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Temporal factors in mental work: Effects of interrupted activities

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Although interruptions are daily occurring events for most working people, little research has been done on the impacts of interruptions on workers and their performance. This study examines the effects of interruptions on task performance and its regulation, as well as on workers' psychological and psychophysiological state. Two parallel experiments were carried out in the Netherlands and in Russia, using a common conceptual framework and overlapping designs. Employees with relevant work experience carried out realistic text editing tasks in a simulated office environment, while the frequency and complexity of interruptions were experimentally manipulated.

It was hypothesized that interruptions: (i) would cause a deterioration of performance; (ii) evoke strategies to partially compensate for this deterioration; (iii) affect subjects' emotions and well-being negatively; and (iv) raise the level of effort and activation. It was also hypothesized that greater frequency and complexity of interruptions would enhance the expected effects.

The hypotheses are only partially confirmed. The results show that, contrary to what was expected, interruptions cause people to perform the main task faster while maintaining the level of quality. Participants develop strategies enabling them to deal effectively with the interruptions, while actually over-compensating the potential performance decline. Interruptions do have a negative impact on emotion and well-being, and lead to an increase of effort expenditure, although not to an increase in activation. Thus the improved performance is achieved at the expense of higher psychological costs. Greater complexity evoked more favourable responses among the Dutch participants and more unfavourable ones among the Russian participants. These differences are interpreted in terms of the participants' professional background.

The research demonstrates that the effects of interruptions reach beyond the execution of additional tasks and the change of work strategies. Interruptions appear to have an after-effect, influencing the workers' subsequent readiness to perform. Detailed analysis of the activity in the interruption interval, focusing on

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cognitive processes during episodes of 'change-over' and 'resumption' support this interpretation.

In many occupations people are interrupted several times a day. The most frequently occurring interruptions are 'telephone calls' or 'colleagues walking in for a question, or a chat' (Krediet, Zijlstra & Roe, 1994). Interruptions are often regarded as annoying and frustrating because they keep people from their work. However, interruptions may also function as welcome distracters in boring and monotonous work situations. This demonstrates that there are different perspectives from which interruptions can be studied; e.g. one may focus on the social side of the situation (nice colleague coming in for a chat, a call from an angry client), or the work content (having to complete the main task, being engaged in a dull task). Another perspective puts the focus on the demands posed by the interruption. Apart from the fact that interruptions are often produced by an additional task, which poses its own specific demands, there is the necessity for the worker to resume the original task at a later moment, which requires him/her to remember the status of the main task and to keep his/her motivation to execute that task. Maintaining the readiness to perform, to continue at the point where the activity was stopped, brings along certain demands as well. When such demands are high, as in the case of complex tasks, interruptions may be regarded as a stressor. In this article we focus on yet another perspective, i.e. that of the work flow and the psychological processes by which it is regulated.

The scientific interest in interruptions dates back to the 1920s. Well-known is the study by Zeigarnik (1927), a student of Lewin, who investigated the phenomenon that uncompleted tasks were better recalled than completed tasks. She tried to find empirical evidence for the existence of what Lewin (1926) had called 'tension systems' in the brain—systems which were supposed to keep information concerning ongoing activities available until 'closure' of the task. A later study by Van Bergen (1968) failed to replicate the findings of Zeigarnik. Other researchers (Schiffman & Greist-Bousquet, 1992; Weybrew, 1984), focusing on the effect of interruptions on the perception of time, confirmed that interruptions have an effect on participants' recollection of their environment, but the existence of 'tension systems' was not demonstrated. These studies are of theoretical interest because they represent an attempt to clarify the cognitive processes involved in dealing with interruptions. The status of the 'Zeigarnik effect' is still unresolved: it is commonly interpreted as people not liking to leave their task uncompleted.

Few studies have examined interruptions in relation to work. An interesting laboratory study was done by Cellier & Eyrolle (1992): following a time-sharing paradigm, they investigated the interference between tasks when people have to switch from one task to another. The main objective of the study was to validate a model for the management of information processing resources. In the experimental set-up people were interrupted while performing a (main) task. It was hypothesized that processing resources required for the new task must be activated while those employed in the first task must be inhibited. Failure in either of these processes was supposed to lead to interference. Cellier & Eyrolle did indeed

find evidence of interference: their main conclusion was that interruptions distract the operator in the execution of the primary task and cause a decrease in efficiency, as indicated by an increase in processing time and error rate (Cellier & Eyrolle, 1992).

The tasks that Cellier & Eyrolle used were typical laboratory tasks, and therefore different from tasks performed in daily life. Hardly any research on interruptions has been done on real life work tasks. Kirmeyer's (1988) study on police dispatchers should be mentioned in this respect. She studied the effects of externally imposed interruptions and the type A pattern on role overload stress, observing police radio dispatchers doing their work. Kirmeyer found that coping with competing demands simultaneously caused higher workload estimates and resulted in more coping actions compared to processing these demands sequentially. In addition, type A participants proved to have lower thresholds for appraising demands as overloading. This study demonstrates the effects of interruptions on appraisal and coping, but does not provide a definite explanation for these effects. Kirmeyer suggests that an explanation could be found in Cohen's 'cognitive fatigue model' (Cohen, 1978, 1980), which states that interruptions can be conceived as uncontrollable, unpredictable stressors that produce information overload, thus requiring additional effort and causing cognitive fatigue. When an interruption causes employees to leave certain tasks unfinished, these tasks act as distracters and further effort is required to inhibit attention to them while processing new inputs.

A study dealing explicitly with the regulation of interruptions was performed by Gillie & Broadbent (1989). These researchers tried to explain the everyday experience that some interruptions have disruptive effects, while others have not. For that purpose they did an experiment in which their participants played a computer-based game, in which the task was to proceed along a certain prescribed route, while collecting various items at particular points: bread at the baker store, meat at the butcher's, and so on. The list of items to be collected varied from five to seven (manipulation of memory load). The interruptions were administered by presenting secondary tasks, varying from mental arithmetic tasks to a so-called free recall task. The duration of the interruptions was manipulated. Gillie & Broadbent compared the time spent on each problem and the number of requests for help (i.e. looking at the list of items that had to be memorized), before and after the interruption. The results of this experiment suggest that neither the duration of an interruption nor the opportunity to control the point at which the main task is interrupted, are crucial for predicting whether or not an interruption will have disruptive effects. The nature of the interrupting activity, in particular its similarity to the main task and its complexity in terms of information processing and/or memory demands, appear to be much more important in this respect. Thus, it seems that what makes interruptions demanding is not so much the mere change of activity, but rather the fact that accompanying thought processes are affected, e.g. that (additional) information has to be kept in memory in order to resume work once the interruption has ended.

