AUTOMATIC INFORMATION PROCESSES IN DOCUMENT READING. A STUDY OF INFORMATION HANDLING IN TWO INTENSIVE CARE UNITS.

Else Pettersson

Center for Human Computer Studies
University of Uppsala, Sweden

ABSTRACT

A study was made of information handling in intensive care units in two hospitals. In one of the units the information about the patients was read from paper documents whereas in the other unit the same kind of information was read from computer screens. In both units cooperative work was beeing done with documents or forms containing data regarding seriously ill patients. The results show that in the paperbased environment there is a reason to believe that a number of information activities can be automatized in human cognition sense. In the computerized environment however, these same activities seem to require conscious attention thus leading to high attentional demand.

Introduction

Some models of human cognitive processing distinguishes between - controlled processing and - automatic processing. Controlled processing is conscious, serial, slow, laborious and of limited capacity. Automatic processing is close to sensomotoric level, parallel, does not need conscious attention and have seemingly unlimited capacity. A close cooperation between automatically controlled processes and consciously controlled processes seem to be at hand. (Shiffrin & Schneider 1977). Schneider & Schiffrin 1977, shows that under certain conditions visual search tasks can be trained to automaticity. In these experiments subjects were trained to automatic detection of alphanumeric characters called targets, which was presented together with other alphanumeric characters called distractors. The process of automatic detection of the targets was possible to be performed simultaneously with a second task without any need for more conscious capacity than if the second task was carried out by itself. Thus when a task has become automatic it is possible to add it without any additional need for conscious capacity. Other experiments has shown automatic detection when targets and distractors differs in features like colour (Schneider & Eberts 1980), size, category or spatial position (Schneider & Shiffrin 1977). Also search

for a conjunction of features like colour and category, or category and spatial position, can be automatized, at least weakly. (Treismann & Gelade 1980)

Almost all tasks in working life situations will involve multiple processes and components, some automatic and some controlled. It is possible to break down a task into subcomponents that can be shown to be either automatic or controlled. Encoding of digits was investigated by Francolini and Egeth 1980. They concluded that this is not an automatic process which means that it always requires conscious capacity. When a person attends to an input, for instance a written number on a document, some of its attributes are automatically encoded into memory. One of these attributes are spatial location. (Hasher & Zacks 1979), (Lovelace & Southall 1983). This means that if we for instance read a number on a document we will also, without any effort, register where on the page the number was located. The knowledge gained by automatic processes is accessible to consciousness and can be used in a number of ways. (Hasher & Zacks 1979).

In many work situations there is a set of documents which are used very frequently. The structure and the contents of these documents gets very familiar to the user. The users task is usually not reading it from left to right and from top to bottom. Instead, the task generally involves searching and selectively encoding parts of the information in the document. The data on the document constitutes whole or part of the basis for a decision. Documents of this kind are often a means of communication between people. Different people may enter data to the document and different people may read data from the document.

The aim of this study was to find out if people working with this kind of familiar documents does extract knowledge by the means of automatic processes like encoding spatial relations between information units, and encoding of characteristics of the information media, as a complement to the encoding of numeric and semantic information. The aim was also to investigate how the preconditions for automatic processes were changed when information is computerized, that is when data formerly kept on paper documents are substituted by data presented on screen displays that more or less resembles the paper documents.

General information about the wards under study.

The main part of this study deals with an intensive care unit specially dedicated to the treatment of patients with severe burn injuries. This unit keeps all data on paper documents. Different types of documents deal with numerous laboratory test results, medications and observations.

As a comparison another intensive care unit in another hospital was studied. This unit is specializing in thoracic and pulmonary diseases. The information was computerized in the sense that a main part of the information about the

patients was read from computer screens located bedside or at the nursing office. The work on the computerized unit was similar to the work on the paperbased unit except for the differences due to the different kind of diseases treated. The information being handled was very much the same and also the routines of work were similar. The human-computer interface of the system was based on a hierarchical menu system controlled by pressing of function keys. The information was presented on monochrome screens composed of 24 x 80 alphanumeric characters of a non-proportional type. The computer system was still under development. Paper documents existed together with the screen documents.

