Work and Emotions;

The Role of Interruptions

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CONTENTS

CHAPTER 1 *INTRODUCTION*

Life without telephones is unthinkable nowadays. Have we not all noticed someone making a telephone call in the elevator or in the street? Even business cannot survive without telephones, as 95% of all business orders are made by telephone (Van Bergen and Timmermije, 1995): Modern communication devices, such as modem, fax, e-mail, and mobile telephones, are all widely accepted and frequently used. Customer-oriented services like mail services, cinemas etc. are offering a variety of, automatically handled, services (like tele-information services) that were unknown before. But what if telephone calls are not handled automatically and are not an essential part of the job? Then, it is not difficult to imagine, even from one's own experience, that these calls interrupt ongoing, daily work.

In the past, physical strength and motor skills were needed to perform work tasks. During the last decade, computer information systems were introduced widely and their use increased enormously. In 1985, Goldstein and Fraser found that one out of eight employees used a computer at work. Between 1985 and 1988, computer-use by writers of technical documents increased by 36% (Severson Eklundh and Sjöholm, 1991). In 1991, 55 % of the respondents in a study among 1168 Dutch workers used (modern) information technologies such as a personal computer; 88% of these workers used the computer on a regular basis (Roe, Zijlstra, Schalk, Meijer, Taggenbrock & Neervoort, 1994). Computers are used to perform, facilitate and coordinate activities such as order entry, inventory control, accounting, decision making, etc. More (faster) computers have been installed, for more purposes and in more forms; more computer programmes and learning facilities are available for a larger number of people.

With the growth of the service sector and the increased use of technical equipment, such as computers, electronic mail, computer conference and electronic bulletin boards (Roe, 1989), tasks imply more and more mental and cognitive skills. More emphasis is laid upon "knowledge work" such as planning and designing. Roe and Meijer (1990) designated this kind of work as "Mental Information Work". Due to the fact that mental information work places high demands on the cognitive system, it is likely that this type of work is sensitive to interruptions. For example, if interrupted, one has to remember where in the task the interruption occurred. The performance of the task might be affected more than in other types of work where work objects and/or tools are tangible and physically manifest and display the stage of the work process.

Not only have we ourselves often experienced that interruptions can affect our performance and personal state, for example emotions; a small number of scientific studies confirms these effects (e.g., Carayon-Saintfort, 1992; Kolish, Kuhman & Boucsein, 1991). Most experimental research on the effects of interruptions in modern, mental work discusses interruptions in terms of computer slow/break-downs. Johansson and Aronsson (1984), for instance, observed ninety-five insurance

company workers during four hours of computer work. They found that these workers changed their performance strategies after being interrupted by computer breakdowns and telephone calls: "the pace is forced early in the day to guard against any breakdown later on" (p.177). Also, feelings of mental and emotional strain (irritated, rushed, tired, bored) were reported. Another type of interruption which has been investigated is the imposed rest- or recovery-break, in particular its length (e.g., Boucsein, 1989, 1993; Henning, Sauter, Salvendy and Krieg, 1989; Johansson and Aronsson, 1984; Meijman, 1993; Thum, 1995; Thum, Ray & Boucsein, 1994). In Henning et al.'s research, the performance and the personal state of twenty professional data-entry workers were negatively affected by the introduction of rest breaks: the key-stroke rate lowered, the correction rate increased and the workers got tired and bored. Other research, on the other hand, has shown that a worker needs (long) breaks for rest or recovery, especially when work is tedious or stressful. Kolish et al. (1991) found that 1-3 minute breaks led to feelings of irritation whereas breaks that lasted between 4 and 9 minutes did not. Thum (1995) found that a break schedule with 50 minutes' work/7.5 minute break was more effective in preventing negative subjective outcomes like fatigue and lower well-being in mental workers than a schedule of 100 minutes work/15 minutes break, during mornings. In the afternoon, workers preferred longer, but fewer breaks.

From our first orientations on the occurrence and the effects of interruptions in modern work, we can conclude that interruptions have become an important phenomenon in daily, mental work. It also appears that many sources of interruptions exist, even in a restricted research area like computer work: computer breakdown, rest break, telephone call, etc. In addition, attention is mainly paid to possible negative effects. However, we suspect that positive effects can also be found, for instance an interruption during repetitive work. No research has addressed *daily* interruptions and their effects on *modern work*. This study tries to fill this information gap by investigating which daily occurring interruptions affect performance and how. Research (for example, Johansson and Aronsson, 1984; Kolish et al., 1991) has also made clear that not only the performance of the task is affected by an interruption. The personal state, in particular emotions, can be affected as well. In this study, we will therefore also look at the influence on emotions. We think that these emotions, in turn, can affect performance. For example, in Kolish et al.'s study secretaries, after feeling irritated, (re)organized their work and avoided certain situations.

Before we can formulate the research questions of this study, however, it is necessary to describe the term "interruption" in more detail. Since, moreover, the nature of jobs and tasks in the investigated cases varies, also a more explicit demarcation of "daily mental work" is needed.

1.1 Research area

1.1.1 Daily mental work

Work is a complex concept that can be described from different points of view. Roe (1990) described work - from a psychological point of view - as a set of activities aiming at the achievement of a certain goal. By interacting consciously with the environment, and using knowledge, skills and tools, the person transforms an initial state into a wanted final state. Information-processing structures support this process. The dynamic process through which the worker tries to achieve the work goal, as well as the outcomes, have been defined as "performance" (Roe, 1998). The performance process is described as a complex self-regulated process in which the person activates and executes an action in line with the cognitive representation of the goal. Many task characteristics and personal characteristics influence this process, as do other factors like tools, the physical and social surroundings, etc. The outcome of the performance process is the congruence between what was aimed for and what has been achieved in the end. It can be divided into work outcomes and personal outcomes (the X-model of work; Ten Horn and Roe, 1988). Attributes and characteristics of the work situation (tasks, rules, rewards, etc.) and subjects' functions (skills, cognition, memory) have been found to influence performance, together with motivation and perception of how the performance must take place in order to accomplish the task (accuracy, speed, etc.; Baars, 1988; Barber, 1988; Rasmussen 1986; Slack and Wild, 1975; Winsemius, 1969).

As noted earlier, work activities have become more abstract, more mentalized. Consequently, tasks place high demands on the cognitive (information-processing) system of the worker. Roe and Meijer (1990) speak of "mentalization" of work. They identify a new kind of work, designated as "Mental Information Work" (MIW). MIW is defined as: (re)producing, changing or transforming information objects. Information objects are objects such as paper files, letters, documents, card files, registers, pictures etc. carrying information. Information systems such as computer systems, dictating machines but also paper and telephones, are tools that help to plan, represent, create, and reproduce the task execution. MIW includes both routine and non-routine actions and requires concentration and memory.

It is this new type of work, with its high demands on the cognitive system of the worker, in which the influence of daily interruptions has been identified. This influence will be investigated in this study.

1.1.2 Research on interruptions

Research on the effects of interruptions started in the late nineteen-twenties, when Zeigarnik (1927) and Ovsiankina (1928) studied the effects of completed versus uncompleted physical and mental tasks on memory. In her experiments, Zeigarnik (1927) asked subjects to execute a series of mental (arithmetic) and motor (drawing, constructing) tasks. During some of the tasks, the subjects were interrupted by giving them the material of the next task. When the subjects had to recount which tasks they had executed, it was found that the interrupted tasks were remembered better

than the non-interrupted tasks. This effect was later called "the Zeigarnik effect". One explanation for this effect was the existence of a so-called "quasi-need" (Lewin, 1935). This need arises when the individual has the intention to perform and complete a task, thus evoking a tension or energy state. This tension decreases only when the goal of the task has been achieved. The Zeigarnik effect was also explained by Gestalt theorists. These theorists provided the idea of grouping principles of, for instance, proximity, similarity, continuity, etc. In particular, the principle of closure was considered to be important. Closure can be described as the tendency towards completing a task or problem in order to achieve an organized and coherent field, led by forces which hold it together. The need for closure leads to an increase in effort and a better memory of the interrupted task than of the uninterrupted task (Schiffman and Greist-Bousquet, 1992).

Between the 1930's and the late 1960's, numerous experiments were conducted to gather more information on variables influencing the Zeigarnik effect, such as age, motivation, speed of recall, personality etc. Some of these experiments confirmed the Zeigarnik effect, while other experiments did not. After an extensive review of all related experiments, Van Bergen (1968) concluded that the endorsements of the original results were weak. Cultural differences, influences of fatigue and anxiety (Atkinson, 1953), experimenters' performance attitude (Van Bergen, 1968), as well as the type of tasks (for example complexity; Glixman, 1949; Caron and Wallach, 1957; Van Bergen, 1968) were indicated as causes of some of the contradictory results in replication studies.

More recently, work-related interruption research has been focused on the influence of noise on performance (Broadbent, 1979), the effects of interruptions in terms of technical problems and errors in the industrial production industry (Hartley, Morrison and Arnold, 1973; Rasmussen, 1986) and, as described earlier, the effects of computer breakdowns, rest breaks etc. on performance (e.g. Johansson and Aronsson, 1984; Boucsein, 1989, 1993; Henning et al., 1989). An important difference between the older (before 1970) and the more recent investigations is that interruptions were used as a technique for studying psychological factors such as motivation in earlier studies. In later studies, interruptions are more or less treated as a phenomenon in itself.

As suggested earlier, most of the studies only looked for possible negative effects of interruptions. In work-related studies we found effects on variables like the number of errors made, the increase in execution time, etc. But interruptions can also have positive consequences such as paying (conscious) attention to the situation or the experience of positive emotions. A similar, generally positive, perspective has been found in psychological research on problem solving. Research has shown that interruptions can facilitate problem solving because the problem is set aside (placing a delay) while some unrelated activity is undertaken[1] (Murray and Denny, 1969).

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[1] Related to this concept is the daily-life experience of seeking a name which one cannot remember. After the performance of another, non-related, task the name is often remembered.

This is also known from research on learning. Smith and Vela (1991) found that subjects remembered more drawings when an interval was interposed than when they had to recall the drawings immediately after studying the pictures. Researchers like Britton & Tesser (1982) and Yavin & Meijer (1987) explained this so-called "incubation effect" by stating that mental and physical fatigue occurs during intense effort. During an interruption interval, this fatigue may decrease. Some researchers (cf. Murray & Denny, 1969; Patrick, 1986; Rasmussen, 1986) found that the effect depends on the type of task, the kind of interruption, and on personal characteristics, while others (cf. Beck, 1979; Patrick, 1986) found no incubation effect at all. Following the idea of an incubation effect, we can imagine that a daily occurring interruption in work can have positive outcomes as well, since the interruption places the main task aside.

Apart from having effects on work outcomes, interruptions can also affect the personal state, in particular the emotions, of the worker. Already in 1928, Ovsiankina mentioned the existence of negative emotions as a result of interruptions: subjects felt irritated. Mandler, first in 1964, and later in 1975 and 1984, formulated the relation between interruptions and emotions in more detail. He believed that another phenomenon is involved in the interruption process, besides the tendency to complete, namely, an emotional response. This response can direct workers' behaviour and it does not emerge unless an organized response has been interrupted. So far, no study has yet addressed the issue of emotions in (interrupted) work, although some researchers (for example, Briner, 1995; Pekrun and Frese, 1992) have acknowledged its importance. Nor have the effects been investigated of these so-called interruption-related emotions on performance

1.1.3 **Definition of an interruption**

Ovsiankina (1928) stated that after an interruption the disturbed action is resumed. Founding our definition on her formulation, we define an interruption as an event that results in a temporary (for example half an hour) cessation and postponement of the ongoing activity while the achievement of the goal is still aimed at. After the interruption, the main activity is resumed. For example, a phone call occurs while you are working. When you answer this call, you have to stop the task you are working on. After the phone call, for example after 10 or 30 minutes, you continue to work. When the ongoing activity cannot (or is not) be resumed, for example, because the task has been taken over by a colleague, we speak of a disruption. According to Zeigarnik, during an interruption the existence of a tension towards the completion of the task still exists.

We are aware that our definition is only one way of focusing on the occurrence of interruptions. Other approaches are possible as well. According to our definition, the situation of, for instance, going home after being interrupted by a telephone call at the end of the day and leaving the task for tomorrow, cannot be defined as an interruption (the task is not resumed within a short time), or as a disruption (the possibility of resumption still exist). Just because of the many possibilities, we have decided to focus on one type of interruption, namely on the short time, externally

generated, daily occurring interruption in normal mental work, leaving other options for future research.

Figure 1.1 illustrates an uninterrupted and an interrupted task execution, based on a notation system of task structures in physical work execution (Winsemius, 1969). When we look at Figure 1.1a, we see a normal, uninterrupted, task execution. In the first task phase, three parallel actions (a, b, and c) are executed, and in the second task phase, an activity is executed (d) by means of an object (e). For example, for responding to a letter, you get the original paper (a), some documentation (b) and a pencil (c) for making notes in the first part. In the second part, the letter is written (d) by means of a computer (e). When we look at Figure 1.1b, we see the interrupted task execution. In the first task phase, the same actions (a, b, and c) are executed as in Figure 1.1a but the activity (d) has not been started because of an interruption (f), for example a telephone call. In the third task phase, during the telephone call, other actions are executed first, for instance making a note (g). After the phone call, task phase 2 can finally start (d and e)[2].

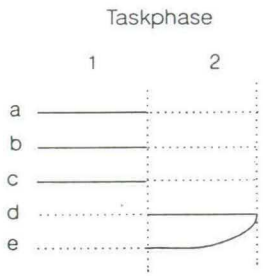

Figure 1.1a

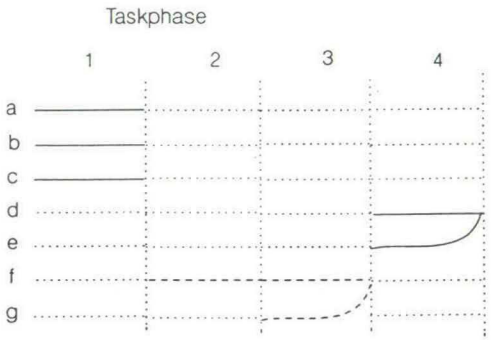

Figure 1.1b

Figure 1.1 Graphic representation of an uninterrupted writing task (Figure 1.1a) and of an interrupted writing task (Figure 1.1b; based on Winsemius (1969) notation system of task structures in physical work execution)

Interruptions can be internally generated (caused by the worker himself)[3] or externally generated (not caused by the worker himself). Internal interruptions depend on the state or the thoughts of the individual, and not on environmental events. For example, we may take a rest because we are tired. Such specific conditions or states can interrupt the activity of a worker but do not necessarily interrupt another worker. Specific task characteristics, such as monotonous working conditions or time pressure, can also lead to internal interruptions, for example,

[2] For the sake of clarity, the illustration is held very simple, leaving out possible other actions, implications, or effects.

[3] The use of the male form in this study only serves practical reasons.

taking a break after a long-lasting situation without any variety in the tasks. Furthermore, non-specific determinants such as heat, noise, and dust, can result in an internal interruption like day-dreaming (Britton and Glynn, 1989; Fisher and Hadrill, 1995; Greiner and Leitner, 1989). External interruptions affect the activity directly; they need attention and often require a short-term, conscious reaction of the worker. The consequence of an external interruption is often that extra information must be searched for before the main activities can be resumed (Greiner and Leitner, 1989). Examples are: someone telephoning for information or enquiring at a desk, and a malfunction of the equipment or a lack of material.

1.2 Conceptual model

In Figure 1.2, our conceptual research model is presented. This model is used as a stepping-stone for our research on the daily-life situation of interruptions in mental information work. The model is compatible with the "X-model" of work, developed by Ten Horn and Roe (1988).

According to this model, activity is considered to depend on situational conditions, including job (e.g., decision latitude) and task characteristics (e.g., complexity) as well as on personal characteristics (such as work motivation and personality). The activity, or the performance process, is supposed to result in a transformation of the work environment, i.e., in work outcomes (e.g., productivity), as well as in subjective experiences (e.g., well-being, fatigue, effort, emotional experiences). Underlying the model is the assumption that many different cognitive and psycho-physiological regulation processes make adjustments to cognitive and psycho-physiological structures in order to achieve the personal goals and to meet the requirements of the organization (Hockey, 1993; Roe, Zijlstra, Krediet, Van Den Berg, Van Den Berg-Lenssen, Leonova, Kouznetsova, Kapitza, Burmistrov, Frenkina, & Belyshkin, 1995).

The loops in our model indicate how an interruption can affect the activity and are only illustrations of how interruptions can affect performance. It is our intention to find out what happens when an interruption occurs. In our model, we suggest that an interruption, with its own characteristics, affects the activity (i.e., activity is temporary stopped). The work outcome is also affected (e.g., task not finished), followed by an effect on the activity (e.g., working harder for making up for the lost time). Cognitive and psycho-physiological processes regulate the activity. In turn, the regulation processes are influenced by the affected activity. Interruption can also affect the personal outcomes (e.g., getting tired), which can affect the activity (e.g., taking a rest). Furthermore, the interruption can affect the personal state and the emotions, which influences regulation processes and can affect the activity of the task and its outcomes. For example, a worker becomes irritated when interrupted. To finish the task, he works faster, with more effort. We suggest that work outcomes and personal outcomes can also influence each other. For instance, when too many errors are made, in spite of an increase in effort that has been made, the worker is

disappointed with the result.

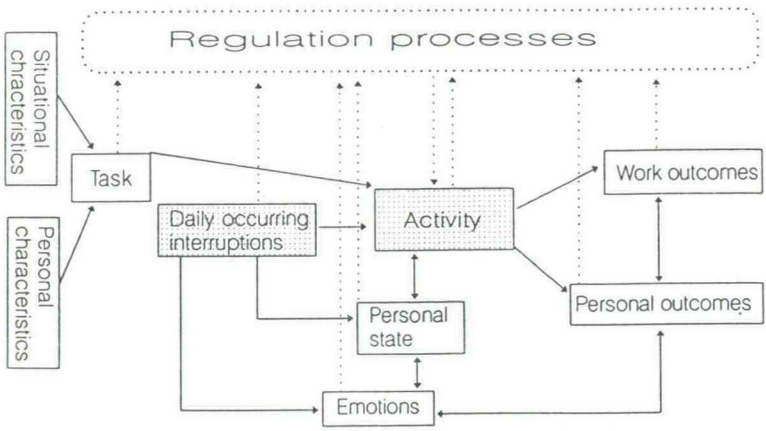

Figure 1.2 Conceptual model of interruptions in goal-directed behaviour

Several lines of research that have recognized the existence and the importance of interruptions in mental work can help us to understand more clearly what happens when an interruption occurs and the role of the regulation processes involved. The cognitive processes involved in the regulation of work is most prominently described in Action Regulation Theory (see Hacker 1973, 1978, 1986, 1998). This theory centres on (hierarchical) mental models and plans. It describes how workers regulate their goal-directed activity, based on cognitive structures at different levels, and uses concepts related to information processing (viz. serial versus parallel processing; automatic versus controlled processing). But since psycho-physiological regulation processes are involved, these processes need to be taken into account as well. Emotions, in general, are described by cognitive emotion theories. The starting point of these theories are the theories of James (1890) and Cannon (1927). They place a strong accent on the cognitive labelling of autonomous physiological processes (Van Olst, Kok, and Orlebeke, 1980). The cognitive emotion theories comprise information-processing aspects such as arousal, activation, cognitive evaluation, specific physiological mechanisms etc. The cognitive emotion theories of Mandler (1975) and Frijda (1988) describe the role of interruptions on emotions. And, although no research exists on the effects of interruption-related emotions, both theories will help us to understand the possible effects of interruptions regard to emotions.

1.3 Aim and plan of our study

In this chapter, we have noted that interruptions are common events in daily work. But although several studies have acknowledged the fact that interruptions can affect mental task performance, it was hardly studied what kind of interruptions occur in

normal working situations, let alone what the effects were.

With the widespread use of modern information and communication systems, work will be more mentally oriented. There are indications that interruptions in modern work can affect work performance as well as the personal state. As mental information work places special demands on the cognitive system of the worker, it is interesting to know how daily occurring interruptions (can) affect mental information work and why. Researchers have found a relation between interruptions and psycho-physiological stress variables like cortisol and adrenaline secretion, heart rate, blood pressure, and positive and negative affects (e.g., Ben Zur and Breznitz, 1981; Carayon-Saintfort, 1992; Carayon and Hajnal, 1993; Johansson and Aronsson, 1984; Lindstrom, 1991). When interruptions occur repeatedly, and when compensatory mechanisms, like effort, fail to compensate for the negative effects, stress and stress-related diseases, such as cardio-vascular and immune diseases, can occur (Johansson and Aronsson, 1984; Kanfer & Stevenson, 1985; Van Ouwerkerk, Meijman and Mulder, 1994). As De Sitter explained (p.152): "It is not the problem itself, but the obstruction to solving them that causes stress." Research on interruptions may throw light on factors that are critical in job and task design and on the improvement of the work environment of mental workers. We hope that our study will contribute to the prevention of negative effects of interruptions and to the creation of healthier workplaces.

Other reasons for studying the influence of interruptions in daily work are the indications that interruptions can lead to a decrease in productivity (e.g., longer execution times). But what about the quality? Are more mistakes made? Real-life examples suggest that this might indeed be the case. Do we not all know the sign on the bus: "do not speak to the driver when he is driving"? And indeed, how often are errors made when people start talking while paying for their shoppings? These examples suggest that interruptions during mental work should be avoided. But does this go for all situations? Probably not, because interruptions are sometimes described as pleasant rather than annoying, for instance during monotonous work. What makes the difference?

The scientific aim of our study is to understand more about how interruptions in mental work affect work activity, psycho-physiological state, work performance and subjective experiences. Existing, useful, theories and models have been developed for other types of tasks, e.g., physical operations or simple decisions tasks. But these theories, such as information-processing theories, Hacker's Action Theory, and cognitive emotion theories, do not describe the influence of interruptions in detail. With this study we hope to ascertain the validity of these theories for mental information work. And, as interruptions are common in daily work, we think that more attention should be paid to the occurrence and effects of interruptions. Their influence should be integrated into existing work-related theories.

During our investigations, we found that researchers used various types of interruptions. Before we can investigate the possible influence of interruptions, one

of the first questions that must be answered is which externally generated interruptions occur frequently in daily mental work. Research has shown that factors, like the complexity and the moment of the interruption, influence performance (Mandler, 1964; Gillie and Broadbent, 1989). If we want to find out more about the effects of interruptions on performance, it is necessary to know which factors play an important role. *The first aim of our project is to find out which daily occurring interruptions there are in mental information work and how they (can) affect performance.*

We also found that the role of emotions in work has not been well elucidated. Researchers (e.g., Frese, 1990; Frese and Zapf, 1994; Mandler, 1988) have reported that emotions in work do occur - also in relation to interruptions - but the role of emotions was often only theoretically acknowledged. *The second goal of our study is to learn more about the influence of interruption-related emotions on daily mental work, that is, how they affect performance and how workers deal with them.*

The set-up of our research has three parts. In the first part, we investigate, by means of a survey study, which interruptions occur in daily mental work. Furthermore, we will, on an explorative basis, gather more information on the work tasks during which the interruptions occur, how the interruptions can affect performance, the factors that influence the effects, whether emotions are involved, and how mental information workers deal with the interruptions. The second part comprises the theoretical discussion of our findings. Based on the results of the survey study and on the literature discussed, we will formulate our hypotheses. In the third part of our study, the hypotheses are investigated in two experiments. In the first experiment, we investigate the effects of (the characteristics of) interruptions on performance in more detail (our first goal). The second experiment focuses on the effects of interruption-related emotions on performance (our second goal). The survey study is used to enhance the ecological validity of our experiments and to demarcate the research area. The combination of both field and laboratory studies - together with generally accepted theories and models - gives a more complete picture of what happens when mental workers are interrupted.

In the following chapter (Chapter 2), the results of our survey study are described. In Chapters 3 and 4, we discuss the theoretical background of our study. Chapter 3 deals with the regulation of the cognitive (interrupted) work process according to Action Regulation Theory. The related information-processing theories are also discussed. The theoretical role of emotions in (interrupted) work is discussed in Chapter 4. Based on the information of our survey study, we designed an experiment to investigate how daily occurring interruptions affect performance, the personal state, and the cognitive and psycho-physiological regulation processes involved. The results of our first experiment are presented in Chapter 5. In our second experimental study, we focus on the role of interruption-related emotions. We examine how these emotions can influence performance. We also look into the cognitive and psycho-physiological regulation processes that are involved. The results are described in Chapter 6. In Chapter 7, we discuss the results of both

experiments in relation to the literature and we evaluate whether our research goals have been achieved. Some suggestions for future research are made.

CHAPTER 2 *SURVEY STUDY: An exploration of daily occurring interruptions*

In the previous chapter we mentioned that little research has been done on the occurrence, the influences, and the effects of interruptions in real-life work situations. In this chapter, we describe a survey study[4] that inventories which interruptions can affect the performance process and performance outcomes in actual work settings. We asked mental information workers to describe their work and examined the specific (interruption-related) factors that (can) affect performance. This survey study also helps us to outline our research domain. Not only do the data serve as a handle for our theoretical research on the interrupted work process, described in Chapter 3 and 4, it is also used for the ecological validation of our experimental studies, reported in Chapter 5 and 6. We believe that by portraying the daily life situations before describing the underlying theories, a clearer picture of our research area can be obtained. The formulation of our hypotheses on the effects of interruptions, the influence of specific factors, and the changes in the processes involved is also based on the results of this survey study.

2.1 Introduction

As we have already noted in Chapter 1, this survey study has two aims. First, we want to find out which interruptions occur in daily mental work. We briefly mentioned that it is also necessary to pay attention to the factors influencing the effects of the interruptions. More explicitly, in this study we will look at externally generated interruptions. We found only one study that describes the different types of externally generated interruptions in daily work. Brouwer-Janse, Scheffer, Vissers & Westrik (1992) found that during secretarial work telephone calls and people entering the room were reported to be the most frequently occurring interruptions.

The second aim of this study has to do with our research domain. In Chapter 1, we noted that most interruption related research lacks a well-defined research domain. We also found that research studies on (the effects of) interruptions differ in purpose, theoretical assumptions, methods, work settings, and investigated variables. Thus, before we can investigate and draw any conclusions, we have to demarcate the research area of interruptions in daily mental work.

For our research, we follow our conceptual model (Figure 1.2). In the survey study, information is gathered about the situational working conditions. For example, the number of people in an office will affect the chance of one person being interrupted by another. Also, information is gathered on the executed tasks. The effects of interruptions are divided into effects on the performance process and on its outcomes - that is on work and personal outcomes - and on the personal state. The

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[4] See Appendix A for details.

effects on the performance process involve questions about possible changes in the strategy used, the avoidance of interruptions, etc. The number of errors made is the main variable for the effects on the work outcomes. Furthermore, we want to know whether interruptions lead to, for instance, changes in concentration and motivation (the personal outcomes) and whether feelings of fatigue are experienced (personal state effects).