The results of research in the domain of human–computer interaction on system breakdown (Johansson & Aronsson, 1984), system response times, and waiting times in computer work (Boucsein, 1987; Holling, 1989; Thum, Boucsein,

Kuhmann & Ray, 1995) can also be interpreted from the latter perspective. In particular, when systems go down or response times are large (> 8 seconds) people may perceive 'temporal uncertainty' which causes aversive reactions, such as feeling 'pressed' (Boucsein, 1987). While waiting for the moment in which the activity can be resumed, thought processes are prolonged as well, but unlike when being interrupted no additional set of information has to be processed.

On the other hand, short breaks (a few minutes) may also have positive effects on performance, as is illustrated by research on micro rest-breaks during work (Hacker & Richter, 1984, p. 195; Henning, Sauter, Salvendy & Kribg, 1989). However, with respect to mental work this appears only to be the case with work of low mental demands, i.e. a high degree of repetitiveness.

Aim of the present study

The aim of the study presented here is to examine the effects of interruptions during work, in particular the effects of interruptions on work performance and underlying regulation processes. Our conceptual framework is the theory of activity regulation by Hacker (1978, 1986). In this theory the execution of work tasks is seen as goal-directed activity, whereby the goal is the personal goal of the worker, as defined on the basis of the task as given, taking into account the external conditions and the worker's personal state and motivation. The key assumption of the theory is that of cognitive control of activity. Actions are produced by executing cognitive schemes, using various computational and energetic resources, under cognitive control (also Rasmussen, 1981, 1983). The cognitive schemes are either developed *ad hoc*, in a process of problem solving and planning, or retrieved from long-term memory. Cognitive control includes the use of a 'strategy' to reach the goal, as well as 'monitoring' of the ongoing activity, and meta-cognitive 'supervision' (cf. Frese & Zapf, 1994; Roe, 1988; Zijlstra, 1993). The execution of actions is supposed to be preceded by action preparation, i.e. a (re)orientation with regard to the (current) work situation and the personal state, and the development or retrieval of an action plan consisting of cognitive schemes.

In terms of the activity regulation framework, the occurrence of interruptions may affect the regulation process in a number of ways. First of all, they call for a modification of the action plan, to include the interrupting event and to change the strategy for achieving the original goal within the new constraints. Interruptions put an additional demand on resources needed for action execution, as well as for the regulation of the activity as a whole (including the interrupting event). Interruptions may also affect the worker's subsequent readiness to perform, by influencing the psychological and psycho-physiological state of the worker. In this way the task goal as set by the worker and/or the resources available for action execution might be affected indirectly.

Our study is guided by a number of hypotheses regarding the effects of interruptions on performance and its regulation. In line with Hacker's notion of work behaviour as 'goal-directed activity' we assume that an action should run its course and that it is aversive when actions are interrupted. Therefore our *first*

hypothesis is that interruptions have a detrimental effect on the performance of the main task in terms of time needed for the execution and of quality. Like Cellier & Eyrolle (1992) in their study on task-switching, we expect the efficiency to diminish as a result of interruptions. Part of our first hypothesis is that the performance effects are larger for complex than for simple interruptions (cf. Gillie & Broadbent, 1989), and that they become larger when the number of interruptions increases. Our *second hypothesis* is that workers develop strategies to counteract these effects. We expect participants to exhibit a change in strategy when they are interrupted, in particular when the number of interruptions increases. A common strategy with people used to interruptions is to continue working on their task instead of directing attention immediately to the source of the interruption. This may show in a delay in picking up the telephone when it rings. Our *third hypothesis* relates to the psychological state of the workers. On the basis of earlier research, showing that interruptions cause increased levels of stress (Boucsein, 1987; Johansson & Aronsson, 1984; Kirmeyer, 1988; Kohlisch, Kuhman & Boucsein, 1991), we expect interruptions to affect the psychological state of the workers in terms of reduced well-being, negative rather than positive emotions, and greater anxiety. Again, we expect stronger effects for complex and more frequent interruptions. Our *fourth hypothesis* is that the occurrence of interruptions is associated with higher levels of activation and effort. This hypothesis is based on the expectation that interruptions pose additional demands on the worker, without reducing the demands regarding the main task. The stronger effects for complex and more frequent interruptions are expected in this case as well.

Method

To study these hypotheses two overlapping experiments have been conducted in an international cooperation between a research group in The Netherlands and a research group in Russia. In both experiments office workers were interrupted during the execution of a text editing task, while the frequency and complexity of the interruptions were manipulated. The gap between real life and laboratory tasks was bridged by means of simulation. Realistic office conditions were created in the laboratory and a job scenario was used to simulate the job of office secretary in a university (Zijlstra, 1997). Professional workers acted as participants and performed realistic tasks, while being interrupted by telephone calls in which the experimenter (acting as supervisor) demanded they perform an additional (short) task with priority.

A series of practical problems impeded the creation of identical circumstances in the two laboratories, thus making an exact replication of the research impossible. For instance, the job of 'secretary' has a quite different meaning and content in Russia compared to that in The Netherlands, and it appeared that the Russian secretaries do not work with computers. Furthermore, there were differences in availability of software and measurement equipment, as well as in expertise in the use of the particular equipment, while language barriers hindered the translation (and validation) of instruments. For these reasons it was decided to adopt a different research strategy, i.e. to conduct overlapping studies departing from the same general conceptual framework and a common set of variables, allowing for certain differences in experimental set-up. This approach has the advantage that complementary analyses could be performed.

Participants

In both experiments participants were professional office workers. In the Dutch study 40 professional secretaries (39 female and 1 male; age 21–64 years) employed by Tilburg University volunteered to

participate during work time, and received an additional financial reward. They were thoroughly familiar with the kind of tasks and situations presented in the experiment. Actually, the experimental set up had been modelled after their work. In the Russian experiment 31 staff members (11 female and 20 male; age 17–38 years) of Moscow State University volunteered to participate, and they also received a financial reward. All participants had secretarial and administrative tasks beside their professional and managerial duties, and all were experienced users of word processors.

