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Types of Interruptions and their Effects on Mental Information Work

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Introduction

New technologies, such as computers and tele-communication, affect work and organizations in both the industrial, trade and administrative sector and other services industries. Organizations like insurance offices, government departments and libraries have changed considerably, while new companies were created offering a variety of services (e.g. tele-information services) that were unknown before. In the past, physical strength and motor skills were needed to perform work tasks. Nowadays tasks imply more mental and cognitive skills. More emphasis is laid upon 'knowledge work' such as planning and designing. Meijer and Roe (1993) speak of 'mentalisation of work'.

The increase of information and technologies can be illustrated by the research of Goldstein en Fraser (1985) and Roe, Zijlstra e.a. (1993). Goldstein and Fraser found in their research on application of computers in organisations that one out of eight of the employees used a computer. Roe, Zijlstra e.a. found in a survey among 1168 Dutch workers that 55 % of the respondents were using (modern) information technologies (IT) such as PC, fax, telex, e-mail etc.; 69% of the IT-workers were using the computer on a regular basis.

The aim of our research is to understand how the work activity of these mental tasks is processed. The assumption is that the performance of mental tasks requires different skills and different resources than the performance of more physical tasks. One of the methods to investigate the process of mental work is by studying the effects of interruptions on different levels (i.e. physical operations, process control). The existed theories of the work process in the traditional, physical, work (Hacker, 1986; Rasmussen. 1982; Volpert, 1983; Miller,
Galanter and Pribram, 1992) will be tested on the usefulness and validity for the processes of mental work.

In this paper, we explain why and how we investigate the work process of mental tasks. Research of the effects of interruptions is done by survey- and experimental studies. A few results are mentioned and show that, not only subjectively and intuitively, also objective measures indicate that interruptions have effects on work outcome and well-being of the workers. Associations with stress and loss of productively show the practical relevance of this research for organizations.

**Theoretical background**

Meijer (1990) introduced the notion of 'mental information work' (MIW). She stressed that work activities consist of transformations of an information object that are carried out by operations of a predominantly mental (rather than physical) nature. MIW includes work on the levels of preparation and execution (data typists, secretary) and on planning, organizing and controlling (managers, executives). It includes both routine and non-routine actions.

With the change from physical- towards more mental tasks, Work-and Organizational Psychology has become interested in the mental aspects of the work process. No systematic knowledge on MIW and higher mental processes in work activity exist. Traditional ideas about how the task is executed are all based on physical tasks performance. Therefore, further research on MIW, specially on the work process is necessary.

One of the traditional ideas of (physical) task performance is described by Winsemius (1969). The performance of a task is seen as a flow of behavior and be defined as:

'a line from left to right, in time, with at the left side the beginning of the task and at the right side the end of the task. The end of the task is the goal that must been reached'.
But, the performance of tasks is not that simple. External and internal factors such as work surrounding (task content, reward, perception, required effort etc.) and personal outcomes (commitment, stress, emotions etc.) effect the task performance in different ways (efficiency, quality) (Ten Horn & Roe, 1988).

The most relevant factors that are important in the work process are (WORC, 1992):

a. variables that refer to determinants of work activity, i.e. various working conditions, task characteristics, motivation, freedom of your work such as choosing work order, the amount of time spend on a task, existence of rules, amount of mental or physical work.

Even so, the occurrence of interruptions and the availability to avoid the interruptions. Other aspects are the personal characteristics.

b. variables that relate to the outcomes of work activity, i.e. strategic performance, work performance, subjective work experiences.

c. variables of the psycho-physiological state such as well-being, fatigue, required effort etc.

All the factors are interrelated and are described in figure 1.
According to this model, interruptions, as a specific work condition, have an impact on the task performance. Based on the ideas of interruptions in the physical task performance (Winsemius, 1969), we use the following definition (figure 3a):

'when something or someone blocks this flow, the performance of the task, the activity is stopped at a particular point, but the goal still exist. When the task is executed again, within a short time, then we speak of an interruption'.

Figure 3a. Definition of an interruption
An interruption is only one of the different disturbances in the work process. A distinction must be made between an interruption and a disruption. The difference between an interruption and a disruption can only be measured afterwards and depends on the fact if, after the disturbance in the task flow, the original task performance is re-started or not. There is no sharp distinction in this time interval.