2.2 Research questions

In order to describe the occurrence and the effects of interruptions in daily mental information work, this survey study explores the following questions:
1 ◇ *What types of interruptions occur in daily mental information work?*
2 ◇ *Which task, interruption, and personal factors influence performance?*
3 ◇ *What are the effects on the personal state, especially on emotions, on the performance process, and on the work and personal outcomes?*

2.3 Method

2.3.1 Procedure

In two pilot studies (Krediet, 1992; Krediet, 1993), 34 Dutch mental information workers were asked to answer open-ended questions concerning the above-mentioned research questions. In the present study, the same questions were transformed into closed questions with response categories ranging from 1 (never present) to 5 (always present). Some questions remained open-ended, such as those about the description of the tasks.

As mentioned earlier, the survey comprised questions related to our conceptual model: the work environment, the characteristics of the (interruption) tasks, the effects on the performance process and on the outcomes. The questionnaire is divided into three parts.
1• The first part includes general biographical questions, about age and profession, etc.;
2• The second part consists of questions related to the respondent's job and work, such as "what are your daily work tasks?" etc. These open-ended questions are followed by 20 closed statements concerning the respondents' work, for instance "my work is regulated by standard procedures", "I experience time pressure";
3• In the last part of the questionnaire information is gathered on the occurrence and the characteristics of interruptions, for example, "Which interruption occurs most frequently?", "How frequently do they occur?", "How long do they last?", "Is the interruption similar to the main task?", etc. Also, 38 questions are asked about specific effects of the interruption like "Does the interruption affect the strategy used?", "Do you experience positive and/or negative emotions?"

Contact persons in the field of mental information work were approached to distribute the questionnaire. In an enclosed letter, the aim of the questionnaire was explained. Each questionnaire started with a short introduction stating the purpose of the survey, followed by our definition of an interruption: "an interruption is an (un)expected event that occurs while you are working and requires attention, leading to positive and/or negative outcomes."

2.3.2 **Subjects**

A total of 220 questionnaires were distributed among Dutch information workers, only 79 of whom (36%) responded (mean age = 34.2 years). Most respondents had completed higher education (59%). The majority (65%) have been with their present employer for less than 4 years and most were not in charge (78%). Respondents had two or less colleagues working in the same room (66%) and many (43%) did not need much consultation for their work.

Based on the description of the occupation and the executed tasks, the jobs of the respondents were classified according to the ROA-Profession Classification (Dekker, De Grip, Van De Loo, 1990) into three professional groups: i.e., clerical (n = 46), business (n = 17), and other professions (n = 16). Typical professions in the clerical group were: head of a financial department, secretary, accountant etc. Manager assistant, advisor, and business trainer were examples of occupations in the business professions group. Lawyer, senior scientist, and electrical engineer were categorized as the other-professions group. A large group of the clerical workers were concerned with administrative tasks like handling mail and correspondence (49%). Because the number of secretaries (n = 29) involved in the administrative professions group (n = 46) is quite large, we have to interpret the data of this group with care. The results can best be described as data of this particular group of clerical workers. Workers with business occupations were involved in gathering, processing and distributing information (17%) as well as in meetings and work discussions (17%). Work in the other-professions group included a range of tasks such as acquisition, supervision, doing research etc. The results were in line with the description of jobs and tasks found in two survey studies on mental information workers (Roe et al., 1994; Schalk, Roe, Meijer and Kuyster, 1993).

2.3.3 **Analyses**

In order to find out how interruptions affect the performance process and the performance outcomes, data were analyzed by descriptive statistical methods. The results are given in percentages of the scores on the "almost always present" (4) and "always present" (5) answer categories (if not stated differently). These scores were calculated for the whole sample and, separately, for the three professional groups and the types of interruptions. Also, the mean scores over the five answer possibilities were calculated: the more the situation was present, the higher the score. Differences in scores between the professional groups and the types of

interruptions were analyzed by means of univariate analysis of variance (ANOVA)[5]. Furthermore, Pearson Correlation Coefficients (two-tailed) were calculated in order to find (linear) relations between work and interruption characteristics and the effects on performance. But since the number of respondents was small, they should be interpreted with care.

2.4 Results

We start with the presentation of the types of interruptions that occur most frequently in mental information work, our first research question. Then, a description of the work of the three groups of mental information workers is given as well as a description of the factors that influence performance, our second research question. In the last section, we describe the effects of interruptions on the personal state, on the performance process and the performance outcomes, our third research question.

2.4.1 Types of interruptions and their formal characteristics

Table 2.1 Types of interruptions in mental information work, the percentages of occurrence and whether they are included in the analyses

Type of interruption	Percentages of occurrence	Included in analyses
Questions from colleagues	24	yes
Urgent orders	16	yes
Someone entering the room	16	yes
Questions from clients	13	yes
Telephone calls	11	yes
Technical failure	7	no
Noise	6	no
Related tasks	4	no
Vicinity of others	3	no

Our first research aim is to find the types of interruptions that occur most frequently in daily mental information work. Table 2.1 represents nine types of interruptions mentioned by the respondents. We decided to include in our analyses only those interruptions that were named by more than 10% of the respondents (with a total cumulative percentage of 80%), leaving us with five types of interruptions: questions from colleagues, urgent orders, someone entering the room, questions from clients, and telephone calls[6].

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[5] The Kruskal-Wallis One-Way Analysis of Variance method was used because of unequal variances and unequal sample sizes.

[6] We also inquired about one type of internally generated interruption: rest breaks introduced by the workers themselves. Because we do not look at this type of interruption, the data are not presented in our results. It was found that rest breaks were introduced by almost all respondents (78.4%, $M = 3.86$, $SD = 1.12$; M is the mean score on the 5-point Likert scale; SD is the standard deviation of this score), but most often by business workers (82.4%, $M = 4.06$, $SD = 1.14$) and less frequently by the other professional workers (75.1%, $M = 3.75$, $SD = 1.06$) and the clerical workers (78.3%, $M = 3.82$, $SD = 1.14$).

Table 2.2 Percentage of occurrence of the five types of interruptions for the three professional groups

Professional groups Type of interruption	Overall %	Clerical workers %	Business workers %	Other professions %
Questions from colleagues	24	21	30	27
Urgent orders	16	21	12	7
Someone entering	16	14	18	20
Questions from others	13	16	6	13
Telephone calls	11	7	18	13

In Table 2.2, the five types of interruptions are presented for the three professional groups. We see that questions from colleagues are the most frequent interruption in all three professional groups. The second most frequently occurring interruption varies: urgent orders for the clerical workers, telephone calls and someone entering the room for the business workers, and someone entering the room for the other workers as well. No significant differences are found between the three professional groups in the types of interruptions that occur during their work (with somewhat more urgent orders during clerical work than during other work and somewhat more telephone calls during business work than during clerical work).

Table 2.3 represents the formal characteristics of the interruptions. For most respondents interruptions are seen as part of the job: they are used to it and have experience in dealing with it. The content of the (unpredictable) interruption varies. Sometimes, special qualities are needed such as "being flexible" (47%) and "extra knowledge" (23%). These special qualities are needed by all types of mental information workers and for all types of interruptions. As subjects mainly execute mental tasks, it is not surprising that the effort needed is mainly mentally oriented. We see a low similarity between the interruption and the interrupted task. There are no significant differences in these formal interruption characteristics between the three professional groups or between the different types of interruptions.

Table 2.3 Formal interruption characteristics, in percentages for the whole group, and in percentages and Means and Standard Deviations (between brackets) for the three professional groups

Professional groups	Overall		Clerical workers	Business workers	Other workers
Interruption characteristics	%	*M (SD)*	%	%	%
Experience with	81	3.9 (.6)	82	82	73
Used to	79	3.9 (.9)	83	65	81
Varied contents	66	3.6 (.6)	63	65	75
Special skills needed	44	3.3 (.9)	41	44	53
Mental effort required	39	3.3 (.8)	41	41	31
Similarity with main task	28	2.9 (.9)	37	17	13
Predictability	5	2.2 (.8)	7	0	6
Physical effort required	4	1.7 (.8)	4	0	6

Note: Scores are given in percentages of the "almost always present"(4)-"always present"(5) answers categories taken together; *M* is the mean score on a 5-point Likert scale; *SD* is the standard deviation.

2.4.2 Description of jobs and work

Table 2.4 Description of work characteristics given in percentages and Means and Standard deviations (between brackets) for the whole group, and Means, Standard Deviations (between brackets) and analyses of variance for the three professional groups

Professional groups	Overall		Clerical workers	Business workers	Other professions	
Work characteristics	%	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*p*
Mental task	85	4.3 (.7)	4.1 (.8)	4.4 (.5)	4.7 (.5)	**
Routine tasks	15	2.6 (.9)	2.8 (.9)	2.4 (.9)	2.3 (.9)	ns
Time pressure	67	3.7 (.7)	3.5 (.7)	4.0 (.7)	4.1 (.6)	***
Concentration	66	3.8 (.7)	3.7 (.7)	4.0 (.8)	4.1 (.6)	*
Time control	74	3.9 (.9)	4.0 (.8)	3.8 (.8)	3.7 (1.1)	ns
Sequence control	82	4.0 (.8)	4.0 (.7)	4.3 (.6)	3.9 (1.1)	ns
Methods control	80	4.0 (.8)	4.1 (.8)	4.1 (.7)	3.9 (1.0)	ns
Organizational rules	33	3.1 (.8)	3.2 (.6)	2.8 (1.0)	3.2 (1.0)	ns
Standard procedures	6	2.5 (.8)	2.7 (.8)	1.9 (.8)	2.4 (.8)	**
Satisfied	84	3.9 (.5)	4.0 (.5)	4.0 (.4)	3.8 (.6)	ns
Finds work interesting	79	4.0 (.7)	4.0 (.7)	4.0 (.6)	4.3 (.9)	ns

Note: Percentages scores are given in percentages of the "almost always present"(4)-"always present"(5) answers categories taken together; *M* is the mean score on a 5-point Likert scale; *SD* is the standard deviation; *p* indicates the results of the Kruskal-Wallis tests over all answers possibilities, with N=79; ns: non-significant; *: $p<.05$; **: $p<.01$; ***: $p<.005$.

Table 2.4 gives the work characteristics for all respondents together. As was intended, jobs covered mainly mental tasks. They involve few routine tasks and are executed under time pressure. All mental information workers seem to have high levels of control, both over the sequence of the work activities and over the working methods used, as well as over the amount of time spent on a task. Work is not regulated by rules or standard procedures. Most subjects seem to like their job: they are satisfied with their work and find it interesting. The results of the Kruskal-Wallis analysis show that there are some significant differences between the three professional groups. Work in the other-professions group comprises significantly more mental work than work in the clerical professions group: $H(2)=8.3$, $p<.01$, with less standard procedures: $H(2)=8.9$, $p=.01$. It also requires more concentration: $H(2)=6.2$, $p<.05$. There is also a significant difference in the degree of time pressure experienced by the workers of the professional groups. Workers in business and other occupations experience significantly more time pressure than clerical workers: $H(2)=10.6$, $p<.005$.

Table 2.5 Correlation-matrix of work characteristics

	MT	RT	TP	C	SC	MC	OR	SP	SA	INT
RT	-.32**									
TP	.05	-.12								
TC	.11	.03	-.20							
SC	-.08	-.16	-.10	.37***						
MC	-.05	-.18	-.01	.38***	.58***					
OR	-.26	.32**	.02	-.37***	-.38***	-.27				
SP	-.16	.23	-.16	-.06	-.05	-.27	.15			
SA	-.05	-.16	.04	-.16	.29**	.29	-.04	-.08		
INT	.18	-.46***	.02	.03	.21	.16	-.30**	-.10	.49***	
CON	.34**	-.33**	.18	-.21	.03	.01	-.03	.06	.00	.25

MT: Mental tasks; RT: Routine tasks; TP: Time pressure; TC: Time control; SC: Sequence control; MC: Methods control; OR: Organizational rules; SP: Standard procedures; SA: Satisfied; INT: Interesting; CON: Concentration; **: $p < .01$; ***: $p < .001$.

Table 2.5 presents the correlation matrix for the various work characteristics. We see that the various correlations are not very high. Mental tasks can be characterized by slightly less routine actions and require concentration. We also see that the more interesting subjects rank their work, the more satisfied they are, especially when less routine procedures exist. Higher correlations are found between the three control measures: the sequence of the work activities, the working method and over the time spent at a task.

2.4.3 **Factors influencing the effects of interruptions**

1. *Duration of the interruptions*

Table 2.6 Duration (in minutes) and analyses of variance of the five types of interruptions for the three professional groups

Professional groups Type of interruption	Overall	Clerical workers	Business workers	Other professions
Questions from colleagues	4.8	6.1	8.0	10.0
Urgent orders	6.8	4.5	4.0	7.0
Someone entering	6.7	5.6	6.0	9.3
Questions from others	10.1	10.9	5.0	10.0
Telephone calls	6.3	4.3	7.6	7.00
Total	9.3	9.5	7.1	11.3
p	.06	ns	ns	ns

ns: non-significant.

On average, respondents estimate the duration of an interruption to be 9 minutes ($SD = 10.5$). As presented in Table 2.6, interruptions in the other-professions group last a bit longer than the interruptions in the other two groups, but the difference is not significant. There appears to be a tendency that questions from others lasts longer than questions from colleagues: $F(2,70) = 2.37$, $p = .06$. What is interesting, is

the relation between the frequency and the length of the interruption: it seems that the more often the worker is interrupted, the shorter the interruption lasts ($r=-.37$, $p<.01$).

2. *Moment of interruptions*
Furthermore, subjects say that interruptions at the beginning (26%) and in the middle (42%) of the task execution cause more disturbing effects than interruptions at the end. Questions from colleagues (32%) are likely to cause more negative effects when they occur at the beginning of the task because, as subjects explain: "it keeps me from finishing the task as quickly as possible" (82%). On the other hand, urgent orders are likely to be more disruptive in the middle of the task execution (32%) because "I have to restart the task" (33%). No significant differences are found between the various professional groups.

3. *Frequency of interruptions*
Work is interrupted almost 16 times a day, on average, by one of the five interruptions. Most workers (58%) are interrupted less than ten times a day, that is, less than twice every hour. It looks as if clerical workers are interrupted most often (17% between 21 and 40 times a day). One reason for this is the large number of secretaries that participated in this study. Part of a secretary's job is "to screen visitors". And this "gatekeeper" role is acknowledged as an important secretarial task" (Pringle, 1989, p.36).

As one might expect the effects of interruptions to be stronger when the number of interruptions increases, we asked subjects what happens when more interruptions occur. As illustrated in Table 2.10, when the number of interruptions increases, respondents are likely to increase their working speed (especially clerical and other workers) or execute other tasks first (especially clerical workers). Subjects name the complexity of the interruption (21.4%) and of the main task (24.3%) as the most important factors determining the length of "the resumption"of the main task after being interrupted.

2.4.4 Effects of interruptions on the personal state

Table 2.7 Emotional labelling, given in percentages, and analyses of variance of the interruptions for the whole group and for the three professional groups

Professional groups Emotions	Overall %	Clerical workers %	Business workers %	Other professions %	p
Positive	46	44	29	69	ns
Negative	43	42	71	19	*
Positive and Negative	9	11	—	12	ns
p	ns	ns	ns	ns	

Note: Scores are given in percentages of the "almost always present"(4)-"always present"(5) answers categories taken together;
*: $p<.05$

As we can see in Table 2.7, subjects experience interruptions as positive almost as often as negative. Respondents may experience negative emotions because "an interruption means extra work" (22%), "the interruption is useless" (17%), or because "the interruption draws away the concentration from the task" (15%).

On the other hand, positive emotions are felt because "the interruptions lead to more variety in work" (38%), "you feel useful" (17%), or because "the interruption gives a refreshed view of the work" (14%). Clerical workers experience positive and negative emotions almost as equally. An interesting result is that business and clerical workers experience more negative emotions than workers in the other-professions group: $H(2) = 7.32$, $p < .05$. So, it seems as if the various jobs influence the experienced emotions.

Table 2.8 Emotional labelling, given in percentages, and analyses of variance, of the five types of interruptions

Type of interruptions	Telephone calls	Question from colleagues	Questions from others	Someone entering	Urgent orders	*p*
Emotions	%	%	%	%	%	
Negative	57.1	38.9	40.0	50.0	36.4	ns
Positive	42.9	38.9	50.0	50.0	63.6	ns
Positive and Negative	—	16.7	10.0	—	—	ns
p	ns	ns	ns	ns	ns	

Note: Scores are given in percentages of the "almost always present"(4)-"always present"(5) answers categories taken together; ns: non-significant.

In Table 2.8, we see a small (non-significant) difference between the five types of interruptions: telephone calls are experienced more negatively, whereas questions from others and urgent orders result in more positive emotions.

Table 2.9 Personal outcomes, given in percentages and Mean and Standard Deviations (between brackets) for the whole group, and Mean, Standard Deviations (between brackets), and analyses of variance for the three professional groups

Professional groups	Overall		Clerical workers	Business workers	Other workers	
Personal outcomes	%	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*p*
Fatigue	13	2.7 (.7)	2.6 (.8)	2.9 (.6)	2.9 (.6)	ns
Effort	39	3.3 (.9)	3.4 (.8)	3.4 (.8)	3.0 (1.1)	ns
Motivation	6	2.4 (.8)	2.3 (.7)	2.6 (.6)	2.4 (1.1)	ns
Concentration	14	2.7 (.8)	2.6 (.9)	2.9 (.8)	2.7 (.6)	ns
Physical complaints	3	1.6 (.9)	1.5 (.5)	1.6 (.8)	1.9 (1.1)	ns
Mental complaints	3	1.7 (.9)	1.8 (.8)	1.5 (.8)	1.8 (1.1)	ns
Feelings of tension	4	2.1 (.9)	1.9 (.7)	2.2 (1.0)	2.3 (1.0)	ns
Afraid	13	1.9 (.9)	1.9 (.9)	1.9 (.8)	1.9 (1.0)	ns

Note: Scores are given in percentages of the "almost always present"(4)-"always present"(5) answers categories taken together; *M* is the mean score on a 5-point Likert scale; *SD* is the standard deviation; *p* indicates the results of the Kruskal-Wallis tests over all answers possibilities, with N = 79; ns: non-significant.

In Table 2.9, other personal state effects are presented. Overall, we do not see a very clear picture, with no differences between the three professional groups: subjects require some additional effort, have some feelings of fatigue and are afraid not to be able to execute the main or interruption task properly.

Also some concentration problems are mentioned. These concentration problems are related to having difficulties in picking up the main task ($r = .90$, $p < .001$) and to feelings of fatigue ($r = .65$, $p < .01$). We do find differences between the effects of the various types of interruptions: telephone calls and questions from others lead to more feelings of fatigue: $H(4) = 10.04$, $p < .05$ than the other types of interruptions.

2.4.5 Effects of interruptions on the performance process

Table 2.10 presents the perceived effects of the interruptions on the performance process. We see that respondents change their priorities and work faster after being interrupted. They change their priorities more often when the contents of the interruptions vary more ($r = .63$, $p < .01$). Normally, respondents have no difficulties in picking up the original tasks (87%).

We also asked whether the respondents experience the execution of the main task as more difficult or not after being interrupted. Only a low percentage (20%) of the respondents, mainly business workers, do.

Table 2.10 Effects of interruptions on the performance process, and with increased frequency, given in percentages and Mean, Standard Deviations (between brackets), and analyses of variance, for the three professional groups

Professional groups	Overall		Clerical workers	Business workers	Other professions	
Interruption effects	%	*M (SD)*	%	%	%	*p*
When interrupted:						
Change priorities	33	x	41	21	17	ns
Work faster	16	x	9	17	40	ns
Avoid interruptions	12	2.5 (1.0)	7	12	19	ns
Problems with picking up	13	2.7 (.7)	13	12	13	ns
Main task more difficult	21	2.8 (.8)	15	35	20	ns
When interrupted more often						
Change priorities	30	x	33	43	10	ns
Work faster	27	x	22	14	50	ns
Avoid interruptions	11	x	15	0	10	ns
Execute other actions	11	x	15	0	10	ns

Note: Scores are given in percentages of the "almost always present"(4)-"always present"(5) answers categories taken together; *M* is the mean score on a 5-point Likert scale; *SD* is the standard deviation; x indicates that no mean and standard deviations are presented because open-ended questions were asked; *p* indicates the results of the Kruskal-Wallis tests over all answer possibilities and between the three professional groups, with N = 79; ns: non-significant.

Of all respondents, only 12% try to avoid the interruptions. The kinds of strategies used to avoid the interruptions do not depend on the type of interruption but differ between the various professional groups: $H(2) = 11.94$, $p < .05$: clerical workers steer clear of the interruptions (22%) or make arrangements about when they can be

called (time management, 22%), while business workers block the use of their telephone (41%) and other workers leave their work setting (53%). The differences in avoiding interruptions may have to do with the differences between the various jobs. For instance, we can image that it is more difficult for a secretary to leave her work setting than for managers and researchers, as it is one of the secretary's tasks to deal with telephone calls and questions from visitors. Work for managers and researchers has already been characterized as less restrictive with respect to place, organizational rules, and standard procedures, thus making leaving the work place much easier.

2.4.6 Effects of interruptions on the work outcomes

Effects on work outcomes are measured by inquiring about the number of errors made and planning problems experienced. Respondents say that making errors is not affected by the occurrence of interruptions (75%; $M = 2.5$, $SD = .8$). The three professional groups and the five types of interruptions do not differ in this respect. Interruptions do lead to some problems in planning, however (14%; $M = 2.8$, $SD = .7$). Most problems are mentioned by the other-professional workers (18%) and concern the period after an interruption by questions from colleagues (14%).

2.5 Discussion and Conclusions

This survey study has given us useful information on the occurrence and the effects of interruptions that seem to occur in mental information work and on some factors that influence the effects as well. When we compare our data on the description of jobs and tasks with the data of Roe et al.'s (1994) and Schalk et al.'s (1993) studies, it seems that our respondents are a (representative) sample of Dutch mental information workers. In general, the results of our study are in line with earlier studies on interruptions. For instance, two of the most frequently occurring interruptions in our study were also named in the research by Brouwer-Janse et al. (1992). And, like Johansson and Aronsson (1984), we found changes in performance strategies, for example people start to worker faster. We also see changes in feelings of mental and emotional strain after they had been interrupted.

In Section 2.2, we formulated three research questions. The first question, i.e. what types of interruptions occur in daily mental work, has been answered. We find five main types of interruptions: urgent calls, questions from colleagues, questions from clients, telephone calls and someone entering the room. Questions from colleagues are the most frequently occurring interruption in all three professional groups. When we look at the types of interruptions, we see that the list is more than an inventory of the type of interruption. Interruptions can be characterized by their form (telephone calls or face to face), their content (urgent actions or just a chat), and by their source (clients or colleagues). We do not find any significant differences between the formal characteristics of the five types of interruptions. So, in general, we can characterize daily occurring interruptions as unpredictable and dissimilar to the interrupted task. They vary in content and require some extra skills. Most subjects are used to being interrupted and are experienced in dealing with it.

We can also answer our second question, i.e., which task, interruption and personal factors play a role. Personal factors like the experience of the worker, have been found to play a part in performance. Also important are the frequency, the length, the moment, and the complexity of the interruption and the main task. We have to make a remark on the perceived length of the interruption, however. Gulliksen (1927) and Weybrew (1984) illustrated that we have to interpret estimated time intervals with care. Based on Zeigarnik's notion of tension following a task interruption, Weybrew found that the execution interval of an interrupted task was overestimated and underestimated in a non-interrupted task. Similarly, Gulliksen found that the time interval following the interruption was underestimated when this period was filled with active task execution. When no activity was performed during that period, the interval was overestimated. In our study, we can only guess about the respondents' over-and/or underestimation of the various time intervals. According to Weybrew, the estimated time interval in our study may be overestimated because workers were interrupted. But when we look at Gulliksen's explanation, we suggest that the duration was underestimated by business workers while the clerical workers may have overestimated the interval because no task was executed after the interruption (e.g., they went to the toilet). In future studies, we would recommend a pilot experimental study, an observation method, or a diary study when information is needed on the time intervals. In our experimental studies, we should not formulate hypotheses on the duration of the intervals but rather hypothesize whether various time intervals will increase or decrease after the interruption.

Before we can answer our third research question of how interruptions affect performance, it is necessary to give a more detailed description of our research domain. Generally, daily mental information work is typified by non-routine, mental tasks, with high levels of control, which is not regulated by rules or standard procedures. There are some differences between the three professional groups we distinguished with regard to these characteristics. Work in the other-professions group comprise more mental tasks, with less standard procedures, and time pressure. Clerical workers execute less mental tasks, which do not require much concentration. They are not troubled by time pressure and their work is regulated by standard procedures. Work in the business occupations group is characterized as in-between the typification of the clerical and other-professions group.

When we look at the effects of interruptions on performance, we see that the effects differ, just because of these differences in work. We expected that clerical work would be sensitive to interruptions, as this work is less flexible (less control possibilities, etc.). Indeed, we see that clerical workers, i.e., secretaries, often start doing something else and change their priorities after being interrupted. Other mental workers, who have more freedom in their work, start to work harder and faster (time pressure). They take fewer rest breaks and try to avoid the interruptions (i.e. more freedom), maybe just because of the "gatekeepers role" of their secretaries. These other mental workers "do not allow for such breaks and they felt unable to stop in the middle of something that was needed urgently" (Pringle, 1989, p.190). These differences arise not only because of the differences in work, but they may

also depend on the job level of the worker. The different kinds of avoidance strategy used by our professional groups support this idea as well: clerical workers do not avoid interruptions so drastically because of their "gatekeepers role", whereas other workers do (start working somewhere else). This is probably also the reason why these other workers resume the main task immediately after the interruption, whereas clerical workers start to do something else (i.e. not the task that was interrupted).

As expected (see Chapter 1), interruptions are experienced both negatively and positively. In particular, clerical and other workers experience interruptions as positive and/or negative, while business workers experience interruptions mainly as negative. So, it seems that differences in emotions arise because of differences in work and in the job level of the worker.