Method

Interviews.

Interviews about the work on the ward and especially the use of documents were made with 6 experienced persons on the ward. (Four nurses, one doctor, one secretary). Each interview lasted about two hours.

Analyses of documents

24 different types of documents used on the ward were studied. For every type of document samples were collected of empty as well as filled documents. The documents were analysed in terms of informational content, purpose, keeping, which categories of personal who writes on the document, and which categories of personal who reads from the document, and how the document is moved according to workspecific rules.

Observation of information handling in work situations

One of the experienced nurses were observed throughout an entire working day. During the observation the writing on, and reading from documents were especially noted.

Studies of document recognition

The interviewed persons were confronted with copies of documents that were manipulated in different ways.

1. Identification of documents by pattern recognition. From three autentic laboratory lists, three trial documents were made where all filled in numerals had been replaced by x´s. In every position where there was a letter or a numeral in the original document, there was instead drawn an x on the trial document. Commas, and slanting lines were as in the original document. Thus the pattern of filled space against the background of unfilled space in the document was the same as in the original one but no letters or numerals were readable. One nurse were asked to as fast as possible identify the three documents.

2. Extraction of knowledge by pattern recognition. From three original laboratory lists, three trial documents were made were all numerals were replaced by x´s, as

in 1. The original documents were from patients unknown to the doctor and the nurse. The trial documents were shown to one nurse and one doctor at separate trials, for a short time (about 20 seconds) and then taken away. The doctor and the nurse were then asked to comment upon what information the document gave about the patient in concern.

3a) Recognition of miniature documents. 24 miniaturized documents were prepared in scale 1:35. These were as the original documents in colour and graphical features, but no letters or numerals were readable. The trial documents were empty, that is no values were filled in. Only the printed headlines and lines were visible. 4 nurses and one secretary were asked to recognize the documents and give their names. All 24 miniatures were presented together.

3b) For a comparison with a computerized setting three miniaturized screen documents were prepared in scale 1:35. These were as the original screen document but no letters or numerals were readable. As it was not possible to do this study on the computerized ward, this study was made in another environment. The documents were from an administrative computer system. A person who uses the screen documents daily were asked to recognize the documents. All three documents were presented together.

Analysis of computer documents.
Since the computer system was not fully operational, the manual which describes the intended use of different types of computer documents was studied. Also printouts of screendisplays were analysed. One interview of about 3 hours was made with a doctor on the ward. This interview concerned the use of the computer system, especially reading of information from computer screens in different working situations.

Results

The location of a document can transmit information.
Several examples were given in the interviews. The position of a document relative to other documents can transmit information. A documents position in a bundle of documents transmits information. The thickness of the bundle then give approximate but instantaneous information about the number of documents in the bundle. The computer documents does not have a body and thus does not have a location. Or rather they all have the same location namely on the screen. There are no spatial relations between documents which indicate their relative order. To know the relative order of documents the user has to encode numerical information.

Different types of documents can be distinguished by means of pattern recognition.
Recognition of miniature documents (trial 3a) were made very easily and without any errors. The screen documents however were not recognizable by the person in trial 3b. The three documents did not differ very much in graphical features as they are designed according to guidelines which emphasizes the importance of consistency and uniformity.

Different instances of a type of document can be distinguished by means of pattern recognition.
In trial 1 the nurse recognized the different instances of the laboratory list. Her basis for recognition was the characteristic patterns corresponding to a) a patient in a stable condition, b) a patient in an acute condition and c) a patient in a relatively stable condition but with a certain problem with the value of potassium in the blood. In the corresponding screen documents there is no mapping of type of test onto columns or of occasions onto rows. Two instances of the screen display that presents test results does look similar as there are no empty fields inbetween values.