Procedure

Participants were recruited via a letter of invitation on a public bulletin board and an internal mailing. Those who expressed their interest were approached by members of the research teams. Before the actual experimental sessions took place, the participants visited the laboratory and were informed about the procedure and the task. They were also familiarized with the measurements to be taken. The participants were not informed about the fact that this study focused explicitly on their behaviour while being interrupted during work; they were told that the equipment was being tested and a debriefing took place after the experiment.

Participants worked in the simulated office on 2 days, with an interval of approximately 1 week. During the experimental sessions participants worked on standardized text editing tasks. Between sessions participants were allowed a short break. This break was also used as a diagnostic session for administering some questionnaires and some measurements that could not be taken on-line. Each experimental session followed by a diagnostic session lasted approximately 70 minutes. In total, participants spent one full working day in the laboratory. In the sessions with interruptions the experimenter made a telephone call to the participant at certain pre-determined points during the execution of the task, thus causing the interruptions to occur at comparable moments. During the experimental sessions the participants were closely watched from the control room. The sessions were entirely taped on video and a time code was added to the video-tape by a time-code generator in order to enable subsequent time-line analysis.

Experimental tasks

In both experiments the participants were asked to edit a text of moderate complexity. Various operations, like replacing text fragments, making handwritten corrections, adjusting layout, alphabetizing the list of references etc., had to be performed on a text file using a word processing program. This was the main task. The task was composed in such a way that the undisturbed execution lasted approximately 45–50 minutes. There were no time limits and participants were free to choose their own work pace and working method. A set of similar tasks was available to be used in the various experimental sessions.

The execution of the text editing could be interrupted by a telephone call from the experimenter with the request to perform an additional (interrupting) task. With respect to the interrupting tasks two levels of complexity had been created, hereafter referred to as the 'simple' and the 'complex' interruption. The 'simple' interruption consisted of a request for some irrelevant information, i.e. to look for a telephone number in a notebook, or the year of publication of a particular article. The 'complex' interruption consisted of a more elaborate task with a greater similarity to the main task, such as an additional short editing task which required the participants to leave the current document (Gillie & Broadbent, 1989). Tasks and interruptions were equivalent in both experiments. In the Dutch study participants used the word processor 'Wordperfect 5.1' and in the Russian study 'Word for Windows 6.0' was used.

Design

In both experiments participants worked twice, during about half a day, in the simulated office. Each research day comprised three experimental sessions in the Dutch experiment, and two experimental sessions in the Russian experiment. During an experimental session participants worked on one task

(a)

Day 1	0 Interruptions	1 Interruption	3 Interruptions
Day 2	0 Interruptions	3 Interruptions	1 Interruption

(b)

Day 1	0 Interruptions	2 Interruptions
Day 2	2 Interruptions	0 Interruptions

Figure 1. (a) Experimental design in the Dutch study. (b) Experimental design in the Russian study.

(i.e. one session is considered to contain one task). As stated previously, there were some differences in the designs of the two studies. In both experiments the factor 'frequency' of the occurrence of interruptions was treated as a within-participants factor. In the Dutch experiment the first session was always without interruptions, and the second and the third sessions comprised either one or three interruptions. The first session was intended to study the uninterrupted flow of activity and therefore could serve as a point of reference (Fig. 1a). This session was scheduled as the first one on each research day, to check on any trivial influences that might have come up just because it was another day.

In the Russian experiment the factor 'frequency of interruptions' had only two levels: zero or two interruptions per session. The interruptions in a single session were either both 'simple' or both 'complex'. This made 'complexity of interruptions' also a within-participants factor in the Russian experiment (Fig. 1b).

In the Dutch experiment the factor 'complexity' of interruptions was treated as a between-participants factor. The interruptions were also either 'simple' or 'complex'. In order to keep the predictability of the experimental sessions from the point of view of the participants as low as possible, the sessions with three interruptions had a mixture of one simple and two complex interruptions. The order of presentation of these three interruptions was systematically varied. As an experimental session was considered as a unit for most of the variables, the simple/complex contrast could only be tested for the sessions with one interruption. And because for each participant the single interruption was either 'simple' in both sessions or 'complex' in both sessions, this resulted in a between-participants design for that part.

To summarize, the Russian design allows both factors 'frequency' and 'complexity' to be tested in a within-participant design, while the Dutch study had a mixed design. Only the factor 'frequency' could be tested in a within-participants design, while the factor 'complexity' could only be tested in a between-participants design in the Dutch study. The Russian design also allowed an examination of the effects of multiple 'simple' or 'complex' interruptions within a session. The order in which the various experimental sessions have been presented was balanced within and between participants.

Dependent variables

The dependent variables in this study can be categorized in three groups: (i) performance characteristics; (ii) psychological state indicators; and (iii) psycho-physiological state indicators.

The *performance characteristics* include five groups of variables: (i) overall time parameters, i.e. duration of the task execution, or total work time (TWT); the net time spent on the main task, or time-on-task (TOT); the time required for the interruptions, or total interruption time (TIT); (ii) types of actions in the flow of activity; (iii) interruption handling strategies; (iv) frequency of use of different interruption handling strategies; (v) numbers of errors and omissions.

'Interruptions' are defined as events which result in the cessation and postponement of an ongoing activity. Typical for interruptions is that the main activity is resumed after a certain lapse of time. In order to distinguish the types of actions in the flow of activity (category ii) a breakdown was made in the following types of action: (a) task related actions; (b) interruption handling actions; (c) supportive actions; and (d) non-relevant actions. Task-related actions are defined as actions relating directly to completing the task, such as inserting text, changing lay-out. Supportive actions are defined as actions that are not directly aimed at accomplishing the task goal, but support or ensure the progress of the activity by tackling the minor 'problems' that arise, or providing additional information, during

execution of the task. Examples are: looking in the help menu, adjusting the printer set-up when printing problems are encountered. Non-relevant actions are those actions that neither contribute to accomplishing the task, nor are obviously supportive. Examples of such actions are: eating, smoking, and looking out of the window.

Most of these measurements have been obtained by on-line registration of the activity flow on video. The videotapes were analysed afterwards by two trained observers using an event-recorder. By means of time-line analysis irregularities in the work flow were identified. The numbers of errors and omissions were counted by checking the documents that had been prepared by the participants. Errors were defined as deviations of the 'product' from the instructions, and omissions were scored when participants apparently had ignored a part of the instructed text correction.