Overall, mental work tasks in the different groups of workers are likely to vary. Because of these differences, interruptions affect work performance in different ways, depending on both job, task, interruptions and personal factors and characteristics. The lack of significant differences in the formal characteristics of the five types of interruptions is also of some importance. It appears that performance is influenced by the occurrence of (any) interruption, regardless of its type. Although the workers reported that they deal with the interruptions in various ways, it seems that all mental information workers in our sample tend to achieve the goals set by the organisation: no effects are found on the self-reported quality and/or the quantity of the work outcomes. One explanation for the absence of negative work outcome effects is that respondents activate various regulation processes to help them to achieve the same work goals as when no interruptions occur. This might be achieved at the expense of the personal state, which does indeed seem to be affected (fatigue). But it could be argued that the positive work outcomes may, in part, be attributed to the respondents' inclination to give more positive answers in the presence of their boss or a colleague who handed out the questionnaire (for example interruptions do no affect the quality of the task performance). The results of our experiments will give us more information on the validity of our survey study.

In this survey study, we have gathered information on the types of interruptions that occur in daily mental information work. We have also gathered some information on the work and job characteristics of three different groups of mental information workers. In addition, we have an indication of possible performance effects, of the factors influencing the interruption effects, and of the emotional effects. In other words, we have explored our research domain. And, taking everything together, we can conclude that both aims of the survey study have been achieved.

We do realize that using a survey study for gathering information on daily interruptions in mental information work, has important disadvantages, particularly in the quality of data that can be obtained (Kidder and Judd, 1987). The first is the response rate. Indeed, with only 36% of the sample responding, there is no way of knowing if the results can be generalized to describe the whole sample or to the describe the three professional groups completely. On the other hand, we wanted

some information from the worker himself, without observational or interviewer bias. Another aspect of data quality is the accuracy and completeness of responses to questions. We do not have information on the motivation of the respondents but we do find that almost all questions have been filled in completely and accurately. Because the information on the interrupted work process will be investigated in a more objective and controlled setting in our experiments, we can conclude that using this information gathering method has proven to be useful for our study, but it has shown some restrictions.

Interesting information from this survey study that will be investigated in more detail in our experimental studies is that:
- Interruptions seem to affect the performance process (e.g., working faster).
- Interruptions seem to have no effects on the quality and/or the quantity of the work outcomes (e.g. no changes in the number of errors are made).
- Interruptions seem to affect the personal state (e.g., effort, emotions etc.).
- Both positive and negative emotions are likely to be experienced after an interruption (depending on the job).
- Both the frequency, the moment and the complexity of interruption seem to affect performance (e.g., the more often one is interrupted, the shorter the interruption seems to last; longer resumption time with more complex interruptions).

As this survey study has shown, the effects on performance will be different with different workers and different factors. Therefore, we have to make some decisions concerning the type of tasks to be executed, the group of mental information workers, the type of interruptions, and the factors influencing the effects of interruptions that are going to be investigated in our experiments. Some information, like the influence of other influential factors, is inevitably left unused and could be investigated in future research.

But, before we can describe our decisions and formulate the hypotheses in more detail, we have to give a theoretical foundation. We will describe a number of theories that can explain the effects in interrupted work and investigate how several factors affect the various processes involved and why.

In this chapter, we discuss the theories underlying our conceptual model of interruptions in work. In our model, we assume that people engage in goal-directed activity, executed to fulfil a task. One of the theories that describes goal-directed work behaviour is Hacker's Action Theory. Action Theory is a cognitive theory of action regulation, which is primarily used in German industrial and organizational psychology. It provides an integrative account of what happens with and to a person working. According to Action Theory, the regulation of work activity is based on cognitive representations. But, it involves information processes and structures like capacity, skills, arousal, effort mobilization, etc. as well (Greif, 1993; Dzida, 1993; Karoly, 1993). Action Theorists have mentioned the occurrence of interruptions in work, but its importance and effects have not been widely investigated. We can therefore only speculate about how interruptions are cognitively regulated. These speculations will be used for the formulation of our hypotheses on the effects of interruptions. These hypotheses will then be investigated in our first experimental study (Chapter 5).

3.1 Action Theory

Action Theory (Hacker, 1973; 1978; 1986; 1998), currently also referred to as Action Regulation Theory, defines work as goal-directed behaviour. To achieve a work goal, tasks have to be executed. These tasks are defined as external or objective tasks. Based on the worker's interpretation, external tasks are re-defined into internal, subjective, tasks (see also Frese and Zapf, 1994). The degree of understanding and the clarity of the external task, the experience of the worker, his expectations, acceptance, and willingness to carry out the task as well as the available material, energy, information, tools, etc. determine the outcome of this transformation (Frese, 1987).

After the re-definition, a plan is designed (or retrieved from memory) and activated. A plan is defined as a mental representation of what has to be done and which operations have to be executed to achieve the goal (e.g., Cohen, Eysenck and le Voi, 1986; Roe, 1998; Semmer and Frese, 1985). Goals are anticipations of future results and should be considered as anticipating cognitive structures that guide action processes (Hacker, 1986). A goal may be to write a letter, or to finish a piece of work. Not only is a goal a point of comparison for the action (the cognitive aspect), the action is also "pulled" by the goal (the motivational aspect; Frese and Zapf, 1994).

Tasks are executed by means of actions. An action is defined as the smallest unit of behaviour that aims at the realisation of a distinct goal. It can be broken down into partial actions, operations, and movements. Every action involves a phase of preparation (or initiation) and a phase of execution. Action preparation involves different phases, i.e., goal setting, orienting on the available information, tools, subjects, etc., analyzing and planning by means of sub-goals, making and/or activating plans, and choosing the right action plan. Action execution comprises the

generation of the action plan and the execution of that plan. A (continuous) monitoring process checks the status of the actual versus the desired state and, when necessary, adjustments are made. When no (further) adjustments are required, the actions of the tasks are finished and the plan is de-activated after the goal has been reached (Chapman and Skinner, 1985).

According to Hacker (1978; 1986) and Rasmussen (1986)[7], cognitive regulation can take place at three levels, on a skill-based or senso-motor level, on a rule-based or perceptive-conceptual level, or on a knowledge or intellectual level. On which level the regulation takes place depends on (the level of) the worker's experience with the task, the nature of the operation to be performed, and the plan. While working on a skill-based or senso-motor level, operations are automatically performed and therefore partly unconscious processed. They are controlled by existing plans. On the rule-based or perceptive-conceptual level, performance is controlled by procedures formed during previous (similar or comparable) executions or prepared on the occasion by conscious problem solving and planning. On the knowledge-based or intellectual level, conscious goals and ad hoc plans determine the regulation process. This conscious activity requires more sequential processing because of the limited capacity of the short-term memory. With practice, the whole process is increasingly regulated at a skill-based level. Processing at this lower level requires less capacity and effort, for example, orienting and developing plans. In addition, fewer decisions have to be made. As a consequence, more capacity is available for anticipating actions. The worker can plan ahead and anticipate future actions and other supervision processes (Logan, 1985; Roe, 1984). With a new task, action regulation takes place at a higher level. There is more controlled processing, and the amount of effort, allocated to the actions, increases. During a normal work process, the three levels alternate, depending on situational and personal characteristics. In many tasks, both skill- and rule-based behaviour are combined, for example, when driving a car. Well-learned operations, such as using gears in a car at the right moment, work together with ad hoc actions, for instance, braking and changing gears when someone crosses the street unexpectedly (Moray, Eisen, Money and Turksen, 1988).

But the goals set are not always achieved, and tasks are not always executed as planned, especially when improper operations occur during action execution. Errors can arise on all three regulation levels (Arnold and Roe, 1987; Morris and Rouse, 1993; Reason, 1990; see also Frese and Zapf, 1994). Errors during performance at the skill-based level can occur because of an unexpected situation or disturbance. Errors on higher levels can arise because of a lack of knowledge about general principles of plans, failure to incorporate the new information, or because of the automatization of inadequate actions (Frese and Zapf, 1994; Schönpflug, 1985). A

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[7] Semmer and Frese (1985) defined four (they included an abstract thinking level) and Oesterreich (1981) five levels. The consensus between the researchers is that the observable work sequence can be predicted by some hierarchical inner regulatory processes where goals, plans, tasks, and the environment determine the process (Greif, 1993).

number of factors have been found to be related to the occurrence of errors, such as the complexity of (a second) task (see later), or distraction, for example, during monotonous[8] tasks (Zijlstra, 1993).

As described, the regulation processes on the different cognitive levels activate various cognitive structures. Action Theory is thus linked with theories on human information processing. In the next section, we will discuss the most prominent concepts of those theories.

3.2 Information-processing theories

Information-processing theories can be divided into theories focusing on energetic processes and those focusing on computational processes (e.g., Hockey, Coles and Gaillard, 1986; Gaillard, 1992; Sanders, 1986, Van Ouwerkerk et al., 1994). Models of energetic processes describe performance in terms of mobilisation of physiological energy from one or more resources or in the actual capacity of the resources (Roe et al, 1995). Typical phenomena are arousal, effort, and emotions, but also heart rate and the production of hormones. Energetic processes contribute, regulate, and are modulated by computational processes (Heemstra, 1986; Hockey, Coles and Gaillard, 1986; Van Ouwerkerk et al. 1994). Computational processes, such as automatic or controlled processing, involve various structures for storing information and different processes by which this information is transferred from one structure to another. Both energetic and computational processes are needed for the comprehension of the regulation of mental processes (Levy and Lord, 1992).

One of the first integrated models of energetic and computational information processing was designed by Sanders in 1983. He incorporated three hypothetical energetic resources into a (computational) stages model. This model is based on the ideas of human information processing of Pribram and McGuiness (1975). According to the model, the three energetic supply or resource systems, i.e., arousal, activation, and effort, are selectively related to specific cognitive computational processing mechanisms. The selection of the right (amount of) resources used in a particular task is called resource allocation. Resource allocation is needed because of the limited capacity of the (short-term) memory structure of the worker (e.g., Baum, Singer and Valins, 1978; Johnson-Laird, 1992; Gopher, 1986; Ursin, 1986). Arousal has been defined as a phasic response to the input, and activation as a tonic readiness to respond (Pribram and McGuiness, 1975). Both arousal and activation are generally a-specific and they vary from little to much (Hockey et al., 1986). Effort is spent when the working memory becomes activated. It coordinates and organizes the activity of arousal and activation when needed. The amount of effort that is invested depends on the complexity of task demands, but it also has a motivational component. So, with more complex tasks, it is not necessarily that more effort is

[8] Monotony is felt when a repetitive task does not give the worker the opportunity to make plans and to take decisions (Greiner and Leitner, 1989).

invested. Workers must be willing to exert additional effort when the tasks become more difficult. It also indicates that, when less effort is invested, the task is not necessarily less difficult. Also, the state of the worker is important. For example, when a worker is tired but he still wants to perform at an acceptable level, he has to invest more effort. This means that the costs to carry out the task will be higher than when he is not tired. Individual preference, knowledge and various task constraints, like the amount of time available, influence the amount of effort that is going to be invested (Zijlstra, 1993)

Another important concept in information processing is the distinction between automatic and controlled processing (Schneider, Dumais and Shiffrin (1984). This was already mentioned when we discussed the different levels of action regulation. In Action Theory, the type of cognitive processing is a matter of the regulation level and it alternates depending on situational and personal characteristics. Automatic processing is generally a fast, parallel, fairly effortless process, which is not limited by capacity of the short-term memory. It accompanies well-developed skilled behaviours. Once it is learned, the process is difficult to suppress, modify, or ignore. Controlled processing, on the other hand, is slow, serial, effortful, and capacity-limited. It is used to deal with novel or inconsistent information. It is easily modified, suppressed, or ignored by the individual. In practice, it rarely happens that an activity is purely controlled or purely automatic. The two processes share the same memory structure and they continuously interact. Without the flexible, voluntary process, an individual cannot deal with new, unexpected events, such as an interruption. And without automatic access, rapid shifting to known (significant) events is impossible (Cellier & Eyrolle, 1992; Tipper, Weaver, Cameron, Brehaut & Bastedo, 1991).

3.3 Interruptions and work-related theories

In this section, we will discuss how both Action Theory and information-processing theories deal with interruptions.

In Action Theory, interruptions are defined as a sub-category of regulation problems (German: Regulationsbehinderungen). Figure 3.1 describes all known types of regulation problems that disturb the regulation of actions[9].

We see that regulation problems are divided into the following items: regulation obstacles (German: Regulationshindernisse), regulation uncertainty, and regulation overtaxation. Regulation obstacles are events or conditions that are directly related to the task at hand. They hinder the achievement of the result and block the preparation and the execution of the action.

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[9] The content of this figure is taken from Leitner, Volpert, Greiner, Weber and Hennes (1987) and Semmer (1984). The terminology comes from Frese and Zapf (1994), who changed the English terminology used by Greiner and Leitner (1989).

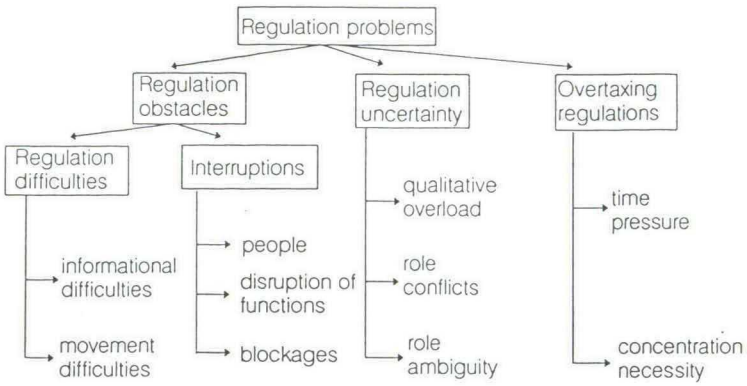

Figure 3.1 Classification of regulation problems (Frese and Zapf, 1994)

Regulation obstacles require short-term reactions from the worker, either automatic or controlled. The consequence of an obstacle is that extra information must be sought for in order to achieve the goal. The best solutions are to remove the obstacle (e.g., the subjects of our survey study block the use of the telephone) or to make arrangements for possible changes to prevent the obstacle in the future (e.g., speeding up the work in the morning in order to guard against interruptions later on). Most workers do not have the possibility to avoid or to remove the obstacle (for instance, the secretaries' gatekeeper role). Then, only less effective possibilities are available, such as an increase in the expenditure of energy (effort). Another option is to reduce the standards of the quality and quantity of the work product. Interruptions (German: Unterbrechungen) hinder any operation, any time, and are produced by unpredictable outside events. They are caused by other people (colleagues, supervisors) or by technical (machine breakdown) or organizational problems (e.g., lack of supplies). In a situation where interruptions occur, the information load on short-term memory can become too high because many aspects of the interrupted task must be kept in the working memory. For example, a worker must remember where in the main task the interruption took place. Regulation uncertainty, the second group of regulation problems, means that one does not know how to achieve a certain goal, for example, which plans are needed. It also involves insufficient or delayed feedback about what has to be done and what has been achieved. The third group of regulation problems is related to non-specific task factors like heat, noise, and dust, and to more specific task factors such as monotonous working conditions, time pressure, etc. Time pressure, for example, produces problems because action regulation cannot be done as planned within a given time frame.

Although this classification has proved useful for the conceptualization of an interruption (see Chapter 1), we believe it is too simple. It ignores the fact that the various regulation problems can also influence each other. For instance, when an

interruption leads to time pressure (overtaxing regulations), less time is available for the execution of the main task. This can affect the capacity of the worker (informational difficulties). Also, this classification does not pay attention to what differentiates an interruption from a disruption, i.e., the resumption of the main task.

To our knowledge, the possible effects of interruptions on the mechanisms of action regulation have not been addressed in the literature. There is little research that has pointed at the consequences of interruptions, like additional effort or phases of the action regulation that have to be repeated. Behavioural consequences, such as disengagement from the task or asking for extra help, were merely mentioned (for example, Frese and Zapf, 1994). Consequently, we can only speculate about the cognitive regulation processes involved in interrupted work performance. In section 3.6.1, we formulate general ideas of how interruptions can affect cognitive processes involved in the regulation of work.

3.4 Factors influencing the effects of interruptions

In our conceptual model we posit that tasks and personal factors influence the performance process and outcomes. How the skill of the worker and the level of regulation can influence performance was already discussed in the previous section. The respondents in our survey study have given us some hints about these influencing factors. They named, for example, the number, the length, the moment, and the complexity of both the interruption and the main task. In this section we discuss research on how the moment, the length, the relevance, and the complexity of the interruption have influenced performance.

Mandler (1964) found that, depending on the moment of the interruption, the performance was more or less affected. He conducted a word-interruption experiment in which subjects were told to learn a sequence of words. Then, the subject's task was to anticipate the next word as soon as he heard the preceding one. He defined an interruption as the occurrence of a word that is not the word the subject predicted or expected to hear. Mandler suggested that an interruption at the beginning of the task requires more capacity because of the activation and adaptation of the (existing) plan, leaving less capacity for dealing with the interruption. Performance was measured by the number of errors made in predicting the word following the interruption. It was found that an interruption during a task that had just been initiated had more disruptive effects than an interruption occurring at the end of the task. Also Van Dusen, Britton, and Glynn (1992) found that an interruption causes more disruptive effects at the beginning of the task than at the end. They illustrated their idea with a real-life example about learning to drive a car (p.60): "suppose a novice is asked by the driving instructor to drive out of a parallel parked position into the traffic. The action plan for this, which the novice would have to transfer into the limited-capacity short-term store, might be as follows: Put the key in the ignition; put your foot on the brake; start the car; turn the steering

wheel to the correct position; put the car in the forward gear; look for oncoming cars; steer out; and accelerate up to speed. Such a large sequence of mental operations (complex action plan) would take a long time to transfer into short-term store; that time corresponds to a long pause between the instructor's request and the beginning of the driver's performance. During that pause, when the driver was interrupted by a question from the instructor which used the limited capacity short-term store, the action plan might be eradicated, and the driver would have to begin to transfer it again." Indeed, in their experiment in which various mental tasks (multiplication, subtraction, monitoring a letter) were interrupted by a simple division problem task (interruption), Van Dusen et al., found that when the interruption occurred before the activated plan was transferred from the long-term memory to the short term memory, the process of activating the plan had to be restarted all over. More effort was invested and the resumption time was longer. When the interruption took place after the transfer to the short-term memory, no restarting of the process was needed. "Some savings had been made and the subjects had retained the current result and marked its place within the short-term store during the interruption interval. When the task was not dealt with in this way, it had to be restarted from the beginning." Restarting the whole process was only found in the complex task condition, that is, when controlled processing was required and when more time was needed for the activation of the action plan (more mental operations).

Heckhausen and Gollwitzer (1987) also investigated the effects of different moments of interruptions during mental task execution. But, in contrast to Mandler and Van Dusen et al., they found that interruptions at the very beginning of the task (i.e., during action preparation) caused fewer disruptive effects than interruptions at the end of the task (i.e., during action execution). They explained their results by suggesting that during the action preparation phase, subjects were more oriented towards receiving information. There was more capacity available compared to the situation in which the interruption occurred during the action execution phase. In this latter phase, more capacity was required for the execution of the task, leaving less capacity for dealing with the interruption. One explanation for the difference in results might be the workers's experience with the task. Because of a possible difference in practice, which we do not know, the available capacity, determined by the different regulation levels, may differ. Also, different kind of tasks had to be executed on both studies. In Heckhausen and Gollwitzer's study, a social sensitivity problem had to be judged (subjects had to make a choice between two available test materials) and a creativity story had to be scrutinized. In their study, the subjects were interrupted either prior to or shortly after making a choice. We do not know what kind of action or operation the subjects in Mandler's experiment were executing at the moment they were interrupted. They may well have just been having a (micro) rest break. Nor do we know the exact definition of 'the beginning of the task performance'. So, it appears that the research on the effects of the different moments of the interruptions is not very conclusive. In our view, many other important factors have not been taken into account yet. For example, the relevance to and/or acceptance of the interruption by the subject. In the research done by Heckhausen and Gollwitzer (1987) and Pekrun and Frese (1992), it was

indicated that, as long as an event is irrelevant to a person's goal, the interruption does not interfere and does not have any negative consequences. The influence of acceptance was also illustrated by Karasek and Theorell (1990). They found, in several studies, that highly involved workers experienced more negative work outcomes (emotions, stress) than workers who were less involved in their job ("I just earn my money").

The complexity, as another important factor, was also mentioned by the respondents of our survey study. The influence of task complexity on performance has been an interesting issue for a long time, resulting in a large amount of literature in the field of mental workload. Complexity is related to the number of stages involved in the execution of a mental task: the more stages, or the more complex the task, the less capacity is available for the execution of a secondary task.[10] Only a few researchers have investigated the influence of task complexity in relation with interruptions. Kanfer and Stevenson (1985) interrupted subjects during a primary task by a complex, secondary mathematical task or by a 10-second delay. They found that, after a complex interruption task, performance decreased more (less recall of the items) than after a delay. Field's (1987) research also indicated that the complexity of the main task was important. In this experiment, he asked subjects to find (simple and complex) answers by searching through a fictitious city with a simple or a more complex computer-based menu. During their work the subjects were interrupted by a question on the computer screen which had to be executed first. Field claimed that the complexity of the task influenced the performance (more screen access and longer resumption time). Unfortunately, we do not know what the subjects were doing the moment they were interrupted. Maybe they had just started to relax. Also, Field did not control for the moment of the interruption nor did he describe the complexity of the task or the effects of the non-interrupted condition in detail, leaving us with inconclusive results.

Much better described is the research of Gillie and Broadbent (1989). They investigated the effects on performance of both the similarity, the complexity, and the length of interruptions. During a computer-based adventure game, subjects had to achieve certain goals (getting bread from the baker, meat from the butcher, etc.). The interruptions were secondary tasks which varied in length, complexity, and similarity to the main task. The researchers found that it was not the length of the interruption task, but its similarity and complexity that affected performance. These results were confirmed by an experiment conducted by Eyrolle and Cellier (1995). In their research, subjects had to select items from a scrolling display of numerical and alphabetical information on a computer. During the execution of the task, they were interrupted by the introduction of a second task. Data showed that the time needed for the task and the error rate increased with more complex interruptions.

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[10] Complexity is described as an objective attribute, independent of the individual. Difficulty, on the other hand, is related to the capacity needed for the execution of the task and to the capacity of the worker. It increases with the amount of capacity needed for the task execution (Van Ouwerkerk et al., 1994).

In our first experimental study, we investigate the influence of the moment and the complexity of the interruption during daily mental work. Although Mandler used a different definition of an interruption, we think that his theory is useful for understanding possible effects in our study. In line with his theory and with the results of our survey study, we assume that a daily occurring interruption at the beginning of the task execution affects performance more than an interruption at the end of the execution. At the beginning of the task, the task execution requires more capacity than at the end, leaving less capacity for the interruption. In line with Gillie and Broadbent's and Field's studies, we suggest that complex interruptions have larger performance effects than simple interruptions as less capacity is available with more complex interruptions.

3.5 Strategy choice

The different ways in which tasks are approached and executed, referred to as strategies, depend on various situational and personal factors (Logan, 1985). A large amount of literature exists on the definition of a strategy. Also, much literature exists on choosing, constructing, executing, and maintaining different types of strategies. Logan (1985) defined a strategy as an optimal organization of cognitive resources or abilities that is designed to achieve some goals in some task environment. According to Helstrup (1989, p.113) "strategy choices are seen as determined by hypotheses about personality abilities (intelligence, motivation, creativity, etc.), the nature of the task (difficulty, novelty, etc.), the solution characteristics (importance, normal performance level, etc.), the available resources (e.g., effort), the characteristics of the situation (e.g., the question comes from my boss or from a colleague), the characteristics of the person (e.g., being nervous), and about what will be the most efficient operations to use (rehearsal, story telling, etc.)." Social-cultural factors also influence the choice. For instance, anger is not allowed to be shown in certain situations (display rules; Ekman and Friesen, 1969; Wagner, Lewis, Ramsay and Krediet, 1992).

Two studies on strategy choices in interrupted work performance show that cognitive structures (e.g., the limited capacity of the worker) and cognitive processes (automatic versus controlled processing), together with task, personal, and situational factors, determine the choice of a work strategy. The studies show that not all persons use the same strategies in the same situation, and that a person does not necessarily use the same strategy in a different situation. Unfortunately, the conditions under which these strategies were selected were not specified. Also, little information was given about the possible differences in effects on performance and personal state. The first study is that of Kirmeijer (1988). She investigated the handling of incoming calls by police radio dispatchers. She found three types of strategies. In the sequential processing strategy, subjects finished the main task before the interruption task was dealt with. In the pre-emption strategy, the subject responded to an incoming demand by immediately putting the main task aside, leaving and attending fully to the new task. In the simultaneous processing strategy,

the subjects continued their ongoing work and simultaneously processed the interruption task. When interrupted, additional demands may occur "because effort is required to evaluate the significance of and decide on an appropriate response to multiple, concurrent inputs" (p. 627). Furthermore, it was suggested that the interruptions put additional demands on the executed activities and require additional capacity. Kirmeijer found that workers who handled the work more sequentially (finishing one task before proceeding to the next) appraised their work as producing less (information) overload and cognitive fatigue. They delayed the work on some of their (presumably lower priority) job responsibilities. The second study comes from Eyrolle and Cellier (1995). They observed ten operators in a commercial telecommunications office. The operators' task was to update data about telephone lines on a computer. They were often interrupted by consumers' calls (interruption task). The operators dealt with the interruption task in different ways. Most often they identified and processed the interruption task immediately. This led to additional mental work load, resulting in, for instance, more errors. Those operators who finished the main task before they dealt with the interruption task or who postponed the identification or the processing of the interruption, had lower work loads and made fewer errors.

In Hockey's control model of state regulation (1986) it was suggested that it is not only the limited capacity of the worker that regulates the processing of information, but the psycho-physiological state of the worker is involved as well. Sometimes the worker's actual state does not correspond with the state that is required to perform a particular task adequately (the target state). According to Hockey, when the (continuous) monitoring process registers a mismatch, the central executive system can change the (external or internal) parameters of the target and/or the actual state in order to reduce the mismatch by, for instance, changing the norms, stopping work on the task, or increasing the effort for the execution of the task. In other words, the worker has several strategies to choose from. The results of the study on interruptions in computerized work by Kohlish, Kuhman, and Boucsein (1991) is in line with Hockey's model. They found that a break during their work led to (unexpected) negative feelings (i.e., mismatch). In order to reduce these negative feelings, they (re)organized their work and avoided certain situations. Using this strategy, they were less exhausted and had fewer physical complaints.

So, not only work and activity-related factors influence the strategy choice, the personal state is also important. This is in line with our conceptual model, which postulates that the personal state, for example, interruption-related emotions, influences performance. This brings us to the second question addressed in this study: How does the personal state, in particular interruption-related emotions, affect performance? Although it has been acknowledged that emotions are interwoven with cognitive processing, their role is quite often ignored in research. According to Hockey, when necessary, the person adjusts the actual state by comparing his actual state with the state required to execute the task. In line with this theory, interruption-related emotions are an example of a personal state that can influence work performance. But before we can investigate their influence in our second

experiment, we first had to know how workers use attention, effort, and other (cognitive and psycho-physiological) regulation processes in order to deal with these interruption-related emotions. The theories that can help us are described in the next chapter.

