Human-Computer Interaction in Office Work: Evaluation of Interaction Patterns Using Office Equipment and Software during Data Entry and Navigation

Ernesto Filgueiras[1,2], Francisco Rebelo[2], and Fernando Moreira da Silva[3]

[1] Beira Interior University – R. Marquês d'Ávila e Bolama, 6201-001 Covilhã – Portugal
ernestovf@gmail.com
[2] Ergonomics Laboratory. FMH/Technical University of Lisbon, Estrada da Costa, 1499-002 Cruz Quebrada - Dafundo, Portugal
frebelo@fmh.utl.pt
[3] Faculty of Architecture - Technical University of Lisbon – R. Sá Nogueira, Alto da Ajuda 1349-055 Lisbon, Portugal
moreiradasilva.fernando@gmail.com

Abstract. This paper presents a study which objective was to investigate the human interaction with the equipment of an office workstation (mouse, keyboard, monitor, paper sheets, pens and calculator) during the activities of reading, writing, data entry and navigation in a computer system for long periods of time and with ecological validation. A sample of 22800 observations, which corresponds to 760 work-hours of 30 office workers, was classified into sixteen Interaction's Categories (IC). The results show that the participants read on the monitor more than on paper and they had a larger use of the mouse instead of the keyboard. Findings of this study allow suggesting what graphical interface designers must seek for new strategies and solutions to reduce the mouse need, exploring other peripherals as keyboard or voice recognition devices; or, at least, diminishing the amplitude of movement with the mouse during the interaction with office's software like the Microsoft® Office 2003.

Keywords: Office workers product interaction, Ergonomics procedures, Observations methods, Video display terminal.

1 Introduction

A rapidly increasing number of people are involved in work with computers for long periods of time. According to Anshel [1], more than 175 million of North Americans frequently use computers at their workplaces. In the beginning of the XXI's century, data from the European Foundation of Living and Working Conditions shown that the percentage of workers who are involved in computer work "all the time" or "almost all the time" is 19% in the European Union [2]. In many of these countries, because of this massification, a constant alert regarding the potential negative effects that the intense use of computers can cause is observed, with many published works in this area [3,4,5]. Most of them indicate that repetitive strain injuries (mainly in the hands,

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shoulders, arms and neck), eye injuries and psychological changes are caused by environmental conditions, excessive workload, and mainly by the several ways of interaction in the workstation of computerized work [6].

In a general way, the data regarding the workers' interaction with the workplace are collected in simulated laboratory conditions or in very controlled real situations. Although this kind of studies interferes with the tasks and with the natural behaviours of the workers, they have some advantage as: an accurate control of variables, a high potential to collect physiological measures and the accuracy of data collected, mainly the quantitative [7,8,9].

Handrick and Kleiner [10] argue that the main element for a good ergonomics analysis of the activity or for the products development is to adopt a systemic approach of activity through the analysis of all interactions possibilities in a real context of work. Thus, the techniques and experimental protocols usually used to evaluate the interaction with Visual Display Terminals (VDTs) fail by: (i) low ecological validity; (ii) lack of systemic evaluation - especially the lack of data-crossing between task, activity and equipment used in the workplace (e.g. keyboard, mouse, monitor); (iii) changing in the study's context due to the need to adapt the environment, the workplace and the individual to the equipment and procedures which are necessary to the data collection; (iv) do not collect all the components of the human behaviour in activity, even when the protocols are done in real work conditions, they use representations (simulation) of the real situation; (v) be very intrusive since they change the environment and even the work task for the studied work requirements.

When objective techniques (e.g. goniometry, pressure maps, electromyography) are used in activities which require the evaluation through long periods of time (as work with VDTs), they have some technological limitations, as they produce too much data and, consequently, there is an overload of the storage system with the impracticability of the statistical treatment of the data (mainly for studies that require periods of time higher than six hours a day).

In order to minimize the difficulty in applying these experimental methods in real context, researchers combine some objective with subjective techniques, which generally are qualitative such as questionnaires, interviews and direct/indirect activity observation. Usually, this approach is related also to the interpretation and evaluation of the comfort or discomfort [11,12,13] that is done through users testimony and the understanding of the real activity through self-report.

IJmker, *et. al.* [14] evaluated studies which made a correlation of muscle-skeletal disorders with the activities of the work with computers between 1967 and 2005. The authors conclude that many studies prefer to classify the interaction activities through the estimates from self-report questionnaires of workers than to do a direct evaluation of these interaction features. IJmker, *et. al.* [14] alerts for the need of studies that aims a better understanding about the computers' use through objective measures of the workers' interaction time with their workstation, namely the use of the main equipment as the mouse and keyboard.