In the Dutch study changes in the characteristics of the *psychological state* were measured by the Positive And Negative Affect Scale (PANAS; Watson, Clark & Tellegen, 1988) which measures the degree of positive and negative feelings of the participant at a particular moment. In the Russian experiment the scale Well-being, Activity and Mood (WAM; Zinchenko, Leonova & Strelkov, 1985) and Spielberger's State Anxiety Scale (Spielberger, 1983) were used. The WAM questionnaire contains statements and adjectives which refer to current feelings of well-being, activation, and mood of the person, such as: 'feeling active', 'feeling bad', and 'feeling strong'. Participants have to indicate on a 4-point scale to what degree these statements apply to how they feel at that particular moment. The Spielberger scale is a similar questionnaire with items reflecting various levels of anxiety. The WAM questionnaire had been translated into Dutch beforehand and was applied in the Dutch study as well. However, the questionnaire has only been administered before and after the experimental sessions on both research days. The main purpose here was to assess changes in the general level of well-being of the participants between both research days.

Furthermore, both studies used the Rating Scale Mental Effort (RSME; Zijlstra, 1993) to assess the level of effort expenditure. The scale consists of verbal anchors expressing different degrees of effort expenditure ('very effortful', 'a bit effortful', etc.), posited along a continuum ranging from 0 to 150. The scale values of the anchor points range from 3 (not at all effortful) to 115 (tremendously effortful). The RSME has proven to be an adequate indicator of psychological costs of task performance, and has demonstrated to be a valuable instrument in both field and experimental studies (Zijlstra, 1993).

In the Russian experiment the Critical Flicker/Fusion Frequency (CFF) technique was used to register differential sensory thresholds in the visual system which reflects the level of activation of the central nervous system (Bartley, 1958). The CFF measure provides two parameters; one being an indication of 'acute fatigue' that is the result of effort investment during task execution (CFF2 component), and the other component (CFF1) is an indication of 'chronic fatigue', which reflects the general level of activation of the central nervous system (Volle, Brisson, Dion & Tanaka, 1978, 1980). CFF is measured in several trials in which the difference between ascending and descending thresholds are established (providing a stability index: CFF2). The change in the thresholds between pre- and post-measurement (CFF1) is regarded to be an index of the general level of activation.

The various measurements have been taken as pre- and post measurements of the distinctive experimental sessions. The effects of 'frequency of interruptions' and 'complexity of interruptions' have been analysed by comparing the indicators in the relevant experimental conditions. Analysis of variance (a within-participants repeated measurement design, or a between-participants design specification when appropriate) was carried out using the ANOVA module of SPSS PC + . An alpha level of .05 was used for all statistical tests, except for the specific situations indicated.

Results

The results of the two studies are presented in two sections: the first section contains results concerning performance, i.e. the influence of interruptions on the flow of activities and the use of strategies (hypotheses 1 and 2); the second section contains the results on the psychological and psycho-physiological state of the participants (hypotheses 3 and 4).

Performance characteristics

First, a check concerning the effect of the factor 'day' and the control variables (ordering variables) used for balancing was carried out. The ordering variables appeared to have no significant effects. However, the factor 'day' appeared to have a significant influence on the variables TWT and TOT (both variables are identical for the uninterrupted first sessions) resulting in a significant two-way interaction 'frequency' by 'day' ($F(2,74) = 3.2$; $p = .04$). Inspection of the mean values of the various sessions revealed that participants used substantially more time in the first (uninterrupted) session on the first day compared to the first session of the second day. Although all participants were very experienced in the type of tasks presented to them, they had to adjust to the specifics of the experimental situation. The fact that they needed less time on the second day can also be understood as a learning effect. It has to be noted that no effect of the factor 'day' has been found for the variable TIT.

Table 1 shows the results of the relevant performance parameters of the Dutch and Russian studies together. In this table the results have been averaged over both research days. The figures show that TWT increased when participants were interrupted: this increase is the logical result of additional time required for dealing with the interrupting tasks. More interesting to see is that TOT decreased significantly when people were interrupted; this is contrary to what was expected. It has to be recalled that no time limits were imposed and participants could work at their own pace. The TOT decreased even more when participants were interrupted more frequently; the total reduction was approximately 9 minutes over the three sessions on the first day, and approximately 4 minutes on the second day; 4 minutes is about 10% of the total working time of the uninterrupted sessions. This finding is quite remarkable, it suggests that the occurrence of interruptions can lead to an improvement, rather than to a decline, in the efficiency in the performance of tasks thus contradicting our first hypothesis. Being interrupted means that people have to divide their attention between (at least) two sources of stimuli: the main task and the interrupting task. We therefore expected that this would have detrimental effects on the performance of the main task but this appears not to be the case: people spend less time on the main task. Additional interruptions mean that participants have to spend more time on the interrupting tasks, but in order to compensate for this they apparently devote less time to the main task. In the Russian study the expected increase in TOT also appeared to be absent. Inspection of the data in Table 1 shows that the Russian participants also seemed to spend less time on the main task when they were interrupted. However, the decrease is not significant in the Russian study and it should be recalled that participants have been interrupted only twice in this study.

Table 2 clearly shows that it takes much more time to deal with a complex interruption than with a simple interruption (i.e. increase in TIT). In both studies an increase in complexity of interruptions led to an increase of all three time-parameters, though the increase in TOT did not reach the level of statistical significance. This finding is in line with our first hypothesis.

Because the findings concerning TOT were not significant in Table 2 we cannot draw any definitive conclusions from these results. Nevertheless, the fact that TOT

Table 1. Changes in time parameters of task execution (in seconds) as a result of an increasing number of interruptions

	Number of interruptions								Analysis of variance: frequency of interruptions		
	Zero		One		Two		Three				
Variables	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*F*	d.f.	*p*
Dutch data											
Total work time	2366.4	713.1	2721.7	839.5			3563.1	771.7	46.22	2/36	< .001
Total interruption time	—	—	674.4	587.6			1610.6	509.4	74.95	1/38	< .001
Time-on-task	2366.4	713.1	2054.6	524.4			1950.9	471.5	10.13	2/36	< .001
Number of errors	14.5	7.4	12.9	5.7			14.3	10.3	0.90	2/33	
Number of omissions	5.8	3.6	5.9	3.6			6.2	5.9	0.40	2/33	
Russian data											
Total work time	2177.5	722.1			2489.9	820.3			4.66	1/57	< .05
Total interruption time	—	—			377.1	128.0				—	
Time-on-task	2177.5	722.1			2112.8	785.7			0.07	1/57	
Number of errors	5.3	3.4			6.6	3.9			2.91	1/57	.09
Number of omissions	3.5	3.0			3.9	3.1			0.39	1/57	