On a document the pattern made by filled space against the background of unfilled space can transmit information.
In trial 2 the doctor gave a fairly good description of the patient. He recognized a row of equally distanced x´s at the top of the page as regulatory controls of a value. A group of x´s at the bottom right side told him that the patient had taken some liver tests, he could also recognize a column as typical for the battery of tests that is taken when a patient enters a ward. An equally distanced row of x´s at the bottom of the page was recognized as diabetes controls. Also the nurse was able to recognize typical patterns in the lists. (Figure 1). As a comparison the screen document presenting laboratory results was treated the same way. All numerals and letters were replaced by x´s. The resulting pattern does not transmit any information. This is due to the fact that there is no mapping of time or occasion onto a row, or of type of test onto a column. (Figure 2). In the interview with the doctor on the computerized ward, he stated that there were problems to read the laboratory list on the screen. The system was to be redesigned in order to find a better presentation form for among other screen documents, the laboratory list.

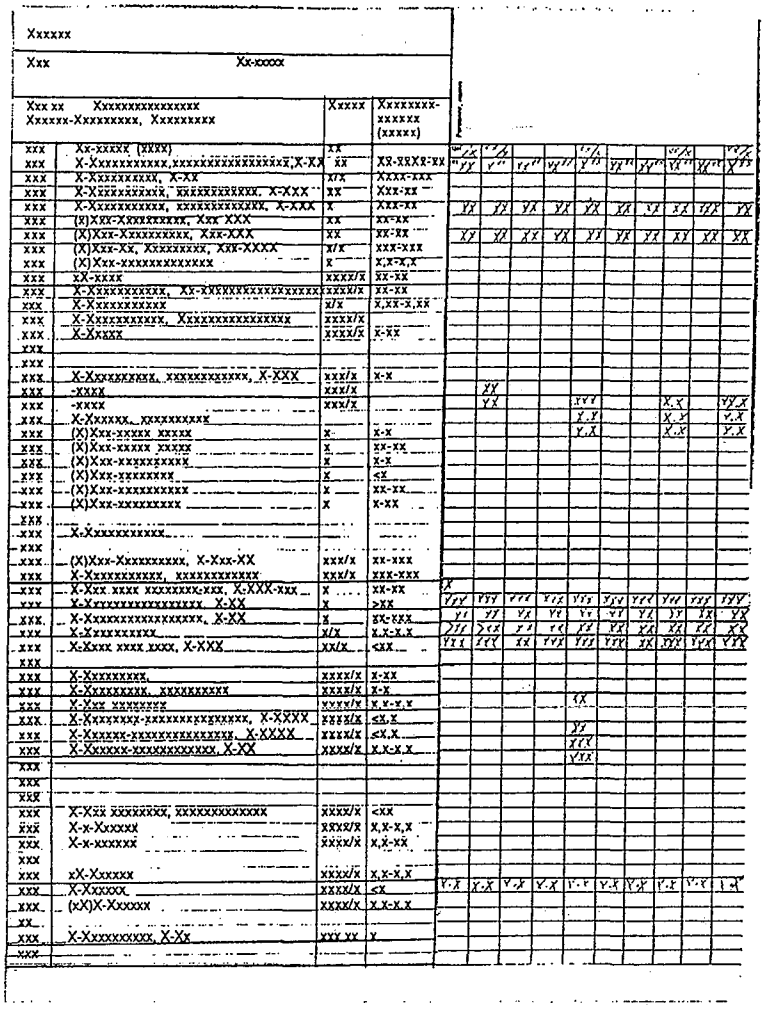

Figure 1

The "laboratory list " is a document on which laboratory test results are registered. The document is composed of one row for every type of test, and a column for every test occasion. The left part of the document contain printed names of tests. The right part of the document contain filled in values. Here all letters and numerals have been replaced by x's. Thus the pattern of digits against the background of unfilled space is the same as in the original document but no letters or numerals are readable.