The definition of a disruption, in the traditional work process theories is described as (figure 3b):

'Whereas the execution of the original task will not be take up again, at least not in a short time, we speak of a disruption'.

Figure 3b. Definition of a disruption

In the research on the work process of MIW, we focus our attention on interruptions because the effects of the interruptions on the (re-started) work process can be studied, on different levels, in relation with the work conditions. So, by using various types of interruptions, while working on various mental tasks, the effects on work activity, psycho-physiological state, performance, effort etc. can be investigated.

A few, general, hypothesis are formulated and are used as the theoretical underground of our research. Hypothesis 1, 2 and 3 will be discussed in this paper.

1. Interruptions during the performance of mental tasks influence the outcome of the work activities, depending on the nature of the interruption and the task (i.e. duration, similarity, complexity), in a positive or negative way.
2. Interruptions can lead to changes in the work activity such as changes in the strategy (avoiding, higher speed)
3. Interruptions influence the person's state both on the emotional and the psychophysiological level.
4. The results of the work activities are in turn influenced by the person's state.
5. Personality characteristics (state and trait) may also play a role in the effect of the interruptions on work activities.

Method

Literature (f.i. Gillie and Broadbent, 1989) show us that research on different aspects of interruptions in mental work effect the work process. Beside literature and theories, subjective and objective measurements will also give us the information about the mental work process. We gathered subjective data by means of survey studies and use this information in real-life setting experiments to get more objective data.

1. Survey studies.

In an effort to discover the typical features of the mental work process, three field-studies were conducted on the occurrence of disturbances in actual work settings. In these surveys, people, who performed mental information work, were asked about their work conditions, the characteristics of interruptions and their effects on the work conditions, on work behavior, and on the person himself.

In the last survey (Krediet, 1993), 79 (out of 210) subjects were, according to a Dutch profession-classification, (Dekker e.a., 1990) divided in middle and high professional groups, according to their profession and their described work.

The middle professional group involved secretaries, general assistant, manager assistant, sales assistant, bookkeeper etc., whereas workers in the high professional group were project leader, head of a financial department, director, manager, lawyer etc.

Before we can answer how interruptions effect the work process, it is necessary to know what
kind of interruptions usually occur during normal task performances (hypothesis 1.). In the survey, it was found that the subjects made no distinction between the kind of the interruptions and the content of the interruptions: telephone calls and someone entering the room were the most important kinds of interruptions, whereas questions (by colleagues or others) and urgent actions were the most important contents of the interruptions.

Both professional groups were mostly interrupted by questions and in both groups these questions came from colleagues. The high professional group was also more interrupted by telephone calls than the middle professional group (table 1).

Table 1. Most important interruptions during mental work, for the professional groups, in percentage scores

<table>
<thead>
<tr>
<th></th>
<th>Middle</th>
<th>High</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telephone call</td>
<td>4,8</td>
<td>20</td>
<td>11,1</td>
</tr>
<tr>
<td>Someone entering</td>
<td>14,3</td>
<td>10</td>
<td>15,3</td>
</tr>
<tr>
<td>Urgent action</td>
<td>16,7</td>
<td>16,7</td>
<td>16,7</td>
</tr>
<tr>
<td>Questions</td>
<td>40,5</td>
<td>30</td>
<td>36,1</td>
</tr>
</tbody>
</table>

In general, most interruptions lasted more than 5 minutes. The interruptions lasted longer in the high professional group than in the middle professional group (Pearson chi-square: 4,29, p < 0.05). In the middle professional group questions from colleagues lasted longer than 5 minutes (26,1%), whereas in the high professional group this was caused by urgent actions (23,8%). (table 2.)