Table 2. Changes in time parameters of task execution (in seconds) as a result of increasing complexity of interruptions

	Complexity of interruptions				Analysis of variance: complexity of interruptions		
	Simple		Complex				
Variables	Mean	SD	Mean	SD	*F*	d.f.	*p*
Dutch data							
Total work time	2187.4	581.4	3318.5	633.8	34.6	1/38	< .001
Total interruption time	147.8	46.4	1180.1	369.4	153.8	1/38	< .001
Time-on-task	2039.6	558.6	2138.5	538.2	0.3	1/38	
Number of errors	8.6	3.5	10.2	5.1	1.2	1/38	
Number of omissions	4.3	2.1	4.6	3.6	0.0	1/38	
Russian data							
Total work time	2253.1	781.7	2733.5	800.6	5.2	1/28	< .05
Total interruption time	167.0	74.2	595.4	181.7	144.7	1/28	< .001
Time-on-task	2086.1	750.9	2140.4	833.4	0.6	1/28	
Number of errors	7.3	3.7	5.9	2.5	2.5	1/28	
Number of omissions	4.8	2.6	3.0	1.9	4.9	1/28	.03

decreased when the number of interruptions increased (Table 1), whereas TOT was not affected (and even seemed to increase) when the interruptions became more complex, suggests that it is not so much the amount of time that people spend on an interruption that causes them to speed up, but rather the frequency of being interrupted. More plainly: being interrupted several times has a greater effect than one interruption that takes longer.

In both studies the quality of the performance, in terms of number of errors and omissions, appeared not to be affected by the factors 'frequency of interruptions' (Table 1) or 'complexity of interruptions' (Table 2). The analysis shows no effect of the factor 'day' on performance. In the Russian study even a small improvement in quality of performance is found as a result of the factor 'complexity'. These findings do not confirm our first hypothesis.

Detailed observations of the video-recordings made it clear that participants develop several strategies for dealing with interruptions. Actually, five interruptions-handling strategies could be distinguished (see Fig. 2). The strategies differ in the extent to which the interrupting telephone call is responded to immediately or with a delay, and executed before, in parallel to, or after the main task is resumed. In only a few cases (in the Russian experiment) participants worked on the interrupting task after the telephone receiver had been put down (the fifth strategy), and 'parallel' strategies were also relatively rare; therefore, we focused on the distinction between 'immediate' and 'delayed' responding to the telephone.

The data on the occurrence of the two main interruption handling strategies (immediate or delayed) under the experimental conditions are presented in Table 3.

Strategy	Sequence of operations
1 Immediate – Prior	signal – pick-up – listen/execute – lay down – (execute)
2 Delayed – Prior	signal – continue task – pick-up – listen/execute – lay down – (execute)
3 Immediate – Parallel	signal – pick-up – continue task and listen/execute – lay down – (execute)
4 Delayed – Parallel	signal – continue task – pick-up – continue task and listen/execute – lay down – (execute)
5 Immediate – Posterior	signal – pick-up – listen – lay down – continue task – execute

Figure 2. Interruption handling strategies.

Table 3. Frequencies of interruption handling strategies

	Complexity of interruptions		Number of interruptions	
Strategy	Simple	Complex	One	Three
Dutch data				
1. Immediate	34	32	39	30
2. Delayed	32	35	27	48
No. of cases	66	67	66	78
Test of significance	$\chi^2(1) = 0.61$, $p = .81$	$\chi^2(1) = 0.13$, $p = .71$	$\chi^2(1) = 2.18$, $p = .07$	$\chi^2(1) = 4.15$, $p = .02$
Russian data				
1. Immediate	74	25		
2. Delayed	8	6		
No. of cases	82	31	Not Considered	
Test of significance	$\chi^2(1) = 53.12$, $p < .001$	$\chi^2(1) = 11.65$, $p = .001$		

The most common strategy in the Russian study appeared to be to answer the telephone and execute the interrupting task immediately, the incidence of delays in picking up the phone was less frequent than in the Dutch study. This may reflect the difference in professional background of the participants. It should be noted that the Dutch participants were professional secretaries who are quite used to being interrupted by the telephone, as this happens numerous times in everyday life. This was not the case with the Russian participants. The results of the Dutch study show that increasing frequency of interruptions leads towards a shift in strategy; the 'delayed' strategy becomes significantly more prevalent in those conditions. This supports our second hypothesis: it appears that participants try to

Table 4. Changes in duration of various stages within the interruption interval (in seconds) as a result of an increasing number of interruptions (Dutch study)

	Number of interruptions				Analysis of variance: frequency of interruptions		
	One		Three				
Variables	Mean	SD	Mean	SD	*F*	d.f.	*p*
Reception and execution and completion	657.6	597.7	1473.8	605.7	60.6	1/39	<.001
Change-over	3.8	5.1	11.7	9.5	39.3	1/39	<.001
Resumption	14.3	29.1	112.0	175.5	20.4	1/39	<.001

control the moment of intrusion of the interrupting event so as to limit its effect on the execution of the main task; complexity of the interruption appeared to have no effect in this respect. This is understandable because participants did not know in advance whether an interruption would be simple or complex.

In order to understand our findings better, the course of action within the interruption interval was studied in more detail. The interruption interval itself was subdivided into segments by marking the moments between which participants picked up the telephone receiver (start of the interval) and put the telephone receiver down again. Furthermore, the moments at which participants recommenced work on the main task, and the point at which they resumed their activities where they had stopped it, were marked. This results in four episodes:

(i) interruption reception and execution: the person answers the telephone, and listens to instructions/questions, provides the required information, or starts working on the interrupting task, puts down the receiver again;
(ii) interruption completion: in relevant cases the person completes the interrupting task after having put the receiver down;
(iii) change-over: no visible activity, the assumption is that the person disengages from the interrupting task, and reorients to the main task;
(iv) resumption: the person starts working on the main task, and returns to the point where his activities were interrupted.

In the time-line analysis the first two episodes 'interruption reception and execution', and 'interruption completion' have been integrated in one parameter, called 'reception, execution and completion'.