In this context, the main objective of this study apply a systematic observations of the activities at the workstation through digital video recording using a methodology proposed by Rebelo, Filgueiras & Soares [16], to understand the human interaction with the equipment of an office workstation (e.g. mouse, keyboard, files, paper sheets, computer, among others) during the activities of reading, writing, data entry and navigation and using a computer system for long periods of time and with ecological validity. This knowledge will allow to: a) understand the origin and incidence of many work situations and problems; and, b) elaborate more specific recommendations to the products' development. However, for this paper we will present only the results for interaction patterns during the use of a set of specific Interaction Category - IC [16] (Typing, using the mouse and reading).

2 Methodology

This paper presents a part on a larger study and is based on the observation of a group of workers with the same work activity type (works with VDT's), working hours (eight hours/day), accessing to the same group of equipment and using the same model of chair, in order to analyze if there are similar patterns of interaction between users and the devices they use for data entry (mouse and keyboard) and reading (papers and monitor).

2.1 Study Site and Workstation Properties

Data were collected at the offices of a Portuguese company of food distribution. Thirty workstations with workers performing the same activity were selected. The workstations were in an open-space environment and all of them had: a) minimum of eight hours daily of work; b) similar activities, characterized as office work [15]; c) same devices (monitor, keyboard, mouse); d) same furniture and equipment (chair, desktop, cabinets, files, staplers, telephone and calculator); and, e) computers with the same hardware and software. Printer, fax and scanner are collective.

The company did not have software made specifically to address it needs so workers use those available in the market. All administrative activities were made using the pack of software available for all computers (Microsoft® Windows Vista Enterprise OEM, Microsoft® Office 2003 - with Word, Excel, Explorer, Outlook and Powerpoint - Internet Explorer and Mozila® FireFox). The computers did not have hard drive and the software installation was controlled by the main server. Internet Explorer and the Outlook were rarely used according users report in an informal interview.

2.2 The Subjects and Job Tasks

oThirty office workers (28 female and 2 male) were volunteers in this study (mean = 32 years old, SD = 8). The workers were distributed to: Accounting occupations (n = 8), Fleet Control (n = 7), Human Resources Management (n = 7) e Buying/Stock Control (n = 8). In an informal interview, none of the volunteers declared having chronic health problems or special conditions at the workstation. The data collection order was not influenced by the management section and it was decided by the participants.

Participants were informed about the study's objective through a group meeting and an individual approach in the day before of each video recording. All video collection was authorized by the participants through a form of consent.

Finally, participants were instructed to perform their tasks as usual and do not change their work schedule (amount of work using the computer) due to the presence of the cameras.

2.3 Recording Procedure and Features

The participants' interactions with the computer were video recorded on a normal working day and were assessed using: a) two infrared digital cameras (Swann - SW233-H2Y 2,5 GHz – color); b) one multiplexer video recorder (Bosch - DVR-8K with 8 channels 1 TB) and c) one tripod (Philips SBC-5307). All devices' lights were turned off or hidden and participants were informed about the placement of all cameras. However, they did not know the real video recording time.

The digital video cameras turned on automatically and all the workstation was filmed using two different plans (sagittal and superior) considering the best visualization of the participant and activity (Fig. 1).

In order to ensure similar interaction times in the workstation and to not interfere in the workers daily activity, all volunteers were filmed during three days during eight hours continuously (starting at 8:30 a.m.). After the filming period for each participant, a quick analysis of the video was done in order to select the best two days, according the following criteria:

- Longer retention of workers in the workplace (preferred > 6 hours);
- More than 60% of the video was with good visualization of the activities conditions.

If after the video analysis these criteria were not verified for two days of video, a fourth day was video recorded.

Fig. 1. Images of the two different plans (sagittal and superior) of the workstation Observations

The data, collected through video using a methodology proposed by Rebelo, Filgueiras & Soares [16], was analyzed regarding the register of interactions categories and was done using software developed for this purpose. The videos were observed and the ICs were classified by two trained observers in different moments. In this way, two groups of activities were defined: (i) Reading, and (ii) Data Entry and Navigation. The use of the computer was defined as the time attached to the computer with the hands (active use of mouse/keyboard or passive resting on mouse/keyboard) or eyes (viewing the screen).

2.4 Observations Interaction Categories - IC

Sixteen ICs were classified from the activity observation of real situations and from similar situations in the literature [17,18]. Table 1 and Table 2 present the codes and description for ICs “Reading” and “Data Entry/Navigation” groups.