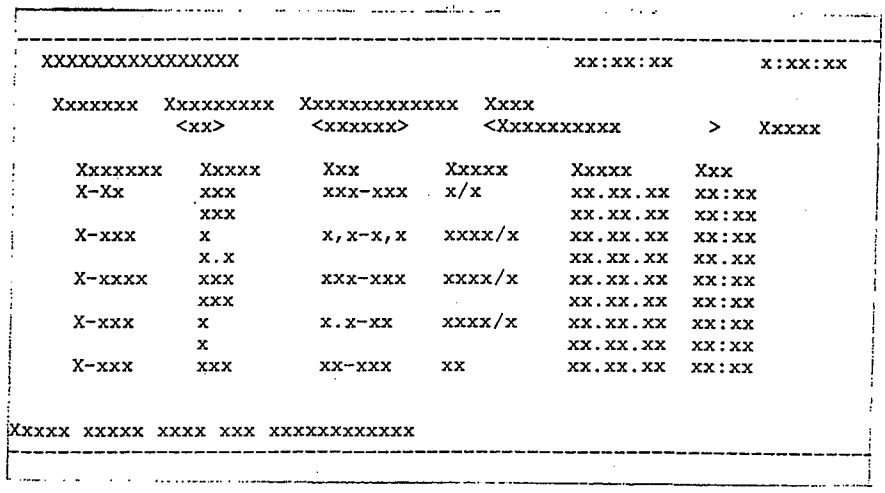

Figure 2

The screen document presenting laboratory results. All numerals and letters are replaced by x's. To the left the names of tests that have been taken are displayed. They are displayed in alphabetic order with one test on a separate row. A certain type of test can be displayed on different rows depending on what other test have been taken and their precedence or subsequence in alphabetic sense. The test occasion is presented as a date and a time in the form 89.07.13 07.30. The time fields are always filled, there are never any empty spaces inbetween. Since there is no mapping of occasion onto a spatial position there is no pattern.

Spatial relations between filled-in digits in a form helps coordination of values in time.

On a document called the surveillance list occasion in time is mapped onto spatial position. The more to the right the notation of an event is made on the document, the later on the day the event occurred. A notation that is to the left of another notation, means that the former preceded the later in time. In the corresponding computer document there is no mapping of time onto spatial position. Time is presented as a time value, for instance 07:30. Therefore it is nescessary for the reader to encode numerical data to be able to state whether an event precedes another event in time.

The appearance of a field can transmit information.

A field in a document is a delimited space intended to be filled in with a value. Work specific rules states how values should be entered into a field. Values are often entered in a certain sequence that is connected to a sequence of events. Thus the degree of filling in the field corresponds to the ocurrence of events. An empty field between filled fields means that the corresponding event has not ocurred. On the corresponding screen document ocurrence of an event is connected to updating of a field. This means that the field is almost always filled. To know that an event has not ocurred as expected, the numerical time value has to be encoded.

The appearance of letters and numerals can transmit information.
Headlines are in print and filled in values are in handwriting. The colour and the type of pencil used and the handwriting transmits information. The interviews showed that this information was encoded and used by the doctors and nurses. The screen documents use only one type of letters and numerals. No colours are used.

Some decision-making tasks involve rapid changes of focal attention.
To the doctor the surveillance list is a basis for complex judgments and decision-making. As he considers timerelations between status variables and actions taken, he is changing the point of fixation and hereby the focal attention between different parts of the document. This type of reasoning involves many quick shift of the focal attention. It is done very fast. The corresponding data is presented by the computer system on 4-5 screens. Change of focal attention will in many cases also require a change of screen by pressing a funtion key. To consider time relations between status variables and actions taken, the user has to encode numerical time values and keep them in memory while the displayed screens are changed.

Summary of results
The interviews and the trials showed that in addition to the information extracted by encoding of numerical or semantic information there are also a number of ways in which information can be extracted by the means of pattern recognition and encoding of the characteristics of the media rather than the semantic content. The result shows that the information extracted in this way was is in fact encoded and used by the subjects. In many cases the subjects were unaware of the fact that they encoded and used this information.

