contemporary system designs depend on the user tracking information which is not immediately available on the display – for example, tracking the contents of a hidden buffer (clipboard) in text processors. When user performs any operation that changes the contents of the clipboard, the state of the system changes, but these changes are not visible on the screen and are only known to the user if he mentally keeps track of the effects of the operation. Frequently interrupted work conditions require more apparent indication of the presence of information in the clipboard (e.g. in a small floating window). Otherwise users may lose clipboard information when their attention is occupied by interruptive tasks.

4. Metaphor of "cooling down text" or "drying up ink" is also suggested. We recommend to use colour coding for indicating recently changed or inserted information on the screen, colours being "cooling down" in course of document-specific time from hot colour (most recently changed information) to cold colour (old or unchanged information). This improvement could reduce the time of orientation in main task after completing interruptive task.

Reference

WORC, 1992, *WORC Five Year Plan 1992–1996/7* (Work and Organisation Research Centre, Tilburg).