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1 No Pearson's chi-square test could be executed because more than 20% of the cells had an expected frequency < 5.
Table 2. Duration of the interruptions, for the different professional group, in percentage scores

<table>
<thead>
<tr>
<th></th>
<th>Middle</th>
<th>High</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5 minutes</td>
<td>41.0</td>
<td>20.7</td>
<td>32.4</td>
</tr>
<tr>
<td>&gt; 5 minutes</td>
<td>59.0</td>
<td>79.3</td>
<td>67.6</td>
</tr>
</tbody>
</table>

As hypothesized (hypothesis 2.), interruptions had an effect on the used work strategy. Most subjects (37.7%) in the middle professional group changed their strategy by making new priorities of their work. The high professional group changed their strategy by giving the interruptions the highest priority (28.6%), followed by changing their priorities of their work (23.8%). They also worked harder because of time pressure (19.0%).

Table 3. Changes in strategy as a result of interruptions, for the different professional groups, in percentage scores

<table>
<thead>
<tr>
<th></th>
<th>Middle</th>
<th>High</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Almost)never</td>
<td>34.2</td>
<td>31.3</td>
<td>32.9</td>
</tr>
<tr>
<td>Sometimes (almost)always</td>
<td>65.8</td>
<td>68.8</td>
<td>67.1</td>
</tr>
</tbody>
</table>

Another effect of interruptions on the work process was hypothesized in hypothesis 3.: effects on the psycho-physiological level. One of the effects is the experienced emotions during the work process (table 4.). A significant difference was found between the two professional groups (Pearson chi-square: 6.04, p < 0.05). The middle professional group labelled interruptions as more negative than the high professional group. The reason for this is a loss of concentration (28%). The high professional group, which labelled the interruptions more positively, said that interruptions gave variety in their work (61.5%). These workers were also less often interrupted (no significant correlation between the emotional labelling and the frequency of the
interruptions). (In the middle professional group 47.4% was interrupted less than once a day, whereas subjects in the high professional group were interrupted less than once a day).

Table 4. Emotional labelling of the interruptions for the professional groups, in percentage scores

<table>
<thead>
<tr>
<th></th>
<th>Middle</th>
<th>High</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>32.5</td>
<td>58.1</td>
<td>43.7</td>
</tr>
<tr>
<td>Negative</td>
<td>55.0</td>
<td>32.2</td>
<td>45.1</td>
</tr>
</tbody>
</table>

Conclusion

Subjective data of the survey studies show that interruptions, as a special kind of work condition, have effects on the work process, specially on the relationship between the work activity, work outcome and the psycho-physiological state.

2. Experimental studies

The subjective information of the survey studies must be investigated in a more controlled, objective situation, for a greater ecological validity of the data. Therefore, experiments are being carried out in a simulated work office, with normal and familiar work tasks, and with subjects who are experienced users of the tasks, the kind of interruptions, the conditions and the work surroundings.

In the first of a series of experiments, 40 secretaries had to perform three Word-Perfect tasks, about one hour each, on 2 experimental days. During the performance, they were interrupted. Objective and subjective work activity and work outcome, as described in figure 1, were measured by video- and keystroke registration.
Data from the video will give us information about, for instance, the used strategy, the total amount of time needed to perform the task or the interruption, the time that is needed to restart the task again after the interruption and the amount of time needed to get back at the same point as when the interruptions occurred.

Key stroke data will give us information about the total amount of keys used, which can give us information about the efficiency of the work. Also, the amount of rest-breaks before and after an interruption are measured.

Data was gathered on the psycho-physiological state such as heart-rate, experienced emotions, well-being and on personality characteristics.

Two results will be discussed. One is the relation between the number of interruptions and the amount of effort, required to perform the tasks. Effort was measured by the Rating Scale of Mental Effort (RSME), (Zijlstra, 1993). Results are shown in table 5. Repeated Manova analyses show an interruption effect, no day effect and a interaction effect for the RSME score. After Geisser-Greenhouse adjusted procedure ($\epsilon = .74386$), no significant effect between the required effort and the number of interruptions was found. Simple effect analyses of the interaction between the number of interruptions and the experimental days ($\epsilon = .77234$, $F=3,721$) how that between the days, significant effect existed for the first level of the interruptions: $F(1,38)=6.45$, $p=0.015$, for the second level of interruption $F(1,38)=39.47$, $p < 0.001$ and for the third level of interruptions $F(1,38)=8.24$, $p=0.007$. Significant effect were also found between the conditions on the first day ($\epsilon = .95137$): $F(2,37)=18.92$, $p < 0.001$ and for the second day ($\epsilon = .94268$): $F(2,37)=12.38$, $p < 0.001$, which indicated that the effort on the first day was higher than on the second day.
Table 5. Amount of effort required in the experimental sessions