Table 1. Code, IC and description for “Reading” group

Code	Interaction Categories	Description
R1	Reading on a single sheet of paper	Head directed to small amount of paper (<15 sheets) handling or on the table (i.e. single sheet).
R2	Reading on the screen	Head directed to the monitor screen without switching with Reading on paper.
R3	Reading on a volume of paper sheets	Head directed to big amount of paper (>15 sheets) handling or on the table (i.e. books, files).
R4	Reading on a specific support	Head directed to single paper sheets or files (>15 sheets) on a specific support.
R5	Reading on the screen and single sheet of paper	Head direction switching between small amount of paper (<15 sheets) and monitor screen
R6	Reading on the screen and sheets of paper on files	Head direction switching between big amount of paper (>15 sheets) and monitor screen
R7	Reading on panels	Head directed to magnetic boards, that is visible through the images and place in front of the workstation
R8	Others	Any activity that means some kind of specific Reading which were not anticipated.

Table 2. Code, IC and description for “Data Entry and Navigation” group

Code	Interaction Categories	Description
D1	Writing on sheets of paper or similar	Manipulation of writing devices (pen or pencil) and writing on sheets of paper or others.
D2	Typing on PC keyboard	One or two hands are (actively or passively) on the keyboard and no hand on the mouse.
D3	Navigation (using mouse)	One hand is on the mouse (actively or passively).
D4	Using external calculator	One hand is on the calculator (actively or passively).
D5	Using PC keyboard and mouse	One or two hands are (actively or passively) on the keyboard and sometimes with a hand on the mouse.
D6	Writing and typing	One or two hands are (actively or passively) on the keyboard and writing on sheet or others.
D7	Writing and using mouse	One hand is on the mouse (actively or passively) and writing on sheet of paper or others.
D8	Others	Any activity that means some kind of specific Data Entry and Navigation, which were not anticipated.

As mentioned, the analysis was done using software developed for this purpose. It allows classifying the IC (through video analysis) in levels. Despite the system allowing the observation and register of categories in a continuous time, the high number of categories for this analysis represents a cognitive overload to the observer and may contribute to a significant increase in classification errors. Thus, classifications of systematic activity sequences were done using samples controlled by the software (5 seconds of analysis for each 15 seconds of activity). Each one of these activity sequences represents an "event" which remained in looping (5 seconds) until all ICs were registered (Fig. 2).

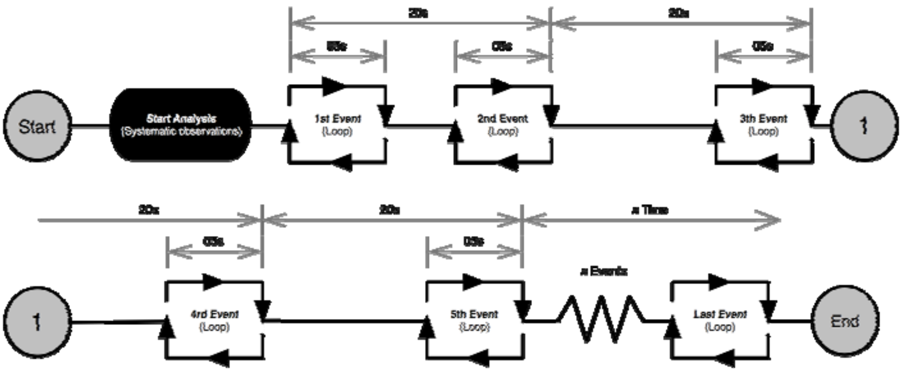

Fig. 2. Flowchart with the systematic observation stages used for the software

3 Results

A sample of 22800 observations, which corresponds to 760 work hours, was classified. The results can be seen on Fig. 3 and Fig. 4.