Tables 4 and 5 present the means and standard deviations of the duration of the various episodes of the interruption intervals.

The results of the Dutch study (Table 4) show that the number of interruptions had a significant effect on all three parameters. The effect on 'reception and execution', and 'change-over' can be explained simply by the fact that three interruptions have three change-over periods. However, with respect to 'resumption', the increase in duration is disproportionate; the increase now

Table 5. Changes in duration of the various stages within the interruption interval (in seconds) as a result of increasing complexity of interruptions

	Complexity of interruptions				Analysis of variance: complexity of interruptions		
	Simple		Complex				
Variables	Mean	SD	Mean	SD	*F*	d.f.	*p*
Dutch data							
Reception and execution and completion	128.5	39.5	1186.6	343.7	187.2	1/38	< .001
Change-over	2.5	1.8	5.0	3.9	6.4	1/38	< .01
Resumption	16.5	27.0	12.1	11.3	0.5	1/38	
Russian data							
Reception and execution and completion	139.3	61.6	469.6	172.4	113.9	1/51	< .001
Change-over	2.7	4.0	4.3	4.9	4.3	1/51	< .05
Resumption	25.0	27.2	27.1	24.2	0.3	1/51	

is approximately eight times the effect of one interruption. This indicates a non-additive effect of multiple interruptions.

In Table 5 the means and standard deviations for the conditions with simple and complex interruptions are presented. From these data it can be read that complex interruptions take more time to handle, as it was expected. However, it is interesting to note that effects on 'change-over' are greater in the case of complex interruptions ($F(1,38) = 6.4$; $p < .01$ in the Dutch study, and $F(1,51) = 4.3$; $p = .04$ in the Russian study). Apparently it takes longer to disengage and reorient to the main task after a complex interruption. This suggests an after-effect of interruptions. There is no significant effect of the factor 'complexity' on 'resumption time'.

Changes in psychological and psycho-physiological state

In both experiments the effects of interruptions on the psychological and psycho-physiological state have been assessed. However, the indices that were used overlapped only partly: the Dutch study focused on the changes in emotional state and assessing the level of effort expenditure; the Russian study concentrated on assessing the feelings of well-being, state anxiety and effort expenditure.

The WAM questionnaire was used in both studies. However, in the Dutch study this questionnaire was only administered before and after the experimental sessions in order to assess changes in the general level of well-being between both research days. Analysis of variance showed that no significant differences in the WAM scores on day 1 compared to day 2 were found in either study (Dutch: $F(2,33) = .29$; $p = .75$; Russian: $F(1,29) = .57$; $p = .45$).

Table 6 shows the means and standard deviations of these indices as a function of the factor 'frequency of interruptions'. Table 7 presents the results caused by the manipulation of the factor 'complexity of interruptions'.

Table 6. Changes in psychological and psycho-physiological characteristics of current states as a result of increasing number of interruptions

	Number of interruptions								Analysis of variance: frequency of interruptions		
	Zero		One		Two		Three				
Variables	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*F*	d.f.	*p*
Dutch data											
Current psychological state											
Positive emotions	31.8	5.1	30.1	4.7			30.3	5.0	10.2	2/74	< .001
Negative emotions	14.8	4.1	14.6	4.0			14.8	3.7	0.4	2/74	
Effort											
Subjective mental effort	28.4	16.6	34.2	17.6			42.4	20.8	28.5	2/76	< .001
Russian data											
Current psychological state											
Subjective well-being	48.6	6.1			46.2	7.0			1.1	1/57	
State anxiety	37.5	5.3			38.0	6.1			0.2	1/57	
Effort											
Subjective mental effort	33.1	17.8			34.2	19.2			1.4	1/57	
CFF-stability	0.9	2.1			1.27	2.2			0.5	1/57	
Activation											
CFF-sensitivity	38.2	3.0			37.2	3.2			0.6	1/57	

Table 7. Changes in characteristics of the current psychological and psychophysiological states as a result of increasing complexity of interruptions

	Complexity of interruptions				Analysis of variance: complexity of interruptions		
	Simple		Complex				
Variables	Mean	SD	Mean	SD	*F*	d.f.	*p*
Dutch data							
Current psychological state							
Positive emotions	29.5	4.7	31.1	4.9	1.0	1/37	
Negative emotions	15.5	5.1	13.5	1.5	2.7	1/38	.10
Effort							
Subjective mental effort	35.0	19.9	31.9	16.5	0.3	1/38	
Russian data							
Current psychological state							
Subjective well-being	47.9	6.3	44.6	6.0	3.7	1/28	.06
State anxiety	36.1	5.7	40.0	6.5	2.8	1/28	.01
Effort							
Subjective mental effort	32.2	18.9	36.2	19.1	3.4	1/28	.08
CFF-stability	0.9	1.1	1.7	1.9	4.8	1/28	.03
Activation							
CFF-sensitivity	37.6	4.0	36.7	4.1	0.2	1/28	

As shown in Table 6 people indicated that they had significantly less positive feelings as the number of interruptions increased. Closer inspection of Table 6 reveals that the decrease in positive emotional feelings was actually found between the condition without interruptions and the condition with one interruption. The introduction of interruptions caused this decrease; a small increase in number of interruptions seemed to have no effect. The negative emotional feelings remained at the same level, and there is a significant increase in ratings of mental effort. These findings suggest that an increasing number of interruptions leads to increasing psychological costs; this is in conformance with our third and fourth hypotheses.

There are no significant results in the Russian study on this point, but when the means in Table 6 are examined it can be seen that they changed in the expected direction. It should be noted that in the Russian experiment a maximum of two interruptions per session were administered, whereas in the Dutch experiment participants were interrupted three times in corresponding sessions.

The results in Table 7 show that increasing complexity of interruptions does not have an effect on the psychological state of the participants when a statistical significance of $\alpha = .05$ was used. However, if a less strict criterion level was used some interesting tendencies become apparent. It appears that increasing complexity leads to noticeable changes in the emotional and psychological state of the participants: in the Dutch study a decrease in negative emotional feelings was found, while positive emotional feelings were increased slightly; in the Russian

study a reduced subjective well-being was found (WAM; $p = .06$), together with higher state anxiety (SA; $p = .01$). Thus, it appears that the Russian participants responded according to our third hypothesis, whereas the Dutch participants did not—they showed an opposite tendency.