3.6 Conclusions

The aim of this chapter was to describe the cognitive theories underlying our conceptual model on interrupted goal-directed behaviour. Action Theory is based on the notion of (hierarchical) mental models and plans, and describes how workers regulate their goal-directed work. It is based on the assumption of different cognitive structures and cognitive levels, and uses concepts related to information-processing theories. For the activation of information-processing structures and processes, goal setting is not a necessary condition. They are activated any time information is processed.

We subscribe to the idea that the regulation of work behaviour involves phases of planning and executing activities, both conscious and unconscious, together with many psycho-physiological processes. "While the actual behaviour guiding goals are usually conscious, they do not have to be in focus of attention all the time. Once a certain action is put into effect, it is not necessary to keep the goal in consciousness. A person still knows and pursues his goal, even if the play of action led astray" (Frese and Zapf, 1994; p 7.). How interruptions affect workers' performance has been found to depend on personal and task factors. These factors, such as the skill of the worker and the complexity of the task, determine the energy demands implied by the task execution (e.g., automatic or controlled processing). Action Theorists have not widely discussed the influence of interruptions on work performance. We only found some research that pointed at consequences, like additional effort or phases of the action regulation that have to be repeated.

In our first experimental study, we investigate how interruptions affect performance and personal state. The influence of the frequency, the complexity, and the moment of interruptions are examined. Following Action Theory and information-processing theories, we assume that the effects will depend on the level of processing that is interrupted. The basic idea is that a worker has activated a plan in order to achieve a goal. The interruption causes a temporary cessation of the achievement of the goal as it requires the execution of a second task.

From the theories discussed, we can envisage the following general ideas of how interruptions can affect cognitive processes involved in the regulation of work. These general ideas will help us to understand the effects of interruptions on performance. More specific hypotheses on the effects of interruptions on performance are formulated in Chapter 5.

1• When appropriate skills are available and regulation takes place at the skill-based level, both the interrupting task and the main task can be executed automatically. We will probably see a parallel execution strategy. It will probably take longer to finish the task. We will also see that more effort is invested as more actions have to be executed. On the other hand, with more practice, less effort may be needed.
2• When one (or both) of the tasks requires conscious processing, a switch is made towards the knowledge-based level. It is on this level that interruptions will be experienced as disruptive because they involve lengthy novel chains of thoughts that are not incorporated in the memory system of a plan. New information - related to the interrupting task - must also be incorporated into the activated plan. This may lead to some additional effort (to achieve the goal within the same time) and call for extra memory capacity (resumption of the main task requires extra monitoring and supervision). According to the limited capacity model, less capacity is then available for performance. This can result in an increase in the number of errors made and in the effort invested. Tasks will probably be processed more sequentially. It can also mean that, after the interruption, the worker has to start anew, for example, because he has forgotten what he was doing at the moment of the interruption (Britton and Glynn, 1989), that some steps have to be repeated (additional action preparation and execution), or that extra help is required. Overall, we suspect that an interruption on the knowledge-based level puts some additional cognitive demands on the worker, resulting in negative performance effects (e.g., longer execution times).
3• In line with the literature discussed, we believe that interruptions also affect the personal state, both negatively (for example, higher arousal and activation, additional effort, feelings of fatigue) and positively (for example, more positive feelings after being interrupted during a monotone task).
4• We also believe that experienced workers deal with interruptions in such a way that the workload and the effects on personal state will be low, i.e., these workers will not react immediately and will execute the interruption and the main task sequentially.
5• Research has supported the result of our survey study that interruption-related factors influence the performance effects. Interruptions, presented at the beginning of the task, have larger performance effects than interruptions presented at the end of the task because activated plans have to be adapted and less capacity is available for the interruption. With more complex interruptions, less capacity is left for the execution of the main task, resulting in more performance effects than when simple interruptions are introduced. Similarly, we assume that when the number of interruptions increases, interruptions will affect performance more as more (repeated) cognitive processing is needed (e.g., the processes of storage and resumption of the primary task are repeated more often, more adaptation of activated plans is required, etc.).

In the previous chapter, we discussed the cognitive regulation processes involved in interrupted goal-directed behaviour and the underlying capacity regulation mechanisms (energetical and computational resources and structures). We described how performance and its outcomes can vary, depending on various task and person-related factors like the task demands, the activated action plan, the level of action regulation, and the psycho-physiological state of the worker. We also mentioned the fact that the personal state can influence performance. In this chapter, we focus on one component of the personal state, i.e., interruption-related emotions. We discuss whether and how emotions occur during (interrupted) work and describe their effects on the various regulation processes involved.

4.1 Introduction

Emotions have been found to influence work performance both with respect to processes and outcomes. For instance, when a person is in a negative mood when starting to work at a new position, the development of positive expectations and value appraisals is hindered. Negative emotions can also block the development of positive work motivation (Carver and Scheier, 1990; Pekrun and Frese, 1992; Teasdale, 1993). Emotions have also been found to lead to new work strategies (Humphreys and Revell, 1984). Imagine, for example, that a worker experiences some feelings of helplessness because he does not know how to deal with a specific computer problem. After trying to deal with this problem unsuccessfully, he finally asks the helpdesk for advice. When his colleague is confronted with the same problem, the person experiences some feelings of pride because he knows how to deal with the problem. The next time, he is confronted with a computer problem again, he will probably contact the helpdesk at a much earlier stage.

But although the occurrence of emotions in work has been recognized, their influence, in terms of an independent research variable, has received only limited attention in psychology, and especially in work psychology (Pekrun and Frese, 1992; Briner, 1995). As Briner stated (p.6): "People at work experience a diverse range of affective states which have remained largely unexplored by organisational psychologists." Some researchers have begun only recently to see the relation between emotions and interrupted work as an important research topic. For instance, in a four-day field study among bank secretaries, Kolish et al. (1991) investigated the effects of imposed breaks on the personal state. They found that short (imposed) breaks (1-3 minutes) led to feelings of irritation whereas long breaks did not. Henning et al. (1989) found that (imposed) rest breaks during a 40-minute data-entry task led to an increase of negative emotions such as irritation and tiredness. They also found an increase in the total number of key strokes and no changes in the number of errors. In Johansson and Aronsson's experiment (1984), a four-hour computer break-down led to agitation and feelings of irritation, boredom, and stress. Jacobshagen (1990) investigated the emotions of workers who were interrupted during stencilling a greeting card. Interestingly, subjects who were not interrupted had more negative emotions about their product than subjects who were interrupted.

These studies show that interruptions, like computer break-downs and (imposed) rest breaks lead to changes in emotions. But what about the influence on emotions of daily occurring interruptions, such as telephone calls? And more importantly, how do these emotions affect performance? Unfortunately, no study has focused on these issues, although research has shown that an important relation exists. Just because of their importance, we have decided to look at the relation between daily occurring interruptions and emotions in greater detail. We will investigate whether (positive and/or negative) emotions arise in relation to these interruptions, and how they can affect performance. How these emotions arise and why will not be detailed in our study.

Before we can answer the above mentioned questions, we first have to define some of the basic emotional concepts involved. We will then focus on cognitive emotion theories in relation to interruptions and discuss how workers can cope with (interruption-related) emotions.

4.2 Emotion theories

Notwithstanding the lack of research in the work context, emotions constitute a very extensively investigated psycho-physiological phenomenon. Even so, there is still no consensus on what emotions are, under which conditions they are initiated, whether they involve consciousness or not, and how they must be measured (Ekman and Davidson, 1994).

Two theories mark the beginning of emotion research. According to the body reaction theory (James, 1890), an emotional stimulus generates both visceral and skeletal muscle changes. The perceptions of these specific autonomic patterns of activation are defined as emotions. Cannon (1927) proposed an alternative theory, the central neural theory. He doubted whether the visceral system is capable of such a differentiation and emphasized the similarities in the physiological patterns of different emotions. He concluded that visceral changes are indeed an important condition for emotional experience, but only in conjunction with other factors such as cognition. James emphasized the pre-cognitive aspects of the physiological activation, whereas Cannon accentuated the post-cognitive aspects (Van Olst, Kok, & Orlebeke, 1980). The conflict between these two theories has produced extensive research into the psycho-physiology of emotions. It has also led to several new theories on emotions. These new theories can be categorized into four different groups: evolutionary theories (emotions are needed for survival), psycho-physiological theories (see above), neuro-physiological theories (these theories describe the relation between brain processes and structures and emotions), and cognitive theories. The last mentioned group of theories can be divided into cognitive appraisal theories (emotions depend on the appraisal and evaluation of the situation) and cognitive arousal theories (emotions occur because of arousal). All these different emotion theories vary in their emphasis on different components, but the notion that different structures and determinants are involved in the cognitive,

the psycho-physiological, and the behaviourial processes of emotion has not been challenged (Dodge, 1989).

The present study makes use of cognitive emotions theories. These theories can help us to understand the emotional processes involved in (cognitive) interrupted work performance. They use the same cognitive and information structures and processes for explaining the regulation processes involved as Action Theory does. In terms of Action Theory, emotions that require controlled processing require more capacity of the worker and will mainly affect tasks executed on the knowledge level and the rule-based level. "Parts of the action plan calling for regulation at the knowledge level are skipped and replaced by well-known routines. Since such routines are often less adequate, this leads to less accurate performance and increases the chance of errors" (Roe, 1998, p.18). Emotions can cause an imbalance in the physiological systems, which is manifested in reactions such as a higher heart rate, increased blood pressure, and a higher secretion of hormones. Physiological regulation processes restore the balance by means of inhibition or activation of physiological activity (Mandler, 1984; Frijda, 1988). The effects level off and disappear after some time. The physiological reactions can be divided into three categories: autonomic reactions, mediated by the autonomous nervous system (e.g., heart rate), hormone secretion (e.g., adrenaline), and neurological reactions (brain responses). Some researchers (in line with James Lang's theory) say that the physiological reactions are the result of emotions, others (in line with Cannon's theory) say the opposite: physiological reactions are a necessary condition for emotions. Overall, it is clear that emotions and physiological changes are closely related, but how they are connected and how they influence performance is not yet clear.

4.2.1 Cognitive emotion theories and interruptions

When we look at the literature (see Plutchik, 1994, for an overview) on the cognitive processes and structures involved in (interruption-related) emotions, we see differences in the explanations for the occurrence of emotions. Some researchers (e.g., Lang, 1984; Leventhal, 1984; Bower, 1981; Clark and Isen, 1982) have suggested that all cognitive processes include affective memory structures, or schemata, or nodes, in which emotions are coded as components. When a particular plan is activated for the execution of a task (see Chapter 3), the related emotions are activated as well (Leventhal, 1984; Safran, 1989). Carver and Scheier (1990) proposed that whether emotions arise depends only on how rapidly the interruptions are dealt with: when the goal is achieved according to the expected rate, no emotions will be experienced; when the progress is lower or higher than expected, the worker will experience negative or positive emotions. The expectancy depends on memories or prior experiences with the task. We partly agree with this idea, as we think that the speed is one component in the emotion process. Other factors, like the relevance of the event, the content, or the moment of the interruption can play a role as well.

An important concept in cognitive emotion theories (see also Action Theory and related information-processing theories, Chapter 2 and Chapter 3) is automatic versus

controlled processing. Scientific evidence of the automatic processing of emotions can be found in state-dependent learning effects (Bower, 1981). During encoding, emotions are linked with the specific situation one experiences. When that same situation occurs again, the associated emotions are activated. When learning takes place in a specific state, the learned material is better remembered when the learner is again in that state. Automatic processing of emotions is also shown in the study by Clark and Isen (1982). They found that subjects who were in a positive state acted in a more "positive" way (giving greater rewards, being more helpful, etc.) than subjects who were negatively aroused. We suggest that when one is in a negative state, possible "negative behaviours" stored in memory along with negative feelings, such as aggressive behaviour, may be activated. In this case, controlled processing may be more suitable. The idea that negative emotions require more controlled processing than positive emotions is in agreement with Mandler's (1975; 1984) ideas but not those of Hettema, Leidelmeijer, and Greenen's (1996) 'gating model'. According to Mandler, negative emotions indicate that the situation is not as expected and more adaptations (internal/ external) of the activated plan have to be made. Thus, negative emotions require (more) space in the working memory, interfere with other cognitive activities such as the storage and retrieval of information, and will affect performance more than positive emotions. Positive emotions can also require controlled processing and can affect performance negatively, for instance, when sufficiently intense task-irrelevant thinking (e.g., when falling in love) takes up all the available capacity. On the other hand, both negative and positive emotions can facilitate performance, for instance, both emotions can stimulate one to study hard (again) to achieve a high(er) degree. According to Hettema's 'gating model', controlled processing takes place when changes are needed. Automatic processing is activated when information is not significant. Automatic processes "preserve important parts of the behavioural structures established earlier" (p.39). Contradictory to Mandler, Hettema et al. found support for the idea that negative emotions have a defensive effect, that is they close the gates to controlled processing, while positive emotions seem to act in the opposite direction, i.e., they open the gates to controlled processing. Overall, we can conclude that it is not quite clear how emotions are processed. But it is generally agreed that both automatic and controlled processing are involved. And, due to the limited capacity, central processing will be reduced when emotions are involved.

In Mandler's (1975; 1984) cognitive emotion theory, an emotion arises as a result of a discrepancy between what is expected and what actually happens in the environment, such as an interruption during an ongoing cognitive activity. The interruption produces a state of autonomous arousal, which may be caused by a pre-programmed automatic release of the autonomic nervous system or by an appraisal of the situation. The arousal is followed by emotions of varying intensity, with an affective, a (physiological) body-perceptual, and a cognitive component. The same interruption can result in negative emotions but also in pleasant ones, depending on task and personal characteristics, and the appraisal of the situation. The intensity of the emotion is determined by the level of the autonomic arousal. Autonomic arousal signals the mental organization for attention and alertness. Arousal thus directs

attention to the environmental events that caused the emotions. So, both the perception of the arousal as well as the cognitive evaluation of the emotional experiences are necessary in the emotion process. However, the role of arousal in emotions is not quite clear. For example, the psychopharmacological literature indicates that many drugs can have profound effects on emotional feelings and behaviour without having any effect on the autonomic nervous system. It has often been suggested (e.g., Van Olst et al., 1980; Frijda, 1988) that variation in the level of arousal does not play as important a role in emotions as Mandler suggested. Reisenzein (1983) and Manstead & Wagner (1981) also suggested a more limited (not necessary) role of arousal in the general process of emotions, as arousal does not always lead to the experience of emotions. This can be illustrated by the experiment conducted by Marshall and Zimbardo (1979) in which subjects were exposed to a euphoric cognitive context. No differences were found between subjects in the experimental condition (autonomic, physical activation generated by adrenaline injections) and subjects in the control condition (no adrenaline injections). This was later explained by the existence of a differential arousal system (Boucsein, 1991), and by the so-called network model which stated that arousal has to reach a certain threshold of the affective memory cues (Bower, 1981; Clark and Isen, 1982; Leventhal, 1980; Wells and Matthews, 1994).

According to Frijda's cognitive emotion theory, it is not the arousal but the action tendency that is most important in the emotion process. An action tendency is evoked by events that are of relevance to the individual in the situation such as an interruption, an emergency, or a difficulty: as long as something is no irrelevant to a person's goal, there are no consequences of being interrupted. When a relevant event occurs, the internal process of judging the relevance and appraising the situation is followed by the generation of a plan of action or an action tendency. Depending on the nature of the action tendency, a physiological change generator produces bodily changes of an appropriate sort, followed by an action. The intensity of the emotions depends on the seriousness of the situation to the person. Besides the action tendency, the flexibility of the reaction pattern and the ability to inhibit or control behaviour are essential features of emotions in Frijda's emotion theory.

In general, emotions may arise when a change in the environment occurs. When this situation is appraised as being relevant for the worker, activation in terms of autonomic responses, arousal, action tendency, and actions can occur (not necessarily in this order). For example, when a snake is seen while walking, one becomes afraid. The heart rate increases and one runs away. Although we know that strong emotions like anger or fear can sometimes occur while working (for example, being afraid of getting fired, resulting in stomach pains and in reporting sick), we also know that drastic reactions, such as the one in our example, do not occur often. Emotions in work, and in particular in relation with interruptions, are often not that strong (e.g., in terms of relevancy, arousal, physiological and behaviourial reactions). Research on interruptions reports only less strong emotions such as irritation, boredom, helplessness, etc. These last type of emotions will be the focus of our study. We will investigate how these emotions arise in relation to interruptions, and

how they can affect performance.

4.3 Coping with emotions

Coping refers to all cognitive and behavioural efforts to master, reduce, or tolerate the internal or external demands caused by the environment (Folkman, 1984). There are different ways of coping with a situation. Lazarus (1993) differentiated two types of coping: emotion-focused and problem-focused coping. In emotional coping, the individual tries to influence the emotions directly, for instance, by thinking about something else. "Such activities are likely to hinder the execution of the work task, but they can help to restore the state in which the person is able to perform effectively" (Roe, 1998, p.21). Problem-focused coping is aimed at solving the problem that has caused the emotions. An example of this latter type of coping is given in the research of Kolish et al. (1991). Secretaries (re)organized their work and avoided certain situations, which resulted in less irritation.

Related to coping is the concept of control. Objective control is related to the definition of the task. It implies a certain degree of freedom with regard to the sequence, time frame, and the conditions of work (Hackman and Oldham, 1975; Karasek, 1979; Frese and Zapf, 1994). Hockey, Briner, Tattersall, and Wiethoff (1989) found that workers who had little (objective) control, for example, in a sequential ordering task like solving an arithmetic problem, were less productive and experienced more boredom than workers who had more objective control. The subjects in our survey study also showed a (non-significant) tendency to report more positive emotions when they had more (objective) control over the time, the sequence, and the methods of the task executions.

Perceived or subjective control can be described as the availability of plans, actions, and individual resources resulting from previous attempts to cope with the situation (e.g., an interruption) and is an highly individual phenomenon (e.g., Hacker, 1986; Mandler, 1975, 1984). Perceived control is believed to be correlated with emotions (e.g., Mandler, 1975; 1984; Lazarus, 1993; Van Ouwerkerk et al., 1994).

Pekrun and Frese (1992) theorized (see Figure 4.1) that when workers are not in control[11] and are not very competent,[12] an interruption can lead to helplessness. If the interruption is controllable and competence is available, and if failure to deal

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[11] Pekrun and Frese (1992) did not make a distinction between perceived and objective control. They mentioned controllability without further circumscription. But considering the definition, they probably mean perceived control.

[12] Competence was defined by Pekrun and Frese (1992) as the ability to avoid an interruption or to provide alternative responses to the completion of the interrupted sequence. An interruption - in our definition - is an unavoidable incident. The chance of being interrupted may be limited by, for instance, an avoidance strategy such as unplugging the telephone. Perhaps it would be better to state that subjects were accustomed to dealing with interruptions and had gained experience with them.

with the interruption is attributed to other people, anger is experienced. If the interruption is dealt with successfully, and this is attributed to other people, gratitude may be the result. If the achievement of dealing with the interruption is attributed to oneself, pride is experienced. Pride may be heightened when one's own achievement is higher than earlier achievements or other people's achievements.

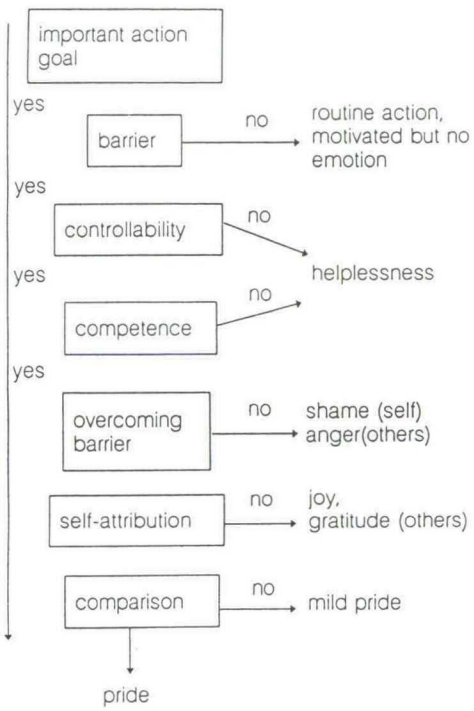

Figure 4.1 Emotions in work (Pekrun and Frese, 1992)

Unfortunately, Pekrun and Frese put (externally and internally generated) interruptions and disruptions into one concept, 'barrier',[13] making it difficult to look at the specific effects and regulation processes involved in interruption-related emotions. Moreover, in our view, Pekrun and Frese's scheme is not complete. We believe that it is not only the control and the competence of the worker that have an influence, but also the type and the content of the task and the interruption. Also,

[13] Pekrun and Frese (1992) defined a barrier as: "a barrier blocks the path to the goal or makes the goal achievement so hard that it cannot be reached. A barrier may mean that the action does not run smoothly, that something unpredictable happens that makes it difficult to continue the normal procedure, that some outside intervention leads to difficulties, or that the goals are set too high that they cannot be reached."

no attention is paid to mediating factors such as the complexity of the task, the available resources, and the relevance of an interruption. For example, although the perceived control is high (the interruption itself can be dealt with), a person gets angry because the content of the interruption requires extra effort or concentration or because it is non-relevant. Furthermore, emotions other than those mentioned can occur during work as well, including relief, shame, or anxiety. Relief is suggested to be related to the completion of the task despite high task demands and interruptions. Shame will occur when task performance has failed, despite low task demands and the absence of interruptions (Pekrun and Frese, 1992). Anxiety is triggered by expectations relating to important negative future events. Anxiety can both interrupt workers' plans and actions and can be the result of an interruption. Numerous experiments have shown that anxiety can facilitate task performance as a result of renewed effort and motivation and of learned skills, on the one hand, and, on the other, disorganize task performance since anxiety reduces the capacity of working memory, leaving less capacity for the tasks (Carver and Scheier, 1988; Greif, 1983; Humphreys and Revelle 1984; Mandler, 1975; Pekrun, 1992; Widlöcher, 1988). Pekrun (1992) assumed that this is not only true for anxiety but also for other (strong) emotions as well, with a higher impact for negative emotions than for positive emotions, as the former require more information processing (see section 4.2.1).

4.4 Conclusions

In this chapter we have discussed how emotions can occur, especially in relation to interruptions during work. We subscribe to the idea that when an interruption breaks in on the work flow activities, other than those originally planned, have to be executed. Various processes are involved in dealing with an interruption, both on a cognitive and on a psycho-physiological level. According to our conceptual model, emotions signal the cognitive and psycho-physiological regulation processes that changes have to be made in order to adapt to the demands of the (work)situation. In turn, the activity will be affected.

In general, emotions are defined as the result of the experience and labelling of an aroused state and are related to the individual's goals in the situation and to motives, relevance, norms, and values (Buck, 1989; Ellsworth, 1994; Frijda et al., 1992; Lazarus, 1993, 1994; Parkinson and Manstead, 1992). Emotions comprise a specific feeling (affective component), perceptions of physiological and expressive processes (body-perceptual component), and specific cognitions (cognitive component) that are to some extent characteristic of each emotion. Emotions give information about how the situation is appraised and inform others (social interaction) about the individual's personal state (for example, a person is angry because he does not like the situation; he is happy because the situation is better than hoped for). There is no simple mapping from appraisal onto emotions. Cognitive emotion theories suggest that the way the worker responds to interruption-related emotions depends on the quality, i.e., its content, on whether the emotions are positive or negative, on the relevance,

and on the quantity, i.e., the intensity of the emotion. Personal characteristics, i.e., the capacity, and the activated plan are also important.

We can formulate the following general ideas of how interruption-related emotions can affect performance. More detailed hypotheses are presented in Chapter 6. We expect that the effects of both positive and negative interruption-related emotions on performance will depend on the level of cognitive processing that is required, the control possibilities, and the relevance of the interruptions. The arousal and activation of the worker, and the intensity of the emotion will influence the effects. Coping strategies are likewise considered to be important. We also expect that the effect of emotions on performance will be rather small as emotions in work are considered to be relatively weak

1• Research has shown that mainly negative emotions are experienced after being interrupted. But considering our survey study and Jacobshagen's study (1990), we believe that positive interruption-related emotions are also experienced. Whether positive and/or negative emotions arise after being interrupted is investigated in our first experiment. In our second experiment, we investigate how both positive and negative interruption-related emotions can affect performance and the personal state. We also study the influence of the interruption-related emotions on cognitive and psycho-physiological regulation processes.

2• As emotions require information processing, the cognitive demands of emotions will impair the performance of mental work. In line with Mandler's interruption theory, we assume that negative interruption-related emotions have larger performance effects than positive interruption-related emotions as negative emotions indicate that more changes have to be made and more controlled processing is required.

3• Similarly, more cognitive and psycho-physiological regulation processes are involved when interruption-related emotions have to be dealt with. Again, we assume that the effects will be larger when negative emotions are involved than when positive interruption-related emotions are experienced.

4• We assume that performance is less affected when workers have a high level of perceived and objective control over their work than when they do not have such control.

5• The respondents of our survey study seem to be more work-oriented (to achieve positive work outcomes) than emotion-focused (resulting in more performance effects with fewer effects on the personal state). In our experiments we investigate whether a similar result occurs in a more controlled setting.

Chapter 5 *EXPERIMENT 1: The effects of interruptions on performance and personal state*[14]

This chapter describes the results of an experiment on the effects of daily occurring interruptions in modern, mental work. We analyze how three interruption-related factors, viz. the number, the complexity, and the moment of interruptions, influence the task performance of a special group of mental information workers, namely secretaries. The effects on the psycho-physiological state are described as well. The data has been collected by observation, physiological recordings and self-report techniques.

5.1 Introduction

In this first study, we examine how daily occurring interruptions affect mental information work and how three factors, i.e. the frequency, the complexity and the moment of interruption, influence this process. Research (e.g., Carayon-Saintfort, 1992; Kolish, Kuhman & Boucsein, 1991) has indicated that interruptions can affect the goal-directed activity of the person (see also our conceptual model in Figure 1.2). But (how) do daily occurring interruptions affect mental work? Indeed, the results of our survey study indicate that daily occurring interruptions affect performance and that the effects depend on job, task and personal characteristics. But before we can draw any conclusions, we have to investigate the interrupted work process in a more objective way, within a controlled setting. Therefore, we designed an experiment, based on the data of our survey study, and on notions from Action Theory and related information-processing theories.