<table>
<thead>
<tr>
<th>Factor</th>
<th>F</th>
<th>d</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>161.90</td>
<td>(1,38)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>interruption</td>
<td>3.59</td>
<td>(2,37)</td>
<td>0.038</td>
</tr>
<tr>
<td>day</td>
<td>3.66</td>
<td>(1,38)</td>
<td>0.063</td>
</tr>
<tr>
<td>interruption by</td>
<td>23.13</td>
<td>(2,37)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>day</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < 0.001, **p < 0.005

It can be concluded that more effort was needed to perform the task on the first day than on the second day, for all interruptions and that on both days, an increase was found in the amount of effort with the number of interruptions.

Another result of the effect of interruptions on the work process is related to the work activity, and involves the strategy of handling a telephone interruption. Data was measured by watching the videotapes, in detail.

Once subjects were interrupted, during their Word Perfect task, 4 kinds of strategies in handling the telephone calls were used:

1. after the signal, they immediately picked up the telephone, listened to the instruction and put the receiver down;
2. after the signal, they first continued with their work, then picked up the telephone, listen to the instruction and after that they put the receiver down;
3. after the signal, they immediately picked up the telephone, listened to the instruction at the same time they continued their work and then put the receiver down;
4. after the signal, they continued with their work, picked up the telephone, listened to the instruction and meanwhile, kept working on the original task, followed by put down the receiver.
It was found that the subjects were determined in their use of strategy: no difference was found between the number of subjects for the different strategies between the 2 experimental days or between the experimental sessions.

A relation was found between number of subjects and their used strategies and the amount (1 or 3) of interruptions: Pearson chi-square test: 11,868, p < 0.01. This indicated that, when interrupted three times, subjects used strategy 2 more (39.7%) and when they were interrupted only once, they used strategy 1 more (48.8%). When the used strategies were controlled for the number of the interruptions and the experimental sessions, a relation was found in the last session on the second day: Pearson chi-square test: 8.458, p < 0.05. The same trend was found as described before: when interrupted three times, strategy 2 is used, when interrupted once, strategy 1 is used.

When the used strategies were controlled for the number of the interruptions and the experimental days, a relation was found for the second day: Pearson chi-square test: 14.168, p < 0.05. with, again, the same trend as described before. Almost a relation was found between the number of subjects and the different strategies and the first, second and third interruption (in the session with three interruptions): Pearson chi-square test: 12.40, p = 0.053. So, strategy 1 and 2 were mostly used in all three interruptions. A decrease in the number of subjects, in the second interruptions, was found for both these strategies whereas an increase in the number of subjects, in the second interruption, was found for strategy 3 and 4.

It can be concluded that strategy 1 and 2 were the most used strategies and that in a session with one interruption strategy number 1 is preferred, whereas when interrupted three times, strategy number 2 is preferred, in all interruptions with strategy 1 as an important alternative in the first interruption.
Conclusion

Experimental data show that, in real-life setting, interruptions have effects on the level of the psycho-physiological state and the work activity level of the work process.

Literature and survey studies of the occurrence and effects of interruptions show that interruptions are very common during the performance of mental information work. It also shows that the effects can be found on many different levels and for different workers.

Experimental data subscribe the effects of interruptions on the work process of the literature- and survey studies. It was shown that different interruptions effect the work activity, the work outcome and the psychophysiological state. The three hypothesis, mentioned on page 3, are all confirmed.

Therefore, it seems that the more traditional theories on (physical) work process, are not completely applicable to the work process of MIW. Which and how these adjustments of these traditional theories must be made is the next step in our research. It is too early to make any conclusions yet. More research on the topic of interruptions in Mental Information Work is necessary.

Following this experiment, other experiments will be conducted to investigate the effects of interruptions in more detail, for instance about the relation between interruptions, time-pressure and their effect on the work activity, work outcome and psycho-physiological state.
References


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