A similar observation can be made concerning the effects on the psycho-physiological state. In the Russian study an increase in effort expenditure was found (CFF2-index: $p = .03$; RSME: $p = .08$) as a result of increasing complexity of interruptions. This is according to our expectations. However, no effect was found in the Dutch study (RSME-scores are even lower for complex interruptions). The CFF1-index of activation is not affected.

These results indicate that the participants in the two studies differed in their responses to simple and complex interruptions. The Dutch participants seemed to respond more favourably to complex interruptions, their emotional state improved and their effort decreased, whereas the opposite was true for the Russian participants. This divergence may be explained by the difference in professional background of the participants: the secretaries in the Dutch study were accustomed to frequent and demanding types of interruptions and they may have perceived complex interruptions as welcome distractions, rather than stressors.

We should also point out another difference, already noted in Table 2: the Russian participants showed significantly less omissions in the condition with complex interruptions. An interpretation could be that more complex interruptions evoke a change in strategy, whereby the task performance standards go up.

Discussion

The two experiments reported here have given us the opportunity to take a closer look at what is often referred to as everyday hassles: being interrupted at work. The goal of this study was to understand what happens when people are interrupted in their work, and how they cope with interruptions. Whenever people are interrupted during their work this means, by definition, that their current flow of activities is temporarily halted, while some additional activity intercedes. On the surface people may seem to continue their task unaffected after a certain lapse of time. However, the results of this study have made clear that this is not exactly the case. First of all, interruptions lead to a change of work strategy: the strategy for executing the main task is modified in such a way that no deterioration in the performance of the main task takes place. The deterioration that one might expect, is fully compensated for, i.e. the quality of performance remained unaffected, while the speed of performance increased. Thus, we have to conclude that our first hypothesis, which predicted an overall deterioration of performance, was not confirmed. The frequency of interruptions did not have the expected negative effects on performance. For complexity we found contrasting effects: the Russian participants showed an improved performance in the case of complex interruptions, whereas the Dutch participants showed a performance decline. We are inclined to attribute the difference to the difference in professional background, especially the expectations and skills of the participants. The Dutch participants, professional secretaries, may

have experienced the simple interruptions as under stimulating and the complex interruptions as approaching a normal work load, whereas the Russian workers evaluated the simple interruptions as disturbing.

The finding that people work faster when interrupted seems to contradict the results reported by Cellier & Eyrolle (1992). They concluded that interruption of one task in order to carry out another task leads to an increase of (processing) time and errors in the primary task. However, Cellier & Eyrolle used a time-sharing paradigm which means that a dual task had to be executed within strict time constraints. This enhances the chance that one task would interfere with another task, and may press people to set priorities. In our experiments participants were free to choose their own pace, which means that there is no immediate time pressure.

The results provide general support for the second hypothesis, concerning the change of strategy, but it must be acknowledged that there was an overcompensation rather than a partial compensation of the impacts of the interruptions on the main task. This overcompensation—a faster performance of the main task at the same level of quality—does not correspond with our hypothesis, as we expected only a partial compensation of the performance decline. It is not really clear how the change of strategy is produced. It might be that in the phase of (re)orientation to the task, people make an estimate of what would be an appropriate amount of time for executing the task, given the same output standards. When interrupted their guess may be that the main task will take too much time, which would make them adjust the original plan and decide to work faster. This would be in line with findings of research on long system response times (Boucsein, 1987; Holling, 1989). The analysis of the activity flow revealed an interesting qualitative change after interruptions, i.e. the number of 'supportive activities' decreased slightly as a result of an increased frequency of interruptions ($F(2,74) = 2.7$; $p = .07$). This can be taken as an indication that a more robust strategy, aiming at a high speed of performance is adopted.

As for the management of the interrupting tasks, several strategies were identified. They reflect different ways of controlling the moment at which the interrupting task enters into the flow of activity, and of combining the main task and the interrupting task (i.e. serial or parallel). It was found that an increase in the frequency of interruptions led to a change in use of the different strategies. The secretaries in the Dutch study tended to postpone the interruption, whereas the Russian participants preferred an immediate response to the interruptions. The decision to postpone the interruption can be understood as a preference to complete a particular part of the action one is currently involved in. Actions are sequentially and hierarchically organized (Volpert, 1982). One action may consist of several 'partial actions' (or subactions), which itself may consist of various operations. Once an action (or part of it) has been completed, it supposedly no longer has a claim on the memory system. For example: after a sentence has been written one no longer has to bother with the formulation, and that part can be released from memory. What remains is the pith of the argument. This is in essence the 'Zeigarnik effect': completion of an activity leads to 'closure'. It may well be that a delay in picking up the phone, actually means that one is

trying to complete a particular part of an action, and thus looking for a more 'suitable moment' to be interrupted. It should be noted that the telephone is generally experienced as a very intrusive medium, few people just let the phone ring. This means that there is only little room for completing substantial parts of an action.

The results concerning the changes in psychological state indicate that interruptions apparently have a negative impact on the emotional level. This is in agreement with our third hypothesis. It is interesting to note that the decrease in positive emotion is associated with the differences between zero and one interruption; the increase from one to three interruptions did not have much effect suggesting that it is less important how often one is interrupted, than whether one is interrupted at all. Here, however, one should keep in mind that the picture may change when the frequency of interruptions increases drastically. The effect of complexity of the interrupting task appeared to be different for the Dutch and the Russian participants: the response of the Russian participants was in line with our expectation, i.e. their subjective well-being was less when complex interruptions were present; in contrast, the Dutch participants displayed a slight (statistically non-significant) increase in positive emotions, and a (marginally significant) decrease in negative emotions.

As for the psycho-physiological state, we have found that interruptions cause a higher level of effort expenditure (RSME), without any change in activation (CFF1). This indicates the subjective cost of being interrupted: interruptions pose additional demands on people's resources. Thus, in order to process the interrupting tasks and to compensate for the impact on the main task by speeding up performance, while maintaining the quality level, higher effort is needed. As far as effort is concerned, our findings are in agreement with the fourth hypothesis: we found an effect of an increase in frequency of interruptions, and there were diverging effects among the Dutch (no effects) and the Russian participants (more effort, reduced well-being) of complexity. This finding points in the same direction as our finding with regard to emotions, as well as with regard to the performance of the main task. The professional secretaries in the Dutch study, who are used to a high level of interruptions in their daily work, respond differently from the university staff in the Russian study. In this connection it should be noted that the Dutch participants reported the experimental situation (including the task) to be quite realistic but also somewhat 'dull' in comparison to their normal work situation. This especially applied to the condition without interruptions. Being interrupted can apparently break a growing feeling of boredom, and complex interruptions may be perceived as challenging and therefore lead to an increase of positive feelings and a reduction of effort. This confirms that interruptions are not necessarily a nuisance, but can also be seen as a source of stimulation and distraction under specific conditions.