According to our definition, an interruption leads to a temporary cessation of the ongoing task execution. Research (e.g., Henning et al., 1989) has shown that dealing with the interrupting task puts an additional demand on resources needed for action execution and for the regulation of the activity. In line with Action Theory and information-processing theories, discussed in Chapter 3, cognitive regulation can take place at different levels, depending on the skill of the worker, the kind of operation that has to be executed, and the activated plan. As interruptions require cognitive processing, less capacity is available for performance or for anticipation. It was suggested that larger performance effects are expected when the interruption requires controlled processing, i.e. on the knowledge-based level, than when the interruption is dealt with automatically, i.e. on the skill-based level. Interruptions also seem to

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[14] This research is part of a joint project "Interruptions in Mental Information Work" executed by the Research Unit on Work and Organizational Psychology of Tilburg University and the Laboratory of Work Psychology of Moscow State University. The project concentrates on the effects of interruptions on work activities, subjects' psycho-physiological state and the interaction between those two (Roe, Zijlstra, Krediet, van den Berg, van den Berg-Lenssen, Leonova, Kouznetsova, Kapitza, Burmistrov, Frenkina and Belyshkin, 1995).

affect the psycho-physiological state of the worker as they put additional demands on the worker, without reducing the demands of the main task. For instance, more effort is required to make up for lost time.

Considering the results of our survey study and the research we investigated, we designed an experiment to study the influence of the frequency, the complexity and the moment of interruptions on performance and personal state.

To investigate how interruptions can affect performance, we adopted the following research strategy. Research in the domain of mental information work requires information from daily work settings. In our survey study, we collected information from three groups of mental information workers, i.e. clerical workers, business workers and other professional workers. In this study, we investigate only one group of mental information workers, namely secretaries. Secretaries were chosen as subjects for a number of reasons. One of the reasons is that in our survey study, the results of the clerical workers were highly dominated by the large number of secretaries that participated in this study. So, the preliminary results of this particular group are clearest. Also, the clerical workers in our survey study are the only group of workers who labelled interruptions as both negative and positive. Furthermore, work contents and the general level of work competence (the motivation to deal with interruptions, experience, knowledge, acceptance, skills etc.) will be more or less similar for all subjects. Personal characteristics, such as temperamental factors, are not controlled for. They will be measured by means of personality tests and treated as covariates in further analyses. The results of these analyses are not discussed here[15]. So, for our investigation on general and emotional effects of interruptions, this group is the most interesting one.

We also concluded from our survey study that five types of interruptions occur frequently in daily, mental work: urgent calls, questions from colleagues, questions from clients, telephone calls and someone entering the room. In a pilot study (Jansen, 1994; Krediet, 1994), it was found that during one of these interruptions, namely someone entering the room, task execution was sometimes continued, i.e. was not interrupted. This last situation was not desirable in our experimental setting[16]. Since we found that the formal characteristics of telephone calls and someone entering the room are not much different from each other, and because telephone calls were found to be one of the most frequently occurring types of interruptions (see Chapter 2; Brouwer-Janse et al., 1993; Pringle, 1989), we decided to use the telephone as the single type of interruption in our experiment.

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[15] The results of the analyses on the influence of various personality variables are discussed in Roe, Zijlstra, Krediet, Van den Berg, van den Berg-Lenssen, Leonova, Kouznetsova, Kapitza, Burmistrov, Frenkina and Belyshkin (1995), and in Van den Berg, Roe, Zijlstra, Krediet (1996).

[16] We did not include this effect in our study because we were mainly interested in the situation where the interruption stops the task execution. The fact that subjects can also continue their work is certainly an issue that has to be investigated in future studies.

5.2 Method

Data from our survey study was used for the design of our experimental study. Hypotheses from the survey study and literature are then tested in a simulated workplace. Here, a detailed and more precise description of the cognitive and psycho-physiological processes can more easily be observed and measured. By choosing this combination of both field-laboratory studies, a regular working day can easily be simulated without unwanted factors and situations (Boucsein, 1993). The work place used in our experiment was designed in agreement with Dutch office standards and with relevant ergonomic criteria (cf. Biemans, 1993). The office measured approximately $45m^2$ and had three work places with regular office tools, such as a PC, a telephone, and mail baskets.

5.2.1 Subjects

Forty secretaries of Tilburg University (the Netherlands) participated in our experiment. Their mean age was 39 years. They were all experienced typists who spent, on average, 3.5 hours a day working with the WordPerfect 5.1 word processing programme. The subjects participated voluntarily and received a financial reward of *f* 10,– per hour afterwards.

5.2.2 Procedure

Subjects were recruited by means of a personal letter. Upon contacting the experimenter, the nature of the experiment was explained[17]. On the first experimental day, subjects were briefly introduced to the laboratory setting by a written instruction and informed about the measures to be taken and about the recording devices. They were not informed about the fact that this study focused explicitly on their behaviour while being interrupted during work.

Subjects worked in the simulated office on two days, with an interval of one week maximally. During the experimental sessions, they worked on standardized text editing tasks. Between sessions, they were allowed a short break. This break was also used for administering some questionnaires. At the end of each day, subjects had to fill in some questionnaires. At the end, subjects were debriefed. They were requested not to talk in detail about the experiment with colleagues who had also volunteered to participate.

In the session with interruptions, the experimenter made a telephone call to the subjects at certain pre-determined points during the execution of the task, thus causing an interruption at comparable moments. Subjects' behaviour was 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.

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[17] See Appendix B for the instructions.

Subjects had to perform six computer text editing tasks using the word processing programme WordPerfect 5.1. Tasks were chosen from a set of comparable texts of equivalent complexity. A printed version of the text containing handwritten instructions for editing was presented along with a diskette containing a text file. The instructions called for typing, formatting the document, changing fonts, replacing parts of the text, correcting, etc. There was no time limit and subjects were free to choose their own working method. The execution of the text editing could be interrupted by a telephone call from the experimenter with the request to perform an additional task. The telephone call and this other task was defined as the interruption in the task performance[18]. For the interruption two levels of complexity had been created. In case of a 'simple' interruption the subject had to find information that was readily available, i.e. looking for a telephone number or the year of publication of a particular article. The 'complex' interruption consisted of a more elaborate task such as an additional short editing task which required the subjects to leave the current document.

5.2.4 **Design**

Subjects worked in the simulated office twice, for half a day. Each day comprised three experimental sessions. The first session was always without interruptions, the second and third session comprised either one or three interruptions.[19] The first session was used as a reference for studying the interrupted performance.

Table 5.1 Overview of experimental conditions

Day	Session 1	Session 2	Session 3
Day 1	0 interruption(s)	1 (3) interruption(s)	3 (1) interruption(s)
Day 2	0 interruption(s)	3 (1) interruption(s)	1 (3) interruption(s)

The 'complexity' of the interruption is treated as a between-subject factor and tested in sessions with one interruption. The interruption is either 'simple' or 'complex'. (In sessions with three interruptions a mixture of one simple, one moderate, and one complex interruption is introduced). The 'frequency' of the interruption, one or three interruptions, is tested in a (repeated) within-subject design and as 'a between factor' (mixed design). The effects of the various 'moments' (begin or end of the task performance) are tested in a session with three interruptions by within-subject analyses.

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[18] See Appendix C for a list of interruptions.

[19] Using a counter-balanced design between the different numbers of interruptions was another option, but then more subjects were required. Other, unwanted, (after-)effects might have influenced the results. For example, the non-interrupted session at the beginning of the experiment is uncomparable with the non-interrupted session after being interrupted several times because performance during this session might be influenced by time pressure.

5.2.5 **Dependent variables**

The dependent variables in this study can be categorized into three groups:

1• Variables that describe the performance process. A distinction is made between variables used for describing the main task and variables that describe how the interrupting task was handled.

2• Variables that describe the performance outcomes.

3• Variables that describe the personal state during an after the (interrupted) task performance

sub 1. Performance process variables

The performance process was recorded on video tape and analysed afterwards by two trained observers using an event-recorder. In order to distinguish the type of operation in the task execution, the following three categories are distinguished:

1• "Task-related operations" which are defined as operations directly relating to completing the task such as typing text, changing lay-out or correcting spelling of words

2• "Supportive operations" which are defined as operations that are not directly aimed at accomplishing the task goal, but at supporting or ensuring the progress of the activity by tackling the minor problems that arise or obtaining additional information during execution of the task. Examples are looking in the help menu or getting a pen.

3• "Non-related operations" which are defined as those operations that neither aim at accomplishing the task nor are obviously supportive. Examples are smoking a cigarette, looking out of the window.

Changes in frequency and duration of these performance process variables, caused by the interruptions, were analysed. As all subjects belong to one particular professional group, a sample size of 16 subjects for observation was determined to be representative. These subjects were randomly chosen from the total sample of subjects.

The cognitive regulation of the interruption was investigated by studying the interruption interval as well as the different strategies used. The video tapes of all subjects were watched and the following episodes were marked as (see Figure 5.1):

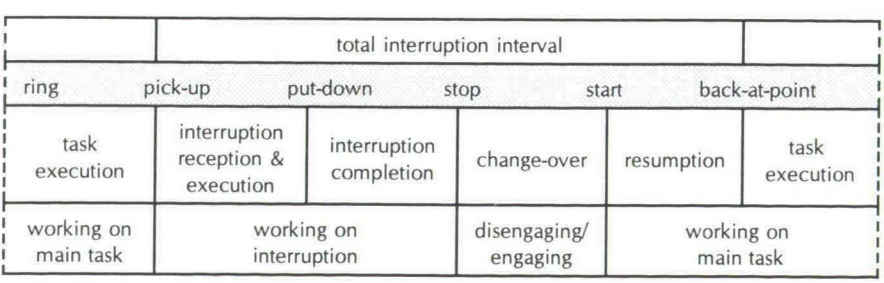

Figure 5.1 Dissection of the interruption interval into handling activities episodes

1• "Interruption reception & execution". This episode starts the moment the telephone receiver is picked-up and ends the moment the receiver is put down again. During this episode the person listens to instructions/questions and provides the required information or starts working on the interrupting task.
2• "Interruption completion". In relevant cases, this episode begins the moment the receiver is put down and ends the moment the interruption is completed.
3• "Change-over ". This episode starts the moment the interruption is completed, and ends the moment the main task is taken up again. In this episode the person reorients to the main task
4• "Resumption of the primary task". This episode begins the moment the main task is resumed at the point where it had been stopped.

Table 5.2 Interruption handling strategies

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)

Videotapes of all 40 subjects were observed, and their strategies for dealing with the interruption were coded. The strategies differ in whether the interrupting telephone call is responded to immediately or with a delay, and whether the interruption and the primary task are executed serially or in parallel. In the serial mode, the interrupting task is executed first and the main task is taken up after its completion. In the parallel mode, the interrupting task is executed in parallel with the main task. The frequency of four different strategies in the various experimental conditions was analysed. These four strategies (see Table 5.2) were coded as:
1• "An immediate reaction to the interruption with serial task execution".
2• "A delayed reaction to the interruption with serial task execution".
3• "An immediate reaction to the interruption with parallel task execution".
4• "A delayed reaction to the interruption with parallel task execution".

sub 2. Performance outcome variables
The performance outcomes were measured by observing the videotapes of all 40 subjects and recording the various time periods of:
1• "The total work time" i.e. the total time spent until the task is completed.
2• "The total interruption time" i.e. the total time required for the interruption task. It is the total sum of the four episodes of each interruption interval (i.e. the interruption reception & execution episode, the interruption completion episode, the change-over episode and the episode of the resumption of the primary task). In sessions with three interruptions, the interruption times of the three interruptions are added.
3• The difference between the two: "the time-on-task" which is the net task time spent on the main task.

The numbers of errors were counted by checking the documents that had been prepared by all 40 subjects. The following variables were defined:
1• "The total number of "errors", which was divided into:
2• "The total number of "omissions" (number of operations not performed).
3• "The total number of "mistakes" (number of wrong operations, i.e. not as instructed).

sub 3. Personal state variables
Data on the psycho-physiological state of all subjects were gathered before, in-between, and at the end of the (interrupted) task execution. Emotional states were assessed by the emotion score of the positive (PA) and negative (NA) emotions scales of the PANAS Questionnaire (Watson, Clark and Tellegen, 1988). Subjects had to indicate to what extent they felt a particular emotion at that moment on a 5 point scale. The labels vary between 'very slightly' or 'not at all' to 'extremely'. The questionnaire contains 10 positive emotions and 10 negative emotions. The mean scores for the positive and the negative emotions were calculated.

Subjective mental effort was measured by the one-dimensional rating scale for mental effort (RSME, Zijlstra, 1993). This questionnaire has been found to be sensitive to both changes in task load and to changes in psycho-physiological state. It contains labels indicating different degrees of effort ('very effortful', 'moderately effortful', 'not effortful' etc.) needed during a short (working) period. Well-being was measured by the Well-Being scale of the Well-being, Activity and Mood Questionnaire (WAM; Zinchenko, Leonova & Strelkov, 1985). Subjects had to indicate on a seven-point scale how they felt at a particular moment. The mean score of the 10 well-being related questions was calculated. It assesses whether there were any changes in the general level of well-being of the subjects between both experimental days.

Several investigators suggested looking at the variability of the heart rate (HRV) as a possible measure of change in effort during different levels of cognitive work (e.g. Veltman and Gaillard, 1993; Mulder, 1986; Wilson and O'Donnell, 1988). The HRV is used as a physiological indicator that mental effort is being exerted. HRV is based on a complex physiological system of the blood pressure regulation system involving baroreceptors. In a number of laboratory and field studies (see Meshkati, 1988; Aasman, et al., 1987), it was found that heart rate could be differentiated in a number of frequency bands. These frequency areas are not all equally sensitive to mental load. Especially the energy in the mid-frequency band (0.07-0.14 Hz) is related to mental task load (Aasman, et al., 1987; Aasman, Wijers, Mulder and Mulder, 1988). The CARSPAN program, developed at the Institute of Experimental Psychology in Groningen, was used to calculate heart rate variability from inter-beat-intervals. It is generally accepted that, with more mental effort, for instance during controlled processing, HRV decreases, especially in the 0,10 Hz component. A decreased HRV is also related to slower reaction times, worse work performance and higher subjective effort ratings (Luczak, 1979; Mulder, 1986; Schleifer and Ley, 1993; Wilson and O'Donnell, 1988). Furthermore, it is suggested that "only when

there is appreciable variation in task difficulty, and when subjects are motivated to exert additional effort during difficult sections of the task, changes in HRV can be found" (Veltman & Gaillard, 1993; p.271).

Table 5.3 Dissection of the interruption interval into HRV measurement episodes

Name	Mean duration	Episodes in 1st interruption	Episodes in 2nd and 3rd interruption
Baseline	4 minutes	1st-5th minute of session	
Episode 1	4 minutes	4 minutes before telephone ringing	4 minutes before telephone ringing
Episode 2	4 minutes	4 minutes after telephone ringing	4 minutes after telephone ringing
Episode 3	4 minutes	5th-1st minute before end of task	

We used the first five minutes of each interrupted session, minus the first minute (adaptation to the experimental situation) as a baseline (see Figure 5.3). Other measurements of HRV were taken during the first five minutes, minus the first minute, before each interruption was introduced. The first four minutes after the beginning of the interruption were also measured. At the end of the session, during the last five minutes minus the last minutes before the end of the task, the HRV was measured. This resulted in four episodes in a session with one interruption and in eight episodes in a session with three interruptions[20]. The variability during the specific episodes was compared with the baseline (difference scores) and analyzed in a (repeated) within-subject design and as 'a between factor' (mixed design).

Heart rate (HR) is used as an indicator of arousal. It reacts to intense, new, important stimuli that require mental or physical activity (e.g., Frijda, 1988; Monat, Averill and Lazarus, 1972; Obrist, 1981). Heart rate accelerates (during short intervals) as a response to (unexpected, new) stimuli and in a situation that requires attention. This acceleration is followed by a deceleration as part of the orientation reaction, and (finally) by a return to the basic level. HR also decreases during the execution of a simple task and increases during the execution of tasks that require (complex) cognitive work (Lacey and Lacey, 1978). Also the skill of the worker plays a role: more experienced pilots showed a peak in HR during take-off and landing whereas pilots who were less experienced had a higher HR during the whole flight (Kakimoto, Nakamura, Tarui, Nagasawa & Yagura, 1988).

[20] The HRV during the non-interrupted session were not included in our analyses because no comparable episodes exist between the interrupted and non-interrupted sessions.

Table 5.4 Dissection of the interruption interval into HR measurement episodes

Name	Mean duration	Episodes in 1st interruption	Episodes in 2nd and 3rd interruption
Baseline	4 minutes	1st-5th minute of session	1 minute after being back at moment of interruption-telephone ringing
Episode 1	4.32 sec.	telephone ringing-picking up the phone	telephone ringing-picking up the phone
Episode 2	83.62 sec.	picking up-putting down	picking up-putting down
Episode 3	493.29 sec.	telephone down-end of interruption	telephone down-end of interruption
Episode 4	18.74 sec.	end of interruption-orientation to main task (change-over)	end of interrupt-orientation to main task (change-over)
Episode 5	39.37 sec.	main task taken up-back at moment of interrupt (resumption)	main task taken up-back at "old point"(resumption)
Episode 6	1 minute	60 sec after back at moment of interrupt	60 sec after back at moment of interrupt

In Table 5.4, we list the various episodes during which the HR was measured. We measured the Inter-Beat-Intervals (IBIs), which were later converted into heart rates (Graham, 1978). The mean heart rate during the first five minutes, minus the first minute (adaptation to the experimental situation) of each interrupted session was used as a baseline (see Figure 5.1). Furthermore, mean heart rate episodes were measured during the various episodes of the interruption interval (see Figure 5.1)[21]. In order to obtain comparable results for the subjects we also calculated difference scores by subtracting the HR during the baseline score from a particular episode of each subject (for example Aasman, Mulder and Mulder, 1987). The difference scores between the number of interruptions were analyzed both in a (repeated) within-subject design and as 'a between factor' (mixed design).

5.3 Hypotheses

In Chapters 3 and 4, we formulated some general ideas on how interruptions can affect performance and the personal state. For the present experiment the following specific hypotheses are conceived, based on the idea that with more and complex interruptions, introduced at the beginning of the task performance, more cognitive processing is required. We suggest that less capacity is left over for executing the main task, resulting in an increase in performance effects.

1 ◇ Performance process

Interruptions affect the performance process in such a way that they lead to an increase in the kind and the duration of the various operations in the task performance and in the duration of (the various episodes of) the interruption interval. For each factor we formulate the following hypotheses:

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[21] The HR during the non-interrupted session were not included in our analyses because no comparable episodes exist between the interrupted and non-interrupted sessions.

1a - Frequency

When subjects are interrupted more often, they will execute more supportive and non-related operations than when they are interrupted only once (see our survey study).

We will also see longer interruption episodes and more delayed and sequential processing when subjects are interrupted more often.

1b - Complexity

After a complex interruption, more supportive operations will be executed. Also, the duration of the various interruption episodes will be longer in case of a complex interruption.

1c - Moment

An interruption, introduced at the beginning of the task execution, will lead to more supportive actions, longer interruption episodes, and to more serial processing than when the interruption is introduced at the end of the task execution.

2 ◇ Performance outcomes

Interruptions affect performance outcomes of the main task in such a way that efficiency of performance will be lowered: longer working times and more errors. For each factor we formulate the following hypotheses:

2a - Frequency

When interruptions occur more often, the working and interruption times will be longer and more errors will be made than when an interruption occurs only once.

2b - Complexity

A complex interruption will lead to longer working and interruption times and more errors than a simple interruption.

2c - Moment

No hypotheses can be formulated on the effects on the work outcome due to our experimental design.[22]

3 ◇ Personal state

- Interruptions affect the psycho-physiological state of the worker in terms of a reduced well-being, slightly more negative emotions (see our survey study), and in higher levels of activation and effort.
- The HR, as an indicator of general arousal, will increase at the beginning of a new situation (for example after an interruption), followed by a decrease at the end due to habituation. For each factor we formulate the following hypotheses:

3a - Frequency

When subjects are not interrupted, the positive emotions will be lower than when they are interrupted once (see Jacobshagen, 1990).

When subjects are interrupted, well-being will be reduced and effort, activation, and negative emotions will increase.

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[22] For example, it is not possible to study the total working time between an interruption at the beginning and at the end phase of the task performance in a session with three interruptions.

More interruptions will not affect the experienced positive and negative emotions (well-trained subjects; see also Chapter 4.2).

3b - Complexity

A complex interruption will lead to a reduction in well-being, more activation and effort, and to slightly more negative emotions than a simple interruption

3c - Moment

An interruption introduced at the beginning of the task performance will lead to more activation and effort than an interruption introduced at the end of the task performance.[23]

5.4 Results[24]

We subsequently describe the effects of interruptions on the performance process, on the work outcomes, and on the personal state.

5.4.1 Descriptive analyses of the performance process

A search was made for differences between the results of the two experimental days and between the balancing orderings. Only for one variable a significant ordering effect was found. Subjects need significantly more time for the resumption of the main task on the first day than on the second day (day 1: $M = 79.96$, $SD = 115.06$; day 2: $M = 45.63$, $SD = 49.49$; $F(1,38) = 4.21$, $p < .05$. Because of this day effect, a two-way interaction analysis (day and complexity/frequency) is executed (within-subject). In cases were no day effect was found, we use the mean score of both experimental days in our analyses.

1. *Types of operations*

Table 5.4 Means, Standard deviations, and analyses of variance of the frequency and the time spent (in seconds) for the three categories of operations (main task only)

Condition	0 Interruption		1 Interruption		3 Interruptions			
Operations	*M*	*SD*	*M*	*SD*	*M*	*SD*	*n*	*p*
Frequency								
Task-related operations	493.78	79.32	510.41	89.50	482.91	78.08	16	ns
Supportive operations	6.63	6.26	7.59	7.37	11.63	9.69	16	*
Non-related operations	13.31	13.28	16.63	24.86	16.13	20.90	16	ns
Time spent on main task								
Task-related operations	1277.66	379.58	1219.18	407.65	1237.13	489.12	16	ns
Supportive operations	267.77	575.04	195.56	185.69	313.47	261.03	16	*
Non-related operations	32.95	31.05	50.17	71.13	47.64	78.10	16	ns

ns: non significant; *: $p < .05$

[23] No hypotheses can be formulated on the effects on the positive and negative emotions as the PANAS questionnaire was given to the subjects at the end of a session.

[24] Because we found so many non-significant effects we decided, because of clarity reasons, not to include the related F- and df values. When needed, more information can be obtained by the writer.

Table 5.5 shows the frequency, i.e. the number of times a particular operation is executed in a particular session, and the duration of the operations, measured in seconds. We see that with more interruptions significantly more operations are needed to support the execution of the main task: $F(2,15) = 13.5$, $p < .05$. Also, significantly more time is spent on supportive operations with more interruptions: $F(2,15) = 10.3$, $p < .05$. But the increase in time is smaller than expected: with three interruptions, the increase is less than three times the time spent in the situation with one interruption. In greater detail, we find that subjects had "trouble finding where they were" in their text (23 times when not interrupted and 31 times when interrupted three times).

Furthermore, there only appears to be a tendency to spend more time on the supportive operations when the interruptions are more complex: $F(1,38) = 2.46$, $p = .14$.

Although no further significant effects are found, it seems that relatively more non-related operations are executed during the first session, that is, when no interruption was presented. Apparently, the subjects orient to the task and the situation in the first session.

2. *Interruption interval*

Table 5.6 Means, Standard deviations, and analyses of variance of the time spent (in seconds) on episodes during the interruption interval in conditions with 1 or 3 interruptions

Condition	1 Interruption		3 Interruptions			
Episodes	*M*	*SD*	*M*	*SD*	*n*	*p*
Reception & execution	81.72	46.52	359.14	99.46	39	****
Completion	598.53	621.48	1125.81	486.92	39	****
Change-over	3.88	3.30	11.87	8.02	39	****
Resumption	14.32	20.59	113.82	144.03	39	****
Total time	689.45	591.26	1610.64	509.03	39	****

****: $p < .001$

When we look at the duration of the four episodes of the interruption interval in Table 5.6, we see that the total interruption interval lasts longer when more interruptions were posed on the subjects: $F(1,38) = 72.13$, $p < .001$. This is logical, as with more interruptions more episodes are found. In greater detail, subjects take more time to answer the telephone call: $F(1,38) = 240.71$, $p < .001$, to complete the interruptions: $F(1,38) = 24.82$, $p < .001$, to disengage from the interruptions: $F(1,38) = 38.41$, $p < .001$ and to resume the main task: $F(1,38) = 57.26$, $p < .001$ when interrupted more often. However, the increase in the execution and the resumption episodes are disproportional as the time needed in a session with three interruptions is more than three times the time needed in a session with one interruption. This suggests a (cumulative) after-effect with multiple interruptions. A remark has to be

made on the results of both the execution and the completion times. These effects can be explained by the difference in duration of the given information and not by the difference in frequency or complexity.

Table 5.7 Means, Standard deviations, and analyses of variance of the time spent (in seconds) on episodes during the interruption interval in conditions with a simple and a complex interruption

Conditions	Simple Interruption		Complex Interruption			
Episodes	*M*	*SD*	*M*	*SD*	*n*	*p*
Reception & execution	117.28	39.16	48.18	14.10	20	****
Completion	11.28	14.78	1138.40	348.34	20	****
Change-over	2.55	1.82	5.03	3.98	20	**
Resumption	16.58	27.03	12.06	11.34	20	ns
Total	147.69	46.21	1203.67	346.08	20	****

ns: non significant; **: $p<.01$; ****: $p<.001$

In Table 5.7, the means and standard deviations for the conditions with a simple and a complex interruption are presented. From this table it can be concluded that a complex interruption takes more time to handle than a simple interruption: $F(1,38)$-$=182,94$ $p<.001$. In greater detail, both the reception and execution: $F(1,38)=50.30$ $p<.001$, the completion of the interruption: $F(1,38)=209.02$ $p<.001$, and the reorientation phase: $F(1,38)=6.45$ $p=.01$, last longer when the interruption is of a higher complexity. The differences in reception and execution and completion times can be explained by experimental design and not by the difference in complexity. During the simple interruption, subjects execute the interruption task immediately, that is mostly during the (reception and execution of) the telephone call. During the complex interruption, on the other hand, the interrupting task is executed after the telephone call has been handled (see paragraph 5.2). Because of this difference, the effects on the change-over and resumption episodes are more interesting than the reception, execution and completion episodes. Apparently, it takes longer to disengage from and to orient to the main task after a complex interruption than after a simple interruption. This suggests an after-effect of interruptions with a higher complexity.

The results on the various moments of interruptions indicate that only the resumption episode is affected by the moment of the interruption. Subjects need significantly longer resumption time when the interruption is introduced at the beginning of the task performance ($M=9.53$, $SD=10.74$) than when it is introduced at the end (($M=5.71$, $SD=4.89$): $F(1,39)=4.42$, $p<.05$. The result is in line with our theory that less capacity is available at the beginning for dealing with the interruption, resulting in more disruptive effects, than when the interruption is introduced at the end of the task execution. But, one remark has to be made. Being interrupted at the end of the session also means that the subject is interrupted for the third time. So, the frequency may have influenced the results of the different

moments. Therefore, we look at the resumption times within the sessions with three interruptions (within-subject analyses). Indeed, we find a significant effect: the resumption time is significantly shorter when the interruption is introduced for the third time than when it occurs the first or the second time: $F(2,158) = 13.02$, $p < .001$. So, we must conclude that the difference in resumption time can not totally be explained by the moment of interruption. Also the frequency influences the resumption episode.