Discussion
When information is computerized, data formerly kept on paper documents are substituted by screen displays which more or less resembles the paper documents. The computerization means that new possibilities to search, sort and put together information are offered to the user. However reading the information from a screen display instead of from a paper also introduces problems. The screen display normally contains a much smaller amount of information than a sheet of paper. In order to perform a complex task such as surveillance, fault detection or decision-making the user has to integrate data across successive displays. This causes a strain on the shortterm memory as the user has to remember information from one screen to another. This is especially true in interfaces which uses 24 x 80 alphanumeric characters as the only output media. There is a risk for "cognitive tunnelvision" which means that the user does not consider all relevant facts for a decision.(Woods 1984). Window-oriented systems allow the user to see information from different documents simultaneously on the screen, but conflicts for the use of screenspace may lead to high cognitive overhead as users must move, reshape, and scroll

windows and shrink or expand icons. (Card & Hendersson 1987). Guidelines for designing screen displays typically recommend not more than 25% filling of screens. These recommendations refers to experiments on visual search tasks in simple artificial displays with a small number of items. (Tullis 1983).

Due to the small number of subjects and the lack of controlled experiments this study does not give any evidence of automatic processes. However it indicates that the following suggestions seem plausible:

- for an experienced person in a familiar paper-based environment, knowledge can be extracted by automatic and parallel encoding of spatial relations between information units, pattern recognition, and from encoding of features of the information media.

- the knowledge extracted can be used for micro-tasks like orientation, attention directing, coordination of values in time, choice of an appropriate search strategy, interpretation of semantic and numerical information, detection of abnormalities and changes, and for getting a fast overview of the informational content.

- in certain computerized settings this kind of knowledge has to be extracted by processes requiring conscious capacity thus decreasing the capacity available for other processing.

- if automatic information processes in a work situation can be identified and described this can be used in the design of the human-computer interface in a way that can reduce problems of cognitive overload.

High resolution colour screens give new possibilities for the design of the human-computer interfaces. It enables the use of colour and fonts as character codes. It enables presentation of more information in parallel. If relevant variables are mapped onto spatial positions it will be possible to design screen documents where filled in values create patterns rich in information. Icons can be designed in the form of miniaturized documents, where the graphical feature of the document is kept intact even if no letters or numerals are readable. This can enable fast transmission of more information than can be done by a symbolic icon only. Fixed positions of icons on the screen can make up patterns rich in information if the relative positions are decided by relevant variables. Relevant quantities can be displayed in a manner which makes them possible to be perceived rather than read.

References

Card S K, Hendersson A, *A Multiple, Virtual-Workspace Interface to Support User Task Switching*. Human Factors in Computing Systems and Graphics Interface, Conference Proceedings 1987.

Francolini C M, Egeth H, *On the non-automaticity of "automatic" activation: evidence of selective seeing*. Perception and Psychophysics 27, 331-342, 1980.

Hasher L, Zacks R T, *Automatic and Effortful Processes in Memory*. Journal of Experimental Psychology: General 108:356-388, 1979.

Lovelace E A, Southall S D, *Memory for words in prose and their locations on the page*. Memory & Cognition 11:429-434, 1983.

Schneider W, Eberts R, *Automatic processing and the unitazation of two features*, Human Attention Research Laboratory. University of Illinois (report 8008), 1980.

Schneider W, Shiffrin R M, *Controlled and Automatic Human Information Processing: II Perceptual Learning, Automatic Attending and a General Theory*, Psychological Review 84:127-190, 1977.

Shiffrin R M, Schneider W, *Controlled and Automatic Human Information Processing: I . Detection, Search and Attention*, Psychological Review 84:1-66, 1977.

Treisman A M, Gelade G, *A feature-integration theory of attention*. Cognitive Psychology 12, 97-136,1980.

Tullis T S, *The Formatting of Alphanumeric Displays: A Review and Analysis*. Human Factors 25:657-682, 1983.

Woods D D, *Visual momentum: a concept to improve the cognitive coupling of person and computer*. International Journal of Man-Machine Studies 21:229-244, 1984.