It should be noted that in analysing the effects of frequency and complexity of interruptions on psychological and psycho-physiological state, we had to adopt a less rigid statistical criterion ($\alpha = .10$). Such a liberal criterion can be justified by the fact that the experimental manipulation may be regarded as relatively weak. The number of interruptions was actually rather low, and of modest complexity.

In order to understand better the effects of interruptions on work behaviour, one should examine the process of activity regulation when the worker is confronted with interruptions. Such an examination is provided by our micro-analysis of the activity stream in the interruption interval, using the video-recordings. It is obvious that a certain amount of time is needed to perceive the interrupting stimulus (phone call), to respond to it (pick up the receiver), to interpret the additional task, and to execute this task. But there is also time needed for the 'change-over' from the interrupting task to the main task, as well as for the 'resumption' of the main task. An interesting finding is that the length of the change-over interval increases as interruptions become more complex. We interpret this as showing that it takes longer to disengage from a complex than from a simple interrupting task: complex tasks call for more elaborate cognitive processes from which it is less easy to disengage. This finding is supported by theoretical notions on the depth of processing (Craik, 1977; Craik & Lockhart, 1972). In terms of information processing, complex interruptions are assumed to require more elaborate and exhaustive search processes in working memory. The non-additive effect of multiple interruptions on the resumption time is less easy to explain. This finding demonstrates that it takes longer to get back to the point where the execution of the main task was stopped after having been interrupted several times. In terms of Hacker's activity theory, people have to re-orient after the interruption—information on the goal of the task, the action plan, and the status of the activity (the point reached) has to be re-retrieved. As has been pointed out before, this 'reloading' of information is to some extent also a motivational process; after having been interrupted several times people may find it difficult to motivate themselves again to devote their attention to the main task once more.

This motivational effect might be understood by looking at the psychological costs of 'cognitive shifts' as referred to in Cohen's (1978) model on cognitive fatigue. According to Cohen people have to scan and evaluate the seriousness (potential threats) of all new information and events that they are confronted with. The frequent changing of the focus of attention causes cognitive (or mental) fatigue, i.e. a decrease in total available attention capacity. This may be the reason why people experiencing many changes (e.g. talking to a lot of people, solving various problems, having several meetings after another) often feel exhausted at the end of the day. It is interesting to recall that Kirmeyer's study (1988) found that interruptions influences participants' appraisal of workload, in particular for type A personalities.

The results of this study made clear that interruptions have an effect beyond the mere change in activity. There is more to interruptions than just incorporating additional tasks in their activity stream. A change in work strategy is called for, both to ensure that the main task is brought to an end in an acceptable way and to deal with the interruptions *per se*. In addition, interruptions appear to have an impact on the worker's psychological and psycho-physiological state, thus affecting his/her subsequent readiness to perform. Earlier research on interruptions (Gillie & Broadbent, 1989) and task-switching (Cellier & Eyrolle, 1992), as well as on system response times (Holling, 1989) and computer breakdown (Johansson & Aronsson, 1984) has suggested that these effects are usually negative, and can be precursors of

mental strain and stress. Our findings are only in partial agreement with this: interruptions tend to affect people's feelings in a negative way, and to increase effort. But we also find clear evidence, especially among the experienced participants in our Dutch study, that interruptions can have a positive effect, leading to more positive feelings and less effort expenditure.

Conclusion

The studies described in this article have resulted in a consistent picture of the effects of interruptions on task execution and workers' state. In order to assess the effects of interruptions one has to differentiate between the effects on performance and work strategies on the one hand, and the effects on the worker's state on the other hand. Using realistic text editing tasks and participants with extensive work experience we found that interruptions have a positive effect on performance, enhancing the speed of task execution, while maintaining the level quality. This performance improvement was realized by means of a change in work strategy. This strategy related partly to the manner in which the main task is executed, and partly to the way of dealing with the interruptions. It is not the same for all participants. Apart from individual variety, we have noted a difference between the two types of workers in our study, i.e. professional secretaries in the Dutch experiment and university staff in the Russian experiment. The Dutch workers, who were accustomed to frequent interruptions in their daily work life, were less bothered by the interruptions and responded more favourably to complex interruptions.

Generally speaking, interruptions were found to have a negative impact on the state of the person. The psychological state was affected in the sense that the emotional feeling became less positive, and well-being diminished. As for the psycho-physiological state an increase in effort expenditure was found. This shows that the improvement in the performance of the main task is achieved at the expense of higher psychological costs. Obviously, there are two sides to the strategy chosen by the participants: the maintenance of high performance standards and the mobilization of additional effort. The difference between the two types of participants in their way of dealing with interruptions and their response to complex interruptions, is also reflected in the findings of the participants' state. The Dutch participants responded to complex interruptions with more positive feelings and lesser effort, whereas for the Russian participants the opposite was true.

Interruptions seem to have a cumulative effect as far as the workers' state is concerned. When the number of interruptions grows the level of effort rises and the resumption time, i.e. the time needed to re-start the task execution, becomes disproportionally longer. This effect may be explained in terms of decreasing motivation and growing mental fatigue. Extrapolating our findings, which show a performance enhancement along with rising psychological costs, we expect an inverted U-curve with respect to the optimal effect of interruptions.

Although this study has augmented our insight in some facets of interrupted work activity, much remains to be investigated. We see three directions for further

research. One is research on the factors that differentiate between positive and negative effects of interruptions, i.e. the improvement vs. deterioration of performance, positive and negative emotional shifts etc. As our research suggests a role of workers' professional experience and skills, a more systematic examination of these factors would be useful. A second direction is the detailed study of the cognitive and energetic processes involved in the regulation of activity when interruptions occur. Especially interesting are the cumulative effects of repeated interruptions found in our study. The third direction is research on the role of interruptions as occupational hazards. Such research should focus on the longer term impacts of interruptions on workers' well-being and health, especially in interaction with other occupational stressors, such as high task demands, time pressure, computer breakdowns etc. Such research might be useful in identifying interventions for reducing the negative effects of interruptions.

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