3. *Strategies used*

Table 5.8 Frequency of interruptions strategies for various numbers and moments of interruptions

Condition	Number					Moment	
Strategy (in total)	One	Three				Beginning	End
	Total	1st	2nd	3rd	Total	Total	Total
1. Immediate-serial (115)	39	28	22	26	76	28	26
2. Delayed-serial (114)	21	38	26	29	93	38	29
3. Immediate-parallel (26)	10	2	10	4	16	2	4
4. Delayed-parallel (59)	10	11	20	18	49	11	18

In Table 5.8 we see that the main and interrupting tasks are more sequentially executed than in parallel. The interruption characteristics have some effect on the choice of strategies. When the number of interruptions increase, the interruptions are handled more serially and with a delay ($Chi^2(3,314) = 11.87$, $p < .10$).[25] Whether the telephone is picked-up immediately or not does not depend on the complexity of the interruption. Therefore, no analyses are executed on the complexity of the interruption. No significant difference is found when interruptions occur at the beginning or at the end of the task.

The fact that workers execute the interruptions more serially confirms our theory. It indicates that more controlled processing is required, i.e. processing takes place at the intellectual level when dealing with an interruption. The usage of more delayed strategies can be interpret as an attempt to get some control over the moment the telephone intrudes and affects performance.

In summary, data on the performance process show that it takes longer to orient to the main task after a complex interruption than after a simple one and it suggests an after-effect. With multiple interruptions we see a prolonging effect on the resumption episode but also a stimulating effect on the reorientation of the main task. Subjects also execute more supportive operations when the number of interruptions and their complexity increased. Finally, more sequential processing is found when workers are interrupted (more often). The interrupting task is also handled with a delay.

[25] Analyses of the influence of the moment of the task could not be executed due to the fact that less than 10% of the cells had an expected frequency of 5 (Huizingh, 1989).

5.4.2 **Effects on the performance outcomes**

A search was made for differences between the results of the two experimental days. Having established the lack of significant differences between the measurements of the two days, the results on the performance outcomes variables have been averaged over both experimental days, except for the total working time. Here a two-factor (day/frequency) within-subject analyse is executed. We found that subjects needed more time for executing the task series on the first day ($M = 3033.98$, $SD = 1052.35$) than on the second day ($M = 2744.24$, $SD = 1012.06$): $F(1,238) = 4{,}73$, $p < .05$.

1. *The quantitative aspects of the task performance*

Table 5.9 Means, Standard deviations, and analyses of variance of the time spent (in seconds) on the primary task and the interruption, for the number of interruptions

Condition	0 interruption		1 interruption		3 interruptions			
Variables	*M*	*SD*	*M*	*SD*	*M*	*SD*	*n*	*p*
Total working time[26]	2411.24	757.24	2752.95	829.73	3569.77	762.63	39	****
Total interruption time	—.–	—.–	663.91	583.76	1610.64	509.41	39	****
Total time on task	2411.24	757.24	2089.04	543.71	1959.13	468.11	39	****

****: $p < .001$

Table 5.9 shows that the total working time increases when subjects are interrupted: $F(2,234) = 33.81$, $p < .005$. This increase is a logical result of the additional time required for dealing with the interruption tasks. Contrary to our expectations, the time spent on the main task shows a significant decrease with more interruptions $F(2,36) = 10.13$, $p < .001$. It is noteworthy that the total time needed to complete the main task is longest in the session without any interruption (2411 seconds = about 40 minutes), and shortest in the session with most interruptions (1959 seconds = 33 minutes)! This is contrary to what one would expect. Maybe subjects try to make up for lost time. It suggests that the occurrence of interruptions can have a stimulating effect on performance.

We also see in Table 5.9 that the interruption handling is longer when subjects were interrupted more often: $F(1,38) = 74.95$, $p < .001$. Indeed, more interruptions make subjects spend more time on the interruption task, but we see that the increase between one and three interruptions is disproportional (an increase in time of 2.4 instead of 3 times).

[26] repeated measurement over the separate day scores.

Table 5.10 Means, Standard deviations, and analyses of variance of the time spent (in seconds) on intervals for simple and complex interruptions

Condition	Simple Interruption			Complex Interruption			
Interval	*M*	*SD*	*n*	*M*	*SD*	*n*	*p*
Total working time	2187.38	581.36	20	3318.53	633.84	20	****
Total interruption time	147.75	46.40	20	1180.07	369.40	20	****
Time on task	2039.62	558.57	20	2138.46	538.21	20	ns

ns: non significant; ****: $p<.001$

Table 5.10 shows that the complexity of the interruption also influences the length of the various intervals. A complex interruption lasts longer than a simple interruption: $F(1,38)=153.77$, $p<.001$), which is not surprising as we have already found that the various episodes in the interruption interval are longer in a complex than in a simple interruption. This also explains the significantly longer total working time in the sessions with a complex interruption: $F(1,38)=34.60$, $p<.001$.

Interestingly is the result that, although the total working time and the interruption time are longer with a more complex interruption, the time needed for the execution of the primary task is not affected by the complexity of the interruption.

2. *The quality of the task performance*

Table 5.11 Means, Standard deviations, and analyses of variance of the number of errors, for the number of interruptions and with different complexity

Quality variables		Errors			Mistakes			Omissions		
Condition		*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
Complex:	simple	5.90	2.41	20	2.98	1.62	20	2.93	1.41	20
	complex	6.95	3.20	20	3.98	1.96	20	2.98	2.18	20
p		ns			ns			ns		
Number:	0	7.11	3.70	40	4.22	2.94	40	2.89	1.80	40
	1	6.43	2.85	40	3.47	1.85	40	2.95	1.81	40
	3	7.29	5.16	38	4.18	2.92	38	3.11	2.96	38
p		ns			ns			ns		

ns: non significant

As can be seen in Table 5.11, no significant effects on the quality of the performance are found when the number or the complexity of interruptions increases.

In summary, being interrupted implies that people have to divide their attention over the main task and the interrupting task. The execution of the main task is thus negatively affected as less capacity is available. We see that, with an increase in the number of interruptions, less time is spent on both the main and the interrupting task. The quality of the task performance is not affected. This suggests that

interruptions have a stimulating effect, leading to more efficient work behaviour. It also suggests that subjects make up for possible negative effects: they still want to achieve the goal they have set. The complexity of the interruption has no influence on quantitative and qualitative aspect of the performance of the main task.

5.4.3 **Effects on the psycho-physiological state**

No differences are found in the personal state variables between the two experimental days. All analyses are therefore executed on the mean score over both days.

1. *Well-being*

We find no significant changes between subjects' well-being on the first day (before: $M = 143.54$, $SD = 22.58$; after: $M = 140.30$, $SD = 23.11$), or on the second day (before: $M = 147.00$, $SD = 21.30$; after: $M = 144.08$, $SD = 22.33$) of the experiment.

2. *Experienced emotions*

Table 5.12 Means, Standard deviations, and analyses of variance of the psycho-physiological state variables for the numbers of interruptions

Condition	0 interruption			1 interruption			3 interruptions			
State	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*p*
Current state:										
Positive emotions	31.82	5.10	38	30.33	4.83	39	30.45	5.09	39	****
Negative emotions	14.83	4.12	38	14.54	3.85	40	14.81	3.61	39	ns
Subjective effort	27.80	16.86	40	33.45	18.12	40	42.38	20.84	39	****

ns: non significant; ****: $p < .001$

As can be seen in Table 5.12, the frequency of the interruptions does affect the positive emotion scores: $F(2,74) = 10.12$, $p < .001$. When we compare the positive emotion scores after a session without an interruption with the session with (one and three) interruptions, subjects indicate that they have less positive feelings when interrupted: $F(2,74) = 13.64$, $p = .001$. In greater detail, it is the introduction of an interruption as such that causes a decrease. The negative emotion scores remain at the same level. They are not influenced by the introduction of one or more interruptions.

Table 5.13 Means, Standard deviations, and analyses of variance of the psycho-physiological state variables for conditions with simple and complex interruptions

Condition	Simple Interruption			Complex Interruption			
State	*M*	*SD*	*n*	*M*	*SD*	*n*	*p*
Current emotional state:							
Positive	29.55	4.73	20	31.07	4.93	20	ns
Negative	15.53	5.11	20	13.55	1.51	20	ns
Subjective effort	35.03	19.92	20	31.88	16.44	20	ns

ns: non significant

Table 5.13 shows no effects on the emotion scores when the complexity of the interruptions increases. This contradicts our hypothesis that more complex interruptions will lead to more negative emotions. Some subjects reported that the experiment was somewhat dull in comparison to their average work situation and work tasks. An interruption can thus be experienced as a source of stimulation or distraction, especially when it involves a complex interruption (the positive emotions show a small increase ($p = .1$). This is in agreement with the findings from our survey study where "interruptions lead to more variety in work" and "the interruption gives a fresh view".

3. *Mental effort*
From Table 5.12 subjective mental effort appears to be greater when the number of interruptions increases: $F(2,37) = 19.69$, $p < .001$, probably because more tasks have to be executed. Also here, when we compare the subjective mental effort after a session without an interruption with the session with (one and three) interruptions, we see that it is the introduction of an interruption as such that causes an increase: $F(2,74) = 13.64$, $p = .001$.[27] As can be seen from Table 5.13, a complex interruption requires somewhat less subjective effort than a simple one but the difference is non-significant. It is interesting to see whether the same results occur when the physiological measures of mental effort (HRV) are investigated.

4. *Heart rate*
The heart rate baseline does not significantly differ between the two days.

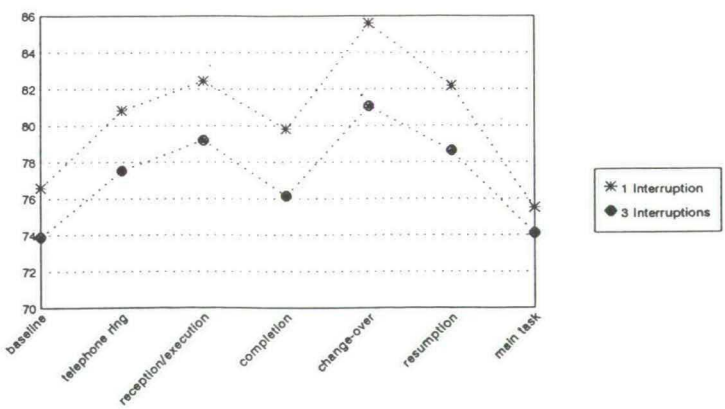

Figure 5.2 Heart rate during sessions with one and three interruptions

[27] When interrupted three times, with more effort also more negative emotions are experienced: $r = .57$, $p < .001$.

In Figure 5.2, we see that the HR is higher when interrupted once than when interrupted three times, for all six episodes. In greater detail (between - factor analyses of variance), the occurrence of the interruption: $F(1,26) = 16.32$, $p < .001$, dealing with the interruption: $F(1,26) = 4.73$, $p < .05$, and the resumption of the main task: $F(1,26) = 7.65$, $p < .001$ require some extra activation when interrupted only once (startle effect). When we calculated the difference scores between the various episodes and the baseline, we find no significant differences between both sessions. This indicates that the number of interruptions does not influence the HR.

The effect of the complexity of the interruption on the HR is investigated in the sessions with one interruption (between - factor analyses of variance). We find no significant effect in the difference scores of the HR between (the third episode of) a session with a complex interruption and a session with a simple interruption. This is not in line with our hypothesis that a complex interruption will be more arousing than a simple interruption. One reason may be that the completion of a complex interruption takes so much longer than the completion of a simple interruption (see Table 5.7). During that longer period, subjects become less aroused as they continue working on the interruption task (habituation). As a result, the mean HR during that period becomes more similar to the, less arousing, simple interruption.

Also contrary to our hypothesis, no significant effects are found in the HR difference scores during an interruption that is presented at the beginning and one that is presented at the end of the task performance.

5. *Heart rate variability*
Heart rate variability (HRV) has been suggested to be a reliable measure for effort during cognitive tasks. The idea is that a decrease of HRV can be interpreted as an increase of effort.

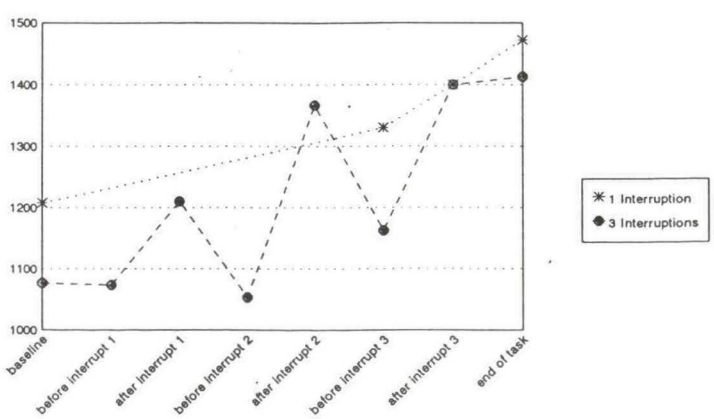

Figure 5.3 Heart rate variability during sessions with one or three interruptions

We find a significantly higher variability during the last interruption on the second day ($M = 1582.20$, $SD = 961.53$) than on the first day ($M = 1230.57$, $SD = 679.42$):

$F(1,101)=4.47$, $p<.05$. This may indicate that subjects have habituated to the experimental conditions on the second day.

Figure 5.3 shows the sessions with one, and with three interruptions. We see that the heart rate variability increases towards the end of both interrupted sessions. Again, we look at the difference scores between the baseline and the HRV during the various episodes. Within-subjects analyses of variance on these difference scores show that, in the session with one interruption, the increase is significant: $F(3,13)=-5.47$, $p<.01$. In sessions with three interruptions, the increase is non-significant. Furthermore, between -factor analyses of variance show also no significant effects in the difference scores between the sessions with one or with three interruptions (i.e. in both conditions the HRV increases, compared to the baseline during the three comparable moments). These results indicate that, contrary to waht we expected, when being interrupted more often, no additonal effort is invested. We also see that, when interrupted three times, more effort is invested just before the interruption, compared to the episodes after the interruption is introduced, especially when the interruption occurs the second time. We cannot explain this effect, as subjects did not know that they were going to be interrupted.

The complexity of the interruptions does not influence the heart rate variability, as we have not found significant effects in the difference scores between a simple and a complex interruption. This result contradicts our expectation that during a session with a complex interruption more effort is invested than a session with a simple interruption.

For the results of the various moments of interruptions we refer to Figure 5.3. Here we see the HRV before and during an interruption that was introduced at the beginning (the first interruption) and at the end (the third interruption) of the task performance. We find no significant changes in the difference scores of the HRV between those two moments although we see that an interruption at the end of the task execution requires somewhat less effort than when it is introduced at the beginning of the task performance.

In summary, the psycho-physiological data suggest that being interrupted leads to some psychological costs as positive emotion scores decrease and more subjective mental effort is invested. Subjects seem to respond more favourably to complex interruptions, their emotional state improves and their subjective effort goes somewhat down. This can be explained by the fact that the subjects, as trained secretaries, are used to being interrupted frequently and to demanding types of interruptions. They may perceive complex interruptions as welcome distractions. Probably, a complex interruption is more in line with their general work, while a simple interruption is experienced as annoying.
The results of the HR analyses show that, especially, the introduction of the first interruption and the following resumption of the main task is arousing. When interrupted more often, the situation becomes familiar to the worker and is therefore less arousing. So, an incident of being interrupted is more arousing than being

interrupted more often. We also find that the HRV is not affected by the frequency, the complexity or the number of interruptions.

5.5 Discussion and Conclusions

Looking at the findings of this chapter, we see that although subjects manage to exert some influence on the moment in which the interruption starts (cf. interruption handling strategies), the interruption tasks are executed with (some) priority over the main tasks.

Our first hypothesis, which led us to expect some changes in the performance process, is partly confirmed. We see that interruptions do indeed lead to changes in the kind and the duration of various operations in the task performance. In line with our expectations, we find (disproportionally) longer resumption and execution episodes, and a postponing of the interruption when subjects are interrupted more often. We also find an increase of supportive[28] and non-related operations. Contrary to our expectations, however, we find that relatively less time is spent on change-over and on completion of the interruption. Furthermore, interruptions are indeed dealt with more serially and with a delay when occurring more often. In line with our expectations, the complexity of the interruption task causes an increase in the supportive operations and in the interruption intervals, with the most interesting result the increase in the change-over episode. An interruption at the beginning of the task execution results in a longer resumption episode, compared with an interruption introduced at the end of the task. But the frequency also affects the resumption episode. All these results suggest that it is mainly the frequency that influences the task execution. It even does so in a more or less positive way, as we see that the speed of the interruption episodes is enhanced.

The data concerning our second hypothesis, on work outcomes, show that interruptions also affect work outcomes. But the results are not completely in line with what we expected. Although the working and interruptions times increase, we see some positive effects as well, since more interruptions lead to proportionally shorter working times while the working and interruption times increase. And, the time spent on the primary task is not affected by the complexity. Furthermore, it is interesting to see that no effects are found on the qualitative work outcomes, that is, in the number and kind of errors made with different interruption frequency or complexity. So, the efficiency of performance is not (necessarily) lowered when interruptions are introduced.

Our third hypothesis, which stated that interruptions will affect the personal state, is confirmed. We also find that the HR data are in agreement with the literature (Lacey and Lacey, 1978): at the beginning, when the situation is new, HR increases. At the end, when subjects habituated to the situation, the HR shows a decrease.

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[28] These supportive operations have initially been defined as "strategic activities" (Roe et al., 1995).

Apparently, interruptions have a negative impact on the emotional state, while the activation and subjective mental effort increases. On the other hand, well-being is not affected by the interruptions. In line with our expectations, more self-reported mental effort is invested when one is interrupted (more often). Lower positive emotion scores are found after being interrupted, but the frequency does, indeed, not affect the experienced emotions. Contrary to what we expected, with more complex interruptions, the positive emotion scores increased, while no significant effects were found on activation, self-reported mental effort and the HRV data. In the situation where only one interruption was introduced, subjects probably experienced the interruption as a welcome source of variety in their task performance. This confirms Jacobshagen's results (1990) that workers had more negative emotions when not interrupted. But our results do not confirm the idea that, with more and complex interruptions introduced at the beginning of the task, people will be getting more aroused (higher HR). We only observed that subjects are more aroused when they were interrupted once and only during the interruption, and the resumption episode. It seems that the fact of being interrupted is more arousing than being interrupted more often, by interruptions of different complexity, at particular moments.

In general, when interrupted, we see that subjects work more efficiently, with more (subjective) effort invested, maybe because more tasks have to be executed. But we see no further increase in the amount of subjective effort or HRV with more complex interruptions. So, it seems that the task load is not that important (maybe because of well-trained subjects). It is more likely that the state of the worker is affected when interrupted. Probably, subjects (are willingly to) invest more subjective effort because they are tired after three hours of work.

When the results on the performance process and the performance outcomes are combined, we see that the influence of the various moments of interruptions is rather small as we only find longer resumption episodes when interrupted at the beginning. Although this is in agreement with our survey data and with Mandler's (1964) and Van Dusen et al.'s (1992) results, we must conclude that the moment of interruption is not an important influencing factor in the interruption effects, as we also found that the frequency influences the resumption episode.

We can conclude that when one is interrupted more often, more time is needed for resuming the main task. Interruptions are also handled more serially and also more supportive operations are needed. This suggests that interruptions, as expected, affect performance negatively. It indicates that interruptions do indeed require controlled processing, e.g. for the preparation of the primary task such as reactivation and adaptation of plans, and for supervision processes (anticipation, status and progress control). The resumption is likely to be spent on action preparation, i.e. re-orientation to the main task and the tools, generating the motivation and effort needed for the unfinished task, and finding the place where to continue. Resources required for the unfinished task are activated, along with the inhibition of the resources employed in the interruption task (Cellier and Eyrolle, 1992). During the

change-over episode, we assume that workers are disengaging for one task (in this case the interruption task) and engaging in the other (in this case the primary) task (see also Figure 5.1).

On the other hand, interruptions also have a positive effect, as we see a mobilization of energy and a stimulation effect on the speed of performance, while the quality is unaffected and more subjective mental effort is invested, with increased frequency. Whereas Wiethof et al. (1995) found that performance effects were smaller with more supportive operations, we find disproportionally less supportive operations when performance is affected. All these results indicate that peoples' work behaviour becomes more efficient when they are interrupted more often. This result is in agreement with the results of the survey study where subjects stated that the more they are interrupted, the faster they execute the main task, and the shorter the interruption lasts. This stimulating effect can be explained by the level of processing. When interrupted more often, appropriate skills become more available (integrated in the activated plan). Processing then takes place on the rule-based or skill-based level, with more automatic processing, resulting in shorter execution times.

In line with earlier studies (Gillie and Broadbent, 1989; Van Dusen et al., 1992), we find that the performance declined somewhat (for instance longer change-over episodes) with more complex interruptions. It seems that complex tasks require more cognitive processing from which it apparently is more difficult to disengage. The result that complex interruptions can have positive repercussions as well is interesting, as we find higher positive emotions scores and less effort after complex interruptions. We suggested that subjects were a bit bored, and an interruption brings more variety in their work. A complex interruption may be perceived as challenging and may therefore lead to an increase of positive emotion scores and a reduction of subjective mental effort. The fact that the time spent on the main task is not affected while the working and interruption time increase, are in line with this suggestion. The results are also in agreement with research findings on the relation between interruptions and emotions. Fischer and Hadrail (1995) found that an interruption during the execution of a low attentional (simple) task, was welcomed more than an interruption during a high attentional (complex) task. When no interruption occurred, subjects had the highest boredom score.

The goal of this study was to understand how interruptions affect performance and how people deal with them. Interruptions cause a mismatch between planned achievements and what is achieved at the particular moment. To restore the match, an activation of computational-energetic processes is required. What we see in our results is that subjects do indeed try to compensate for a possible deterioration of the performance outcomes; for instance, they work harder as they try to make up for lost time, while the quality of the work is not affected. Zijlstra (1993) speaks of an 'effort-consuming' strategy, compared to a 'time consuming' strategy (more time to complete the task in order to reduced the level of effort): "both things, time and effort should preferably be envisaged as two dimensions of the concept of psychological costs" (p.96). Interruptions do have a negative impact on the state of

the worker as the emotions become somewhat less positive and more subjective mental effort is invested. More frequent, and more complex, interruptions call for more cognitive processing and mobilization of additional resources, all with the aim of maintaining the effectiveness of work behaviour. Similar to the result of the survey study, it seems that achieving these positive work outcomes have its subjective costs.

We do not know how, or even whether, people deal with these negative personal effects. Nor do we know whether the regulation processes were indeed activated to achieve efficient work behaviour, as suggested. We can also imagine that various regulation processes became activated to prevent even more negative personal effects, such as an increase of negative emotions. The small effects on emotions seem to agree with this idea. And, the fact that significant correlations are found between the amount of subjective mental effort and the negative emotion scores suggests that this might be the case. On the other hand, maybe the effects on emotions are small because, with well-trained subjects, the personal significance of the interruptions is rather small (interruptions are a part of the activated plans), resulting in weak emotional effects.

This study shows that being interrupted leads to changes in emotions, for example, positive emotions are experienced when the complexity of the interruption increases. We also found, in line with cognitive emotions theorists, that the frequency of the interruptions does not influence emotions. Overall, we can conclude that the results are encouraging enough to continue our research on how these interruption-related emotions influence performance in turn. This brings us to our second goal: How do these emotions affect performance? Are regulation processes activated in order to prevent further negative effects? Or are they activated to achieve the goal(s) of the organization at the expense of personal outcomes? And what is the role of positive and/or negative emotions? These questions will be investigated in our second experiment, discussed in the next chapter.

CHAPTER 6 *EXPERIMENT 2: Effects of interruption-related emotions on performance and personal state*

In this experiment, we investigate how the performance process, its outcomes, and the personal state are affected when interruption-related emotions are introduced during task execution. In greater detail, we introduce a neutral, a positive, and a negative emotional interruption during a computer task and examine how cognitive and psycho-physiological regulation processes are affected.

6.1 Introduction

Some researchers (e.g., Jacobshagen, 1990; Johansson and Aronsson, 1984; Kolish et al., 1991; Fischer and Hadrail, 1995 etc.) have found a relationship between specific work conditions, like the occurrence of interruptions, and emotions. The data of our survey study and our first experiment show that both positive and negative emotions can be experienced after being interrupted. In line with earlier research (e.g., Johansson and Aronssson, 1984; Henning et al, 1989), we find in our first experiment somewhat more negative emotions after being interrupted, compared to the non-interrupted condition. In this chapter, we focus on the theory that positive and negative emotions can follow interruptions, hence interruption-related emotions, and that these emotions can influence performance. So far, only a few researchers have acknowledged the fact that emotions can affect performance (e.g., Briner, 1995; Mandler, 1986; Pekrun and Frese, 1992).

In our second experiment, we will investigate how interruption-related emotions affect performance and which cognitive and psycho-physiological processes are involved in the regulation of these emotions. It has been suggested (Mandler, 1975; 1984) that negative emotions require more controlled processing than positive emotions because they indicate that the situation is not as expected and that more adaptations (internally/externally) towards the activated plan have to be made. According to this view, negative emotions take more space in the working memory, and interfere with other cognitive activities such as storage and retrieval of information. This requires extra capacity, resulting in more effects on performance and personal state than when positive emotions are experienced.

As in our first experiment (Chapter 5), we will look at the work domain of mental information work when investigating the effects of interruption-related emotions on performance and personal state. Our survey study showed that secretaries experienced interruptions both as positive and as negative. However, we have noted that the effects of experimentally induced interruptions on emotions are rather small perhaps because, with well-trained subjects, interruptions are a part of the activated plan. In this study, we asked students to participate. During some student-related clerical computer tasks they were interrupted.

We also had to decide on the type of interruption. In a pilot study (Jansen, 1994; Krediet, 1994), it was found that students did not always answer the telephone when it rang. They did not see the telephone call as a part of the experiment and therefore ignored its occurrence. Someone's appearance into the room is another type of interruption named by the subjects of our survey study. And, as we have found in our survey study that the formal characteristics of the telephone call and someone's entrance into the room do not differ that much, we decided, also for practical reasons, to use this type of interruption in our experiment.