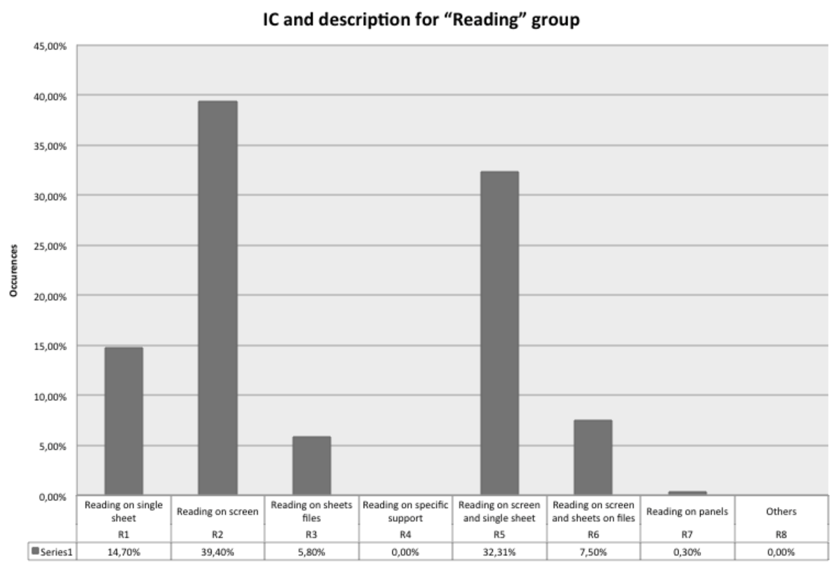

Fig. 3. Results for IC in "Reading" group

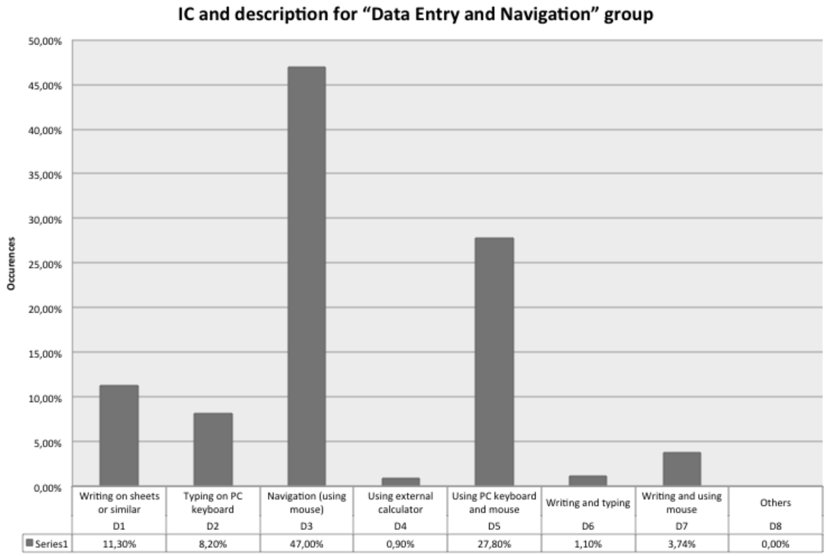

Fig. 4. Results for IC "Data Entry and Navigation" group

The Reading and/or Data Entry and Navigation are in 70.4% of all classifications. In the ICs of Reading codes, R2 occurs 39.4%, R5 corresponds to 32.3%, R1 occurs 14.7%, R6 occurs 7.50%, R3 5.8%, R7 occurs 0.3% and only 0.01% of all activities of reading at the workplace do not involve one of these categories (R8). For Data Entry and Navigation codes, D3 corresponds to 47.0%, D1 represents 11.3%, D2 with 8.2% and D4 corresponds to 0.8% of the registers. The simultaneous use of the keyboard and the mouse (D5) corresponds to 27.8% of the register, followed by mousse and writing (D7) with 3.7% and keyboard and writing (D6) with 1.1% of the registers for the occurrence of combined ICs for the Data Entry and Navigation.

4 Conclusions

The ICs of Reading and Data Input are in the most tasks of the office work. We verified a high percentage of reading from the monitor (R2 + R5 + R6 = 85.5%) in comparison with the Reading from paper (R1 + R3 + R5 + R6 = 59%), it might mean the decreasing of the use of paper as information support at modern offices. The large use of the mouse (D3) was noticed in the most of the ICs (D3 + D5 + D7 = 78.9%) and all ICs with keyboard corresponds to the half of the interaction with the mouse (D2 + D5 + D6 = 37.1%). The writing represents only 16.4% of the registered interactions (D1 + D6 + D7 = 16.4%). The influence of the mouse on the physiological damage in office workers with activities of computer assisted drawing - CAD is already known [19,20,21]. These studies also reveal the high use of this peripheral in the actual text editors and spread sheets software used at offices. These data can be related with the increase of the muscle-skeletal problems, which can be found among workers of traditional offices as found in Ijmker et al. [14].

Although we did not register the specific use of each software while users' interaction with the mouse and keyboard or only one of them, this study suggests that the graphical interface design must seek for new strategies and solutions to reduce the mouse's need using another peripheral as the keyboard or voice recognition devices; or, at least, to diminish the amplitude of movement with the mouse during the interaction with office software.

Finally, this methodology was considered efficient for the proposed objectives and the findings suggest new challenges for future research. For example, this methodology can be used to compare if different types of interaction for the same software can influence the interaction patterns. Usually these data are evaluated through the observation of the activation of keys, clicks and movements, independently of the activity and other interactions.

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