How do we induce interruption-related emotions during mental information work? One of the frequently used methods of inducing emotions in experimental emotion research is that of showing movies (e.g., Gerrards-Hesse and Hesse, 1994; Gross and Levenson, 1995; Hettema et al. 1996). However, this method cannot be used in a work-related experiment. A more suitable method has been used by Baron (1988 and 1990), and Larsen and Ketelaar (1989). They induced emotions by means of (improper) positive or negative feedback during task execution. When negative information was given about past performance, more negative emotions were reported than when positive information was given.

To investigate the general ideas on how interruption-related emotions affect performance (formulated in Chapter 4), we add two physiological variables to the variables used in our first experiment on interrupted work behaviour. Physiological recordings are objective measures that can be taken continuously during work. They can easily be obtained at computer workplaces (Boucsein, 1993). The first variable is related to the perspiratory system. Research has found that the electrodermal system reacts after a new, unexpected, or significant situation, but also after an emotional, relevant event such as hearing one's own name (Frijda, 1988; Boucsein, 1993; Van Olst et al., 1980). There are two types of reaction: a phasic response and a tonic response. The phasic response of the electrodermal system (EDR) is a decrease in the electrical resistance of the skin - which means an increase in skin conductance. It starts between one and a half and four seconds after the beginning of a stimulus, is followed by a maximum, and then returns very quickly to its rest level. A tonic electrodermal response is also characterized by an increase in skin conductance. It arises spontaneously or after a change in personal state. Hence, it is called spontaneous or non-specific (Frijda, 1988). Researchers, who have studied the effects of computer breakdowns or rest breaks (e.g., Kuhman, Boucsein, Schaefer and Alexander, 1987; Kuhman 1989; Schaefer, 1990; Thum, 1995), have shown that particularly negative feelings were related with an increase in the number of non-specific electrodermal responses. A response to a specific stimulus (EDR) and a non-specific response (NS_EDR) can be distinguished by selecting a time frame following the stimulus onset (e.g., Boucsein, 1992). Boucsein (1992) suggested a time window of 5 seconds after a stimulus for a NS_EDR to occur. Others, for example Levinson and Edelberger (1985), suggested a more narrow window of 1-2.4 seconds.

The hormone system has been found to provide indicators of emotional arousal (e.g. Boucsein, 1993). One of the hormones is cortisol, which can be measured in blood

as well as in saliva (e.g., Hellhammer, Rottger, Lorenzen, 1986; Kirschbaum and Hellhammer, 1989; 1994). It is released when a person experiences a (relevant) change in his (work) environment. This can happen both during daily events and during stressful situations. Research has indicated that many factors influence the release of cortisol. For example, Frankenhaeuser and Johansson (1986) found an increase in cortisol only when subjects were not in control over the pace of unpredictable work. Hellhammer et al. (1986) and Hellhammer, Kirschbaum, and Belkien (1987) found that the cortisol level is higher when a stimulus/situation is unpredictable, uncertain or novel. Research has further indicated that an increase in cortisol is often associated with negative emotions. For example, Kirschbaum, Hellhammer, Strasburger, Tiling Kamp and Lüddecke (1989) found that the cortisol level in subjects who watched a negative emotional film was higher than in subjects who watched a neutral film. Researchers (Kugler and Kalveram, 1989) have recommended examining the levels of cortisol by comparing the baseline measurement, obtained 0-5 minutes before the stimulus, to the level 20-25 minutes after the stimulus. Baseline measures are needed because levels of cortisol vary during the day (Hellhammer et al., 1986; Hellhammer et al., 1987).

6.2 Method

The experiment took place in the same setting as the first experiment (see Chapter 5).

6.2.1 Subjects

A total of 30 Dutch students participated in the experiment. Their mean age was 23 years. They participated voluntarily and received a financial reward of *f* 10,-- per hour afterwards.

6.2.2 Procedure

Subjects, who were familiar with the WordPerfect 5.1 word processing program, subscribed for participation in the experiment. After they had been contacted, a date was set for the training session and for the experimental day[29].

During the training session, which lasted about 15 minutes, subjects got acquainted with one of the experimental tasks, i.e. scheduling train trips. A pilot study (Jansen, 1994; Krediet, 1994) had shown that not all subjects were familiar with this particular task. Subjects were also informed about the physiological measurements taken during the experiment. During the training session, a saliva sample was taken. Three other samples were taken at set times during the same day. Before those samples were taken, subjects were asked to clean their mouth with water in order to reduce the influence of (earlier) eating, drinking or smoking. On the experimental day, after a short introduction, saliva samples were taken before, in-between, and

[29] See Appendix D for the instructions.

after each session. Subjects were also asked to fill in some questionnaires before the experiment started. Electrodes for measuring heart rate and electrodermal activity were fixed and the measurement devices were tested. Then the subject was given the opportunity to ask for clarifications and the experiment started. After each session, subjects could relax for approximately 5 minutes. At the end of the experiment, subjects had to fill in some questionnaires about their current psychological state. They were debriefed and paid for their participation.

6.2.3 **Tasks**

Subjects had to perform nine different tasks, divided over three sessions of three tasks each (see Figure 6.1).

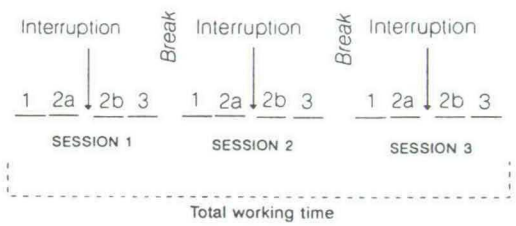

Figure 6.1 Schedule of the experiment

Each session started with a short introduction, followed by an explanation of the task. All tasks were related to the organization of a week with international students visiting the university. It comprised making a poster for the acquisition of participants, looking up telephone numbers and mail codes, completing a mailing list, making a week schedule, planning a train trip, inserting this information into a table, writing a short promotion text on the town, planning the ideal car route for picking up the participants at their accommodation, and inserting this information into a table. There was no time limit for the execution of each task. Within each session, during the execution of the second task, the experimenter entered the room. He asked the subject to stop his work and gave neutral, positive or negative feedback according to the scheme presented in the following paragraph[30]. After the interruption, the subject continued the task execution. In pilot studies, the resemblances in structure, difficulty and in execution time between both parts of the second task (before and after the interruption) were tested (Meuwissen and Sijbers, 1996). The order of both parts was counterbalanced. The other six tasks were all different from each other with the aim of preventing subjects from experiencing the situation as tedious (see the first experiment).

6.2.4 **Design**

Subjects worked half a day in the simulated office (see Chapter 5). The working hours were manipulated experimentally by assigning half of the sample to the

[30] See Appendix E for the list of interruptions.

morning condition and half to the afternoon condition. Each experiment comprised three sessions. During each session, an interruption(-related emotion) was induced. Subjects were randomly assigned to one of the three experimental conditions (see Table 6.1).

Table 6.1 Overview of experimental conditions

Condition	Session 1	Session 2	Session 3	n
Positive	neutral	positive	positive	10
Negative	neutral	negative	negative	10
Neutral	neutral	neutral	neutral	10

In all three conditions, a neutral interruption, which included information about the technical equipment of the experiment, was introduced as the first interruption. This was done in order to control for possible after-effects of the previous interruption that might influence the personal state. In the positive condition, the neutral interruption was followed by two positive interruptions; in the negative condition, the neutral interruption was followed by two negative interruptions; in the neutral condition, all three interruptions were neutral. The negative and positive interruptions included negative or positive information about the subjects' performance, respectively. The results before and after an interruption are tested in a (repeated) within-subjects design. The effects in the first session are compared to the second and third session in a (repeated) within-subject design and with the three experimental condition as 'a between factor' (mixed design). Within the same session, the influence of the three conditions is tested as 'a between factor'.

6.2.5 **Dependent variables**

Similar to our first experiment, the dependent variables can be categorized into three groups:

1• Variables that describe the performance process. These variables are based on a description of patterns of actions along the time line. A distinction is made between variables that describe how the interruption is handled and variables that describe the execution of the main task. These last variables are categorized as:

2• Performance outcome-related variables, i.e. quantitative aspects of the task performance.

3• Variables that describe the personal state during and after the execution of the (interrupted) task.

sub 1. Performance process variables

Similar to the first experiment, subjects' behaviour was entirely taped and analysed afterwards by two trained observers using an event recorder. After the experiment, the videotapes were watched and the beginning and end of different episodes was marked. A distinction was made between episodes of the main task and episodes of the interruption. The duration of the episodes in the three conditions was measured

and analysed in order to asses the influence of the interruption-related emotions.

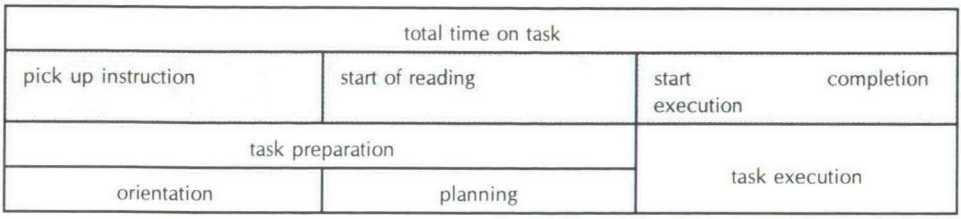

Figure 6.2 Dissection of the main task interval into activity episodes

Within each session, the main task was divided into the following episodes, illustrated in Figure 6.2. "The preparation time episode" of the task execution is divided into:
1• "The orientation episode", which starts the moment the subject picks up the instruction and ends as soon as the subject starts to read.
2• "The planning episode", which begins as soon as the subject starts to read and ends when he starts to work on the main task.

When the experimenter entered the experimental room, subjects were asked to stop their work and the feedback was given (i.e. interruption).

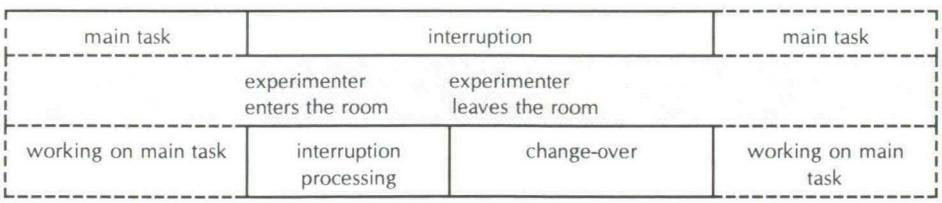

Figure 6.3 Dissection of the interruption interval into two episodes

The interruption interval is divided the following episodes (see Figure 6.3):
1• "Interruption processing episode". This episode is defined as the time between the entrance and departure of the experimenter. This episode is not further analysed as the duration depends on the period the experimenter is in the experimental room and is not influenced by the experimental condition.
2• "Change-over episode". This episode starts the moment the experimenter leaves the room, and ends the moment the main task is taken up again. During this episode, the person reorients to the main task.

Subjects' strategies determine the way they restart their main task. The strategies defined in Chapter 5, describe how subjects deal with the beginning of the interruptions. Because in this experiment, subjects were asked to stop working immediately when the experimenter entered the room, it was not possible to react to the interruption in different ways, like there was with the telephone call in our first experiment. We, therefore, looked at how subjects restarted the main task after

the interruptions had been introduced. The following three strategies were observed:
1• "Anticipatory processing of the main task": subjects start to reorient to their work before the experimenter leaves the room;
2• "Immediate processing of the main task": subjects start to reorient to their work within two seconds[31] after the experimenter leaves the room;
3• "Delayed processing of the main task": subjects take longer than two seconds to reorient to the task.

sub 2. Performance outcome variables
The quantitative performance outcomes were measured by watching the videotapes of all subjects and marking the distinct time periods of:
1• "The total time on task", which is defined as the time needed to execute the main task. This interval starts the moment the subject picks up the instruction and ends as soon as the papers are put aside (see Figure 6.2).
2• "The total session time", which is defined as the amount of time needed for executing all three tasks in one session (i.e. without interruption).

sub 3. Personal state variables
Data on subjects' psycho-physiological state were gathered before, during, and after each session. The measures of the personal outcomes were the same as in the first experiment. After each session, emotions were assessed by the PANAS Questionnaire (Watson, Clark and Tellegen, 1982). The amount of mental effort spent on the task was measured by the RSME (Zijlstra, 1993) and administered after each session. Before and after the experiment, subjects' well-being was measured by the well-being scale of the Well-being, Activity and Mood Questionnaire (Zinchenko et al., 1985).

Physiological processes were investigated by a number of physiological variables. We used the heart rate (HR) again as an indicator of general arousal. The recorded Inter-Beat-Intervals (IBIs) were transformed into heart rates (Graham, 1978). We calculated the mean heart rate during the last four minutes before the interruption as baseline, during four minutes following the interruptions and during the last four minutes of the task execution. An interval of four minutes was chosen because, after checking the video data, this interval was the minimum amount of time needed to execute the task. Heart rates during the interruption could not be computed because the interruption interval was too short to give reliable data (some interruption intervals lasted less than one minute). The difference scores between the baseline and the several intervals were compared and analysed in a (repeated) within-subject design and with the three conditions as 'a between factor' (mixed design). As in our first experiment, we also used heart rate variability (HRV) as a measure of change in mental effort. Again, the energy band width around 0.10 Hz (0.07 Hz-0.14 Hz) was used. We used the HRV baseline during the first four minutes of the first task (baseline) as well as during the four minutes before and following the interruption,

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[31] According to Van Waes (1991), an interval longer than 3 seconds can be interpreted as a rest break.

and during the last four minutes of the third task. Difference scores between the baseline and the three other intervals were computed and analysed in a (repeated) within-subject design and with the three experimental condition as 'a between factor' (mixed design).

Changes in cortisol level have been used as a second indicator of the experienced emotions (Boucsein, 1992; Kirschbaum & Hellhammer, 1989). Cortisol samples were gathered by means of saliva tubes: subjects had to chew a sterile absorbent cotton (Salvette, Sarstedt Inc.) during 45 seconds. The sample was centrifuged and the saliva was used for analyses of the cortisol level.[32] To control for possible technical mistakes, each cortisol sample was analysed twice (spit-half). The mean of both measurements was used for further analyses. Hellhammer et al., (1987) found a circadian rhythm during a day of mental and physical rest. In order to control for this rhythm, the samples on the training day serve as a control measurement. Analyses on the cortisol measures and on the difference score between the control measurements and the cortisol after the interruption were analysed in a (repeated) within-subjects design, with the experimental conditions as 'a between factor' (mixed design).

The number of non-specific electrodermal responses (NS_EDR) was used as an indicator for emotional arousal. Some additional equipment was required for recording the electrodermal activity. Electrodermal activity was measured using two Ag/AgCl electrodes on the inside of the right foot, using special paste, masking glue, and tape (Boucsein 1992, Figure 28; Thum, 1995, page 72). The number of non-specific electrodermal responses (NS_EDR) during specific intervals were detected by means of a program designed by the University of Wuppertal (Boucsein, 1992). The number of electrodermal responses was calculated during three time intervals: an interval four minutes before the interruption was introduced (the baseline); an interval that started 5 seconds[33] following the interruption and lasted four minutes; and an interval of the last four minutes of the task execution. Data were (visually) checked for clippings and spikes.[34] When the duration of those intervals was shorter than 2 minutes, data were excluded. In order to obtain comparable results over subjects, difference scores between those intervals were calculated. We subtracted the number of responses during the baseline (before the interruption) from the number of responses after the interruption and at the end of the task. These scores were analysed both in a (repeated) within-subject design and a mixed design.

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[32] We would like to thank the *Centraal Klinisch Chemisch en Hematologisch Laboratorium* of the St. Elisabeth Hospital in Tilburg for their support, in particular Dr. A.A.J. van Landeghem.

[33] An interval of 5 seconds was chosen because some researchers suggest that a response within 5 seconds after a stimulus should be considered as an EDR (Boucsein, 1992).

[34] During a clipping, the signal could not be measured as the signal is at its maximum for some time. A spike is another artifact in the signal. During a spike, we see a very short and sudden increase or decrease of the signal, instead of a relatively long latency (normally between 1 and 2 seconds), followed by a slow return to the mean level (see also Boucsein, 1992 p. 133 and 234).

6.3 Hypotheses

In Chapter 4, we formulated some general ideas on how interruption-related emotions can affect performance. We expect that (negative) interruption-related emotions affect performance and the personal state, as they signal for adaptation of the activated plan (cognitive processing). We also expect that interruption-related emotions will have a higher impact the first time they are introduced. Then, the situation is appraised as relevant for the worker, and activation, in terms of arousal, action tendency and autonomic responses, and actions can occur. The second time the interruption-related emotions are introduced, less adaptations are needed in the activated plan (no action tendency).

On the basis of these general ideas, the following specific hypotheses are conceived for the present experimental conditions.

1 ◇ Performance process

1a - When people are interrupted and when interruption-related emotions are involved, we expect that the task and interruption intervals and episodes will be longer than when no interruption-related emotions are involved.

1b - Due to cognitive processing, we expect a more delayed processing of the main task when interruption-related emotions are involved.

1c - When negative interruption-related emotions are involved, we will find longer task and interruption intervals and episodes and more delayed processing than when positive interruptions-related emotions are involved.

2 ◇ Performance outcomes

2a - When people are interrupted and when interruption-related emotions are involved, performance outcomes of the main task will be affected in such a way that more time will be needed for the task execution than when no interruption-related emotions are involved.

2b - We further expect that the time needed for executing the whole session will also be longer when interruption-related emotions are involved than when no interruption-related emotions are experienced.

2c - In the negative condition, we expect to find longer task and session intervals compared to the positive condition. In the positive condition the intervals will be somewhat longer than in the neutral condition.

3 ◇ Psycho-physiological state

3a - When people are interrupted, the emotional state will be negatively affected while the activation and mental effort increases. On the other hand, well-being will not be not affected (see Chapter 5).
When negative interruptions-related emotions are involved, we expect to find a reduced well-being, slightly more negative than positive emotions, higher activation and more effort than when positive interruption-related emotions are involved.

3b - We also expect to find more electrodermal responses and a higher cortisol level in the negative condition than in the positive conditions as subjects will be more emotionally aroused when negative emotions are evoked than when positive interruption-related emotions are evoked. In the neutral condition, no effects on the emotional arousal will be found.

3c - When people are interrupted, we will find that the HR, as an indicator of general arousal, will increase at the beginning, followed by a decrease at the end. When interruptions-related emotions are involved, after the increase in HR, we expect a smaller decrease in the negative condition than in the positive condition.

6.4 Results[35]

In the first session, where no experimental manipulation had been introduced, we expect to find no differences in the results of the three conditions. Indeed, no differences are found in the performance process, the performance outcomes, and in the psycho-physiological state variables.

Next, we checked whether the interruption-related emotions had been successfully induced. We compared the emotion scores in the first session with the emotion scores of the second session, where the emotions were introduced for the first time. We also investigated whether the emotion scores are different between the emotional condition (the mean score of the positive and negative conditions) and the non-emotional condition (neutral condition), and between the three conditions separately, in the second session.

Table 6.2 Mean scores, Standard deviations (between brackets), and analyses of variance of the experienced positive and negative emotions for each condition, after the first and the second session (PANAS)

Emotions	Positive emotions			Negative emotions		
Session / Condition	1	2	*p*	1	2	*p*
Overall	31.76(5.75)	29.17(6.90)	***	14.63(2.36)	15.07(3.11)	ns
Neutral	31.50(5.13)	27.00(6.25)	***	14.90(1.91)	14.30(2.75)	ns
Negative	31.40(7.56)	30.10(8.45)	ns	14.90(2.85)	16.20(3.05)	ns
Positive	32.40(4.72)	30.40(5.91)	ns	14.10(1.66)	14.70(3.47)	ns
	ns	ns		ns	ns	

ns: non-significant; ***: $p<.005$

[35] Again, because of clearity reasons, the related F- and df values of the non-significant effects are not mentioned. When needed, detailed information can be obtained by the writer.

In Table 6.2, we see that the positive emotion scores show a decrease from the first to the second session: $F(1,29) = 11.07$, $p < .005$. We find that the experimental conditions influence the positive emotion scores as we find a significant larger decrease in the non-emotional condition compared to the emotional condition: $F(1,28) = 14.82$, $p < .001$. When we look at the three conditions separately we see the largest decrease in positive emotion score in the neutral condition, compared to the negative and positive condition: $F(1,9) = 7.11$, $p < .005$. The positive and negative emotion scores, after the first or the second session, are not affected by the (three) different conditions.

For the physiological variables, we find that the cortisol levels does not significantly change from the first to the second session, with a small (non-significant) increase in the negative condition ($p = .2$). In the second session, between the non-emotional and the emotional condition or between the three conditions separately, no significant differences are found.

The number of electrodermal responses decrease from the first to the second session: $F(5,21) = 4.64$, $p < .005$. Being interrupted does not influence the number of electrodermal responses as we find no significant effect between the difference scores of the number of electrodermal responses after and before the interruptions, or between the end of the task and before the interruption is introduced, both in the first and in the second session. As expected, in the first session the emotions do not influence the number of responses as we find no effects in the difference scores. In the second session, we find no difference between the non-emotional and the emotional conditions. But we do find a higher increase in responses at the end of the session, compared to the number of responses before the interruption was introduced after a positive interruption-related emotion is introduced than when a negative interruption-related emotion is introduced: $F(2,25) = 3.37$, $p = .05$.

Overall, we find only a few significant effects. This maybe caused by the small number of subjects in each condition. But, we must not forget that the small effects are in line with our expectations, as emotions in work are considered to be relatively weak (see Chapter 4). The results on the PANAS questionnaire, in particular the positive emotion scores, the cortisol levels and the number of electrodermal responses, indicate that the experimental, emotional condition influence emotions, compared to the non-emotional condition. We can conclude that, indeed, interruption-related emotions have been successfully manipulated. And, although the effects are rather small, it seems that negative interruption-related emotions are somewhat more emotionally arousing than positive emotions. We can further conclude that the combination of both subjective and physiological has been an useful method for measuring interruption-related emotions effects.

We subsequently describe the effects of the interruption-related emotions on the performance process, on the work outcomes, and on the psycho-physiological state.

6.4.1 **Descriptive analyses of the performance process**

1. *Main task*

Table 6.3 Means, Standard deviations (between brackets), and analyses of variance of the time spent (in seconds) on the orientation and planning of the task before and after the interruption

Session	1			2			3		
Moment	before	after	*p*	before	after	*p*	before	after	*p*
Orientation	38.3(3.0)	17.3(4.1)	****	5.2(5.4)	22.1(9.9)	****	2.7(1.6)	16.2(8.7)	****
Planning	56.4(17.4)	18.3(8.5)	****	77.7(28.4)	23.7(13.5)	****	185.2(52.7)	89.3(34.9)	****

****: $p < .001$

In Table 6.3 we see that the orientation time is significantly longer after the interruption than before the interruption was introduced, in the first: $F(1,29) = 284.41$, $p < .001$, the second session: $F(1,29) = 78.36$, $p < .001$, and in the third session: $F(1,29) = 64.12$, $p < .001$ (the tasks are only comparable within the same session). The results are similar to the results of our first experiment, where it was found that after being interrupted, the time for (re)orientation increased.

Is the orientation episode affected by the interruption-related emotions? Both in the second and third session, we find no differences between the non-emotional and the emotional condition, nor between the three experimental conditions separately. So, it seems that, after being interrupted, somewhat more cognitive processing is needed while the interruption-related emotions do not required some additional cognitive processing.

In Table 6.3, also the means and standard deviations of the time needed for the planning episodes are presented. From this table, it can be concluded that subjects need significantly less time for planning after they have been interrupted than before, both in the first: $F(1,29) = 130.40$, $p < .001$, the second: $F(1,29) = 91.35$, $p < .001$, and the third session: $F(1,29) = 98.95$, $p < .001$. Interestingly, in the second session significantly more time is needed for planning in the emotional condition ($M = 27.8$; $SD = 12.97$) than in the non-emotional conditions ($M = 15.4$; $SD = 10.84$): $F(1,28) = 6.71$, $p < .01$. In greater detail, subjects need extra planning time after the positive interruption than after the neutral interruption: $F(2,27) = 3.52$, $p < .05$. So, with the tasks before and after the interruption being the same, less time is needed for reading the instruction of the task and for (re)activating the existing plan. And, when (positive) interruption-related emotions are involved, some additional cognitive processing is required as the existing plans need some adjustments.

2. *Interruption interval*

In the third session, subjects need more time ($M = 90.9$; $SD = 35.2$) for the reorienting

to the main task than in the second ($M = 28.3$; $SD = 15.1$) or in the first session ($M = 18.4$; $SD = 18.6$): $F(2,28) = 67.25$, $p < .001$, with no difference between the three conditions. This result is similar to the results of our first experiment were also longer change-over episode were found towards the end of the experiment. Interestingly are the results in the second session, where we find a significantly longer change-over episode after the positive ($M = 36.0$; $SD = 10.3$) and the negative interruption ($M = 32.5$; $SD = 12.2$), compared with the neutral interruption ($M = 16.3$; $SD = 10.3$): $F(2,27) = 6.71$, $p < .005$. The second time the interruption is presented, i.e. in the third session, this effect is non-significant. So, the data suggest that interruption-related emotions require extra cognitive processing, compared to the non-emotional conditions, and when they are introduced for the first time.

3. *Strategies used*

The change-over episode can be investigated in greater detail by looking at the various strategies used for restarting the main task.[36]

Table 6.4 Number of people that use a particular strategy after a neutral, negative or positive interruption

Session	1			2			3			
Strategy / Condition	Im	De	An	Im	De	An	Im	De	An	N
Neutral	2	2	6	3	2	5	0	0	10	10
Negative	0	0	10	1	9	0	2	6	2	10
Positive	0	0	10	1	3	6	2	0	8	10
Total	2	2	26	5	14	11	4	6	20	30

Im: Immediate processing of the main task; De: Delayed processing of the main task; An: Anticipatory processing of the main task.

In Table 6.4, we see that the kind of strategies change during the experiment. After the first interruption, subjects restart their work often before the experimenter has left the room. This strategy is still frequently used in the second and third session. In the second session, subjects in the emotional conditions use a more delayed strategy, compared to the non-emotional condition. In greater detail, a more delayed strategy is used when negative interruption-related emotions are involved. In the third session, the immediate processing of the main task is often used. Also here, we see that a delayed strategy is used after a negative interruption. These results are in agreement with the longer change-over times found. It suggests that negative interruption-related emotions require (more) cognitive processing than positive or neutral interruption-related emotions do.

[36] The differences in strategies used could not be analysed because less than 10% of the cells had an expected frequency of 5 (Huizingh, 1989).

In summary, data on the performance process show that interruptions require cognitive processing as longer orientation time and change-over time are needed. On the other hand, less planning is then needed. Interruption-related emotions affect the duration of the planning and change-over episodes, especially when they are involved for the first time. It seems that negative interruption-related emotions requires somewhat more cognitive processing as we find longer change-over episodes and probably more delayed processing of the main task. The planning time is not affected by the differences in the interruption-related emotions.

6.4.2 **Effects on the performance outcomes**

1. *The quantitative aspects of the task performance*
The effects of the interruption-related emotions on the quantitative work outcomes were investigated by looking at the total time on the task and the total session time.

Similar to our first experiment, the time spent on the main task shows a decrease in the first session (before: $M = 587.8$, $SD = 135.5$; after: $M = 522.4$, $SD = 124.9$): $F(1,29) = 11.98$, $p < .005$. This effect can probably be explained by the fact that interruptions have a mobilizing effect. Also, in the second interruption the time spent on the task decreases (before: $M = 755.3$, $SD = 186.9$; after: $M = 637.4$, $SD = 152.4$): $F(1,29) = 16.74$, $p < .001$, as well as in the third session (before: $M = 697.0$, $SD = 206.9$; after: $M = 502.6$, $SD = 133.2$): $F(1,29) = 51.66$, $p < .001$. But in the second session, we see that the decrease in time is smaller in the emotional conditions than in the non-emotional condition: $F(1,28) = 6.78$, $p < = .01$. In greater detail, we find a significantly smaller decrease in execution time after a negative interruption (before: $M = 692.0$, $SD = 154.5$; after: $M = 638.7$, $SD = 185.4$): $F(2,27) = 3.42$, $p < .05$, compared with a neutral interruption (before: $M = 808.6$, $SD = 114.6$; after: $M = 593.9$, $SD = 106.7$). In the third session, no effects of the interruption-related emotions are found.

We expect to find longer session times when interruption-related emotions are involved. But such effects are not found. The finding that the session time is unaffected by the interruption-related emotions, while the main task and interruption episodes show an increase when interruption-related emotions are involved, especially in the negative condition, indicate that subjects make up for possible negative performance effects by the end of the task execution.

6.4.3 **Effects on the psycho-physiological state**

1. *Well-being*
As shown in Table 6.5, a significant decrease is found in subjects' well-being during the experiment: $F(1,29) = 24.74$, $p < .001$. The decrease is larger in the non-emotional (before: $M = 12.12$, $SD = 1.21$; after: $M = 9.78$, $SD = 2.2$) condition than in the emotional conditions (before: $M = 12.40$, $SD = 1.31$; after: $M = 11.78$, $SD = 1.9$): $F(1,28) = 30.83$, $p < .001$, with no difference between the positive and negative conditions. Furthermore, we find that a decrease in well-being is associated with a

lower positive emotion score: $r = .67$, $p < .001$. When we compare these results with the results of our first experiment, where well-being was not affected, the data indicate that subject's well-being seems to be reduced when interruption-related emotions are involved.

Table 6.5 Mean, Standard deviations (between brackets), and analyses of variance of subjects' well-being, subjective effort, positive and negative emotion scores (PANAS) before/after the experiment or during the sessions

Moment/session State	Before/1	2	After/3	p
Well-being	12.30(1.26)		10.77(2.08)	****
Subjective effort	44.8(18.6)	56.9(21.7)	62.8(21.7)	****
Positive emotions	31.7(5.8)	29.2(6.9)	29.9(7.3)	**
Negative emotions	14.6(2.4)	15.1(3.1)	13.7(1.4)	**

ns: non-significant; ****: $p < .001$

2. *Experienced emotions*

As can be concluded from Table 6.5, both the positive emotion score: $F(2,28) = 6.08$, $p < .01$, and the negative emotion score: $F(2,28) = 6.29$ $p < .01$ show a decrease towards the end of the experiment, with no differences between the non-emotional and the emotional conditions, or between the three conditions separately. Between the second and third session[37], we find no effects in the positive emotion scores. But, the negative emotion scores decrease significantly between the second and the third session: $F(1,29) = 6.12$ $p < .01$, with no differences between the various conditions. For example, subjects become less afraid, less jittery and less nervous. Within the same session, no effects are found between the non-emotional and the emotional conditions, or between the three conditions separately.

When we include the results of section 6.4, we see that the results are similar to the results of our first experiment. Again, we can conclude that it is the introduction of the interruption as such that causes a decrease in the positive emotion scores. Furthermore, we see that interruption-related emotions do affect the emotions scores but mainly when (positive) interruption-related emotions are introduced for the first time.

3. *Mental effort*

Also illustrated in Table 6.5 is the invested subjective mental effort. The RMSE is both sensitive to changes in task load and in the state of the worker. We see, similar to our first experiment that, during the experiment, the subjective mental effort increases: $F(2,28) = 17.80$, $p < .001$. We find no differences between the three conditions. Also no differences are found when we compare the subjective mental effort in the non-emotional condition with the emotional conditions. Although not

[37] The results of the emotions scores between the first and the second session are discussed in Chapter 6.4.

significantly, in the third session, we see that less subjective effort is invested in the positive condition: $F(2,27) = 2.72$, $p = .1$. So, subjects do not require more effort because they perform well (according to the experimenter). Subjects need to make fewer changes in the activated plan to achieve the set goal as the positive interruption contained positive information about their achievements, resulting in lower subjective mental effort needed to be invested. So, it seems that more effort is invested because of the state of the worker, rather than because of an increase in the information processing: subjects are getting tired at the end of the experiment. Again, it is interesting to see whether the same results occur when the physiological measures of mental effort (HRV) are investigated.

In summary, the psychological data suggest that subjects' psychological state decreases towards the end of the experiment. It seems that subjects' emotions level off (lower positive and negative emotion scores) while well-being decreases and more subjective effort is needed. Interruption-related emotions influence the psychological state negatively as we find lower positive emotion scores (when the emotions are introduced for the first time), lower well-being than when no interruption-related emotions are involved.

4. *Heart rate*
In Figure 6.4, we see the HR during the experiment. As expected, we see a higher HR at the beginning of the experiment, followed by a decrease, due to habituation (repeated analyses): $F(5,25) = 26{,}80$, $p < .001$. When we compare the HR in the neutral condition with the positive and the negative conditions, both in the second and in the third session, we find that the HR is not affected by the interruption-related emotions.

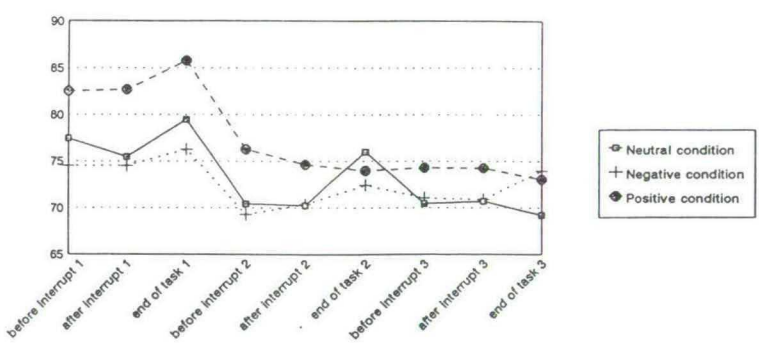

Figure 6.4 Heart rate during various episodes, in the three experimental conditions

When we compare the heart rate at the end of the experiment with the heart rate at the beginning of the experiment (difference scores), we see a significantly larger decrease in the positive condition than in the negative condition: $F(2,27) = 4.36$,

$p < .05$ (mixed design). Furthermore, repeated analyses show no significant effects in the difference scores between the baseline of each interruption and the mean heart rate during the several defined episodes in the same (i.e. the second or third) session.

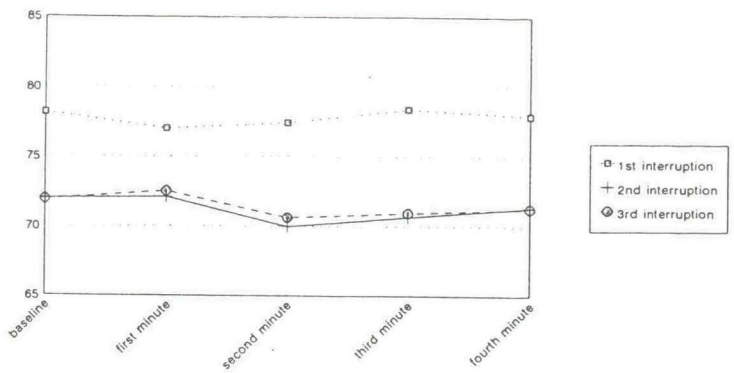

Figure 6.5 Heart rate during the first four minutes following an interruption

Looking in greater detail at what happens with the heart rate during the first four minutes of all three interruptions (repeated analyses with session as a 'between factor'), we see in Figure 6.5 that especially the first session is arousing as the heart rate is higher than the interruption in the second and the third session: $F(11,19) = 16,21$, $p < .001$. This result is in line with the results of our first experiment and with the hypothesis that HR increases at the beginning of a situation. It is probably a general result of an interruption: the interruption is not expected and the situation is new, indicated by a higher arousal level. When people have been interrupted before, the situation is not new any more; they have incorporated the interruption into the activated plan, resulting in a lower arousal level.

Furthermore, in the second session we find a significant decrease during the first two minutes of the positive interruption: $F(2,27) = 4.98$, $p < .01$, compared with the negative and neutral condition. This is also in line with our expectations and suggests that (the beginning of) a negative interruption is more arousing than a positive interruption. In the third session, no effects are found as subjects, in all three conditions, are habituated to the experiment.

5. Heart rate variability

Looking at the HRV in the second session (Figure 6.6a), we see that the HRV increases: $F(3,25) = 7.69$, $p = .001$, and no differences between the three conditions. We subtracted the HRV during the four minutes at the beginning of the second session from the HRV before and after each interruption and during the four minutes at the end of the session. Also, no differences are found between the three

conditions.

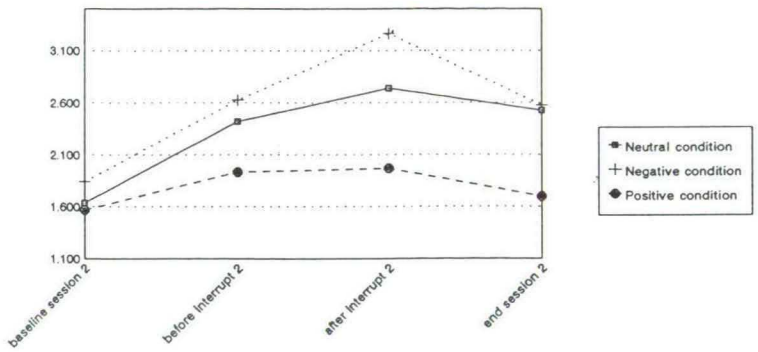

Figure 6.6a Heart rate variability during the second experimental session

In the third session, illustrated in Figure 6.6b, the HRV is more or less similar to the HRV at the beginning of the experiment. During this session, we find no significant effects between the conditions. We also substracted the baseline of the third session from the HRV before and after each interruption and during the four minutes at the end of the session. Again, no differences are found between the three conditions.

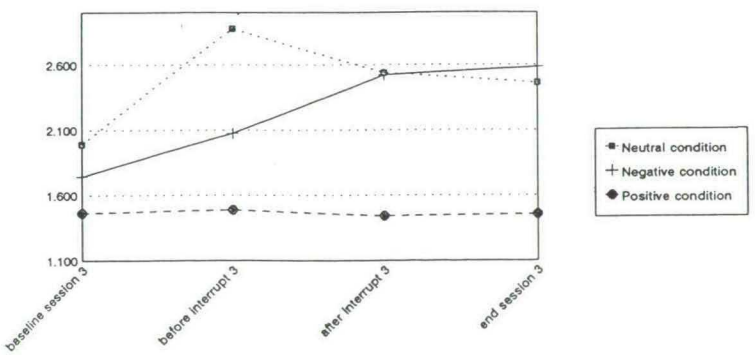

Figure 6.6b Heart rate variability during the third experimental session

Looking at the influence of the interruption-related emotions, we find no significant differences between the three conditions. The results contradict our expectation that more effort is invested when a negative interruption is introduced, compared to a positive interruption. Maybe, instead of increasing the effort for making up for bad performance, subjects are not motivated to invest more effort. Or, they have habituated to the experimental condition.

6. *Cortisol*

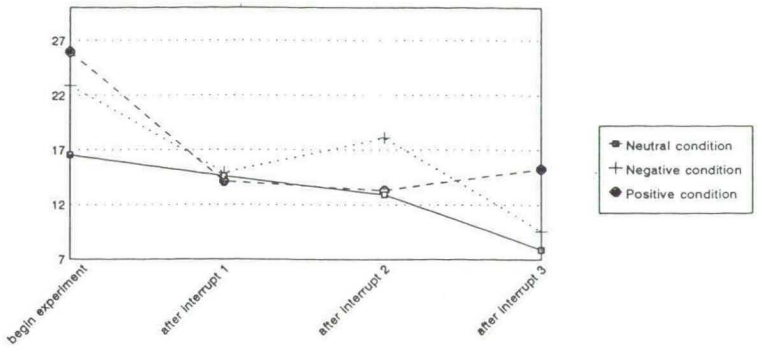

Figure 6.7 Cortisol level in the three experimental conditions (nmol/l)

As illustrated in Figure 6.7, the cortisol level shows a significant decrease: $F(3,24) = 4.33$ $p < .01$. Although we find no significant effects, we do see that the largest decrease in cortisol levels in the negative condition: $F(3,5) = 4.19$ $p < .1$.

Although we find no significant effects between the three conditions, we do see a different pattern for the subjects in the positive condition compared with the neutral or negative conditions. After the second interruption, the cortisol level in the negative and neutral conditions shows an increase. After the third interruption, the increase is followed by a decrease. Subjects in the positive condition, on the other hand, show a small (non-significant) decrease, followed by an increase at the end.

The measurements taken during the training session were used as the control measures needed for the calculations of the difference scores. Although expected (see section 6.3.5; Hellhammer et al., 1987; Kirschbaum et al., 1989), we did not find a circadian rhythm in the cortisol samples taken during and after the training sessions (Meuwissen and Sijbers, 1996). And, since also no information was available on the mental and physical activities, or the use of nicotine (see Kirschbaum and Hellhammer, 1989) before the training session started, we decided not to use the samples of the training session as control measures.

Instead, we used the data from Kirschbaum and Hellhammer's (1989) experiment to control for the circadian rhythm. In their research, the cortisol levels of a large group ($N = 720$) were measured at specific times during a day without mental or physical activity. We compared the moments of our measurements to the moments of measurements of Kirschbaum and Hellhammer. Furthermore, we used the first measurement as a control measure. Since no experimental manipulation had taken place yet, the experimental situation was the same for all subjects. This control measurement was set at 100%. The difference scores were calculated by subtracting the control measure from the cortisol levels after the interruptions. We calculated

both the expected theoretical changes, based on Kirschbaum and Hellhemmer, and the experimental changes found in our experiment (Meuwissen and Sijbers, 1996).

Table 6.6 Theoretical and expected changes in cortisol level (nmol/l), measured after each interruption, in the three experimental conditions

Condition	A: Expected changes (in %)	B: Experimental changes (in %)	C = (B-A): Difference (in %)
Neutral . 2nd interrupt	-15.77	- 5.38	+10.39
. 3rd interrupt	-28.70	-43.27	-14.57
Negative. 2nd interrupt	-14.58	-14.00	+28.58
. 3rd interrupt	-27.16	-17.10	+10.06
Positive . 2nd interrupt	-15.27	-10.61	+ 4.66
. 3rd interrupt	-26.68	- 2.22	+24.46

In Table 6.6, we present the cortisol levels (in %) of both the expected changes (column A) and the experimental changes found (column B). The differences between these two changes (column B-column A) are also presented (column C). In line with the results of Kirschbaum and Hellhammer et al. (column A), we see that the experimental levels (column B) decrease, compare to the baseline (with the exception of the first negative interruption). When we compare the experimental changes found with the expected changes (third column), however, we find no significant effects. But, we do see that (except for the third measurement in the neutral condition) the decrease found is smaller than expected. This indicates that the interruption-related emotions do indeed affect the release of cortisol but that the effects are rather small. In particular, we see that both kinds of interruption-related emotions show opposite results: in the negative and neutral condition, an increase in the second session is followed by a decrease in the third session. In the positive condition, a decrease in the second session is followed by an increase in the third session.

7. Electrodermal response

We present the NS_EDR in Figure 6.8 and see that the NS_EDR decreases during the experiment: $F(3,21) = 96.65$ $p < .001$. In greater detail, this decrease is only significant in the neutral condition: $F(2,6) = 25.06$ $p < .05$. This suggests that subjects in the emotional conditions are somewhat more emotional aroused than subjects in the neutral condition. We do not find any significant differences in the various intervals between the different conditions.

We also looked at the difference scores of the NS_EDR between the baseline and the three time intervals of each session. In the second session, we have already seen that the positive interruptions are more emotionally arousing than the negative interruptions. In the third session, this effect is not found. This result is in line with what we expected: the second time the emotions are induced, no effects are found

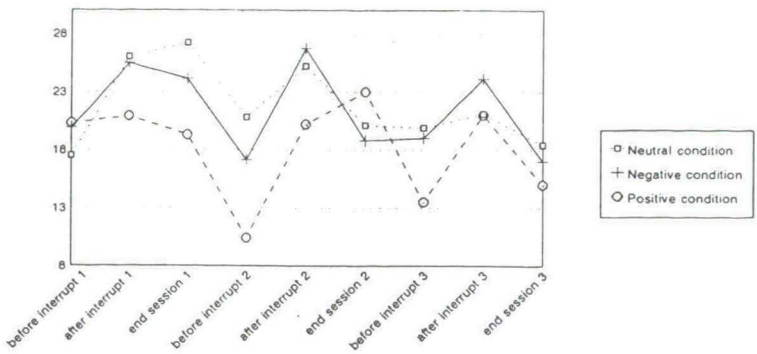

Figure 6.8 Number of electrodermal responses during the three experimental conditions

In summary, the physiological data show us that interruption-related emotions affect the physiological state of the worker. When negative interruption-related emotions are introduced for the first time, the heart rates increases. Contrary to our hypothesis, we find that positive interruption-related emotions are more emotionally arousing than negative interruption-related emotions, indicated by the number of electrodermal responses and a (non-significant) change in the release of cortisol.

6.5 **Experimental comparisons of performance and personal state effects**

This section concentrates on the differences in effects on performance of interruption-related emotions. We look at the results in the second and the third session and compare the results of the non-emotional condition with the emotional condition. And, when differences are found between the interruption-related emotions, these results are given as well. We do not include the results of the first session because, during this session, no manipulation had been introduced, and because no significant differences were found between the three conditions.

In Table 6.7, we see longer orientation and change-over times, and shorter planning and task execution times after the interruptions in the second session. Interruption-related emotions seem to affect these changes. We also see that interruption-related emotions influence the performance process and the performance outcomes: we find longer change-over and relatively longer execution times, and a delayed processing of the main task. When positive interruption-related emotions are introduced, a longer planning episode is needed, compared with the condition that involved negative emotions. In Table 6.4, we have already seen that here a more anticipatory strategy is used here.

Table 6.7 Overview of results on performance in the second and third session

Session	Second session			Third session/Overall		
Conditions / Performance Variables	Overall	Emotional vs Non-emotional	Difference	Overall	Emotional vs Non-emotional	Difference
Orientation	↑*	x	x	↑*	x	x
Planning	↓*	>*	pos > neg	↓*	x	x
Change-over	↑*	>*	x	x	x	x
Strategy	De	De	neg:De	An		Neg:De
TOT	↓*	>*	neg < neutral	↓*	x	x
TST	x	x	x	x	x	x

TOT: the total time spent on the task execution; TST: the time needed to execute the whole session; An: Anticipatory processing of the main task; De: delayed processing of the main task; Im: immediate processing of the main task; ↑: an increase in the scores is found; ↓: a decrease in the scores is found; <: the scores in the first condition is lower than the score in the second condition; >: the score in the first condition is higher than the score in the second condition; *: a significant effect is found; x no effect is found or no analyses are executed; pos: positive condition; neg: negative condition; neutral: neutral condition.

Similar to the second session, in the third session, significantly longer orientation times, shorter planning and task execution times are found. The change-over time is no longer affected by the interruption. Here, an anticipatory strategy of processing the main task is found. In the third session, the effects of the interruption-related emotions are smaller than in the second session as we find no significant differences between the emotional and the non-emotional conditions.

When we look at the effects on the personal state presented in Table 6.8, we see that subjects become somewhat more aroused after being interrupted, and also when negative interruption-related emotions are involved. Positive interruption-related emotions are somewhat more emotionally arousing than negative emotions, indicated by the NS_EDR. At the end of the experiment (third session), we see that subjects' well-being and the emotions scores show a decrease, while the invested subjective effort increases. The influence of the interruption-related-emotions on the emotional arousal has decreased, as shown both by the cortisol levels and the NS_EDR.

Table 6.8 Overview of results on the personal state in the second and third session

Session	Second session			Third session/Overall		
Condition Personal State	Overall	Emotional vs Non-emotional	Difference	Overall	Emotional vs Non-emotional	Difference
Well-being	x	x	x	↓*[39]	x	x
Positive emotions	↓*[38]	>	pos > neg	↓*	x	x
Negative emotions	x	x	x	↓*	x	x
Subjective effort	x	x	x	↑*	x	neg
HR[40]		x	neg > pos	x	x	x
HRV[41]	↑*	x	x	x	x	x
Cortisol[42]	x	x	x	↓*	x	x(neg)
NS_EDR[43]	x	x	pos > neg[44]	↓*	>	x

HR: Heart rate; HRV: Heart rate variability; NS_EDR: number of non-specific electrodermal responses; ↑: an increase in the scores is found; ↓: a decrease in the scores is found; <: the score in the first condition is lower than the score in the second condition; >: the score in the first condition is higher than the score in the second condition; *: a significant effect is found; x: no effect is found or no analyses are executed.

Overall, we see that the task execution went faster, with shorter planning times and more anticipatory processing of the main task, after subjects were interrupted. When we look at the various experimental conditions, we see that, especially, negative interruption-related emotions, that are introduced for the first time, affect performance. They require more cognitive processing as the change-over episode, the execution and the session times are relatively longer. The personal state changes during the experiment: the emotions level off, and well-being reduces. Negative interrupted-related-emotions seem to have a larger affect than positive interruption-related emotions. Subjective invested effort is not affected by the interruption-related emotions. We only found that more subjective effort is invested towards the end of the experiment. This indicates that the subjects become somewhat tired after three hours of interrupted work.

From this overview, we can conclude that the performance process and performance outcome are mainly affected by the interruption-related emotions when they are introduced for the first time. The effects on the personal state are mainly found at the end of the experiment. So, similar to our first experiment, we can conclude that the positive effects on the work outcomes, at the end of the experiment, are achieved

[38] See Table 6.3.

[39] For the positive and negative emotions, well-being, mental effort, heart rate, heart rate variability, cortisol level and the number of electrodermal responses, the overall results during the experiment are presented here.

[40] See Figure 6.5: HR during the first four minutes.

[41] See Figure 6.6: HRV during the second and third session.

[42] See Figure 6.7: Cortisol levels during the experiment.

[43] See Figure 6.8: NS_EDR during the three conditions.

[44] See section 6.4.

at the expense of a decrease in the personal state.

6.6 Discussion and Conclusions

In the first session, where the experimental situation is similar for all subjects, no differences on performance and personal state are found. As it also seems that the interruption-related emotions affect work performance and its outcomes, we may conclude that the manipulation of the interruption-related emotions has been more or less successful. Next, we will discuss the results in relation to our hypotheses.

According to our first hypothesis, the performance process is affected by interruption-related emotions. Indeed, we see that interruption-related emotions affect the subsequent task performance by causing (relatively) longer planning and change-over times than when neutral interruptions were introduced. On the other hand, we find no influence of the emotions on the orientation time. Furthermore, we find a change in strategy towards more delayed restarting of the main task when negative interruption-related emotions are involved. Overall, some additional cognitive processing seems to be required when negative interruption-related emotions are involved.

Our second hypothesis, which stated that interruption-related emotions affect the performance outcomes, is only partly confirmed. In line with our expectation, however, we find that the decrease in time spend on the main task time is smaller when negative interruption-related emotions are involved, but only when introduced for the first time. Contrary to our expectation, the total session time is not affected by the experimental conditions.

The first part of our third hypothesis, about the influence of being interrupted on the personal state, is confirmed. We find that when people are interrupted, the emotional state is negatively affected as the positive emotion scores decrease. Furthermore, also the activation and the invested subjective effort shows an increase. And, with no differences between the conditions, we suggest that the RSME scores reflect the changes in state and not in differences in information processing. Data concerning the influence of the interruption-related emotions show that the personal state is mainly affected when the interruption-related emotions are introduced for the first time. As hypothesised, subjects are somewhat more aroused in the negative condition than subjects in the neutral or positive condition, but no difference is found in well-being, both indicators of effort, or in the negative emotions score. In line with our expectations, the general arousal level is higher at the beginning of the experiment and after the first emotional interruption, followed by a decrease at the end of the experiment. We also find that interruption-related emotions are indeed emotionally arousing. But the hypothesis, that negative emotions are more arousing than positive emotions, is not confirmed. The results even indicate that positive emotions are somewhat more arousing than negative emotions when introduced for the first time.

Looking at the interruption effects on performance (hypothesis 1 and 2), we see that the results are similar to what we found in our first experiment. Interruptions seem to have a stimulating effect, in the sense that people are activated to work faster. We note a decrease in the planning and the main task execution time. The results show that people compensate for a possible loss of time, as we find no effects on the total session time while various main task and interruption episodes increase. Similar to the results of our first experiment, we may conclude that this requires the activation of psycho-physiological processes because we find negative effects on emotions, well-being, subjective mental effort, and general arousal level (the 'effort consuming strategy'). On the other hand, longer orientation and change-over times indicate that interruptions affect performance negatively. This means - again - that interruptions require cognitive processing, e.g., for reorientation to the main task, such as reactivation and adaptations of plans, and for the supervision processes (anticipation, status and progress control). The results also indicate that different episodes of the task preparation have different functions. The orientation episode increases when a new situation or task is introduced, because a plan has to be activated. Planning episodes may decrease after the interruption because only minor adaptations are needed as the plan is already activated.

As the goal of this study was to gain insight into the effect of positive and negative interruption-related emotions on performance, and the way people deal with them, we will look at the results in greater detail. Compared with the situation in which no (interruption-related) emotions are introduced, we see (relatively) longer planning, change-over, and execution times when interruption-related emotions are involved. We can therefore conclude that interruption-related emotions require some additional cognitive processing. Furthermore, it seems that especially negative emotions require cognitive processing, as we find a later restart of the main task than when positive emotions are involved. This concurs with Mandler's (1975; 1984) idea that, when negative emotions are involved, more cognitive processing is required because adaptations of the activated plan are needed. Subjects in the positive condition often restart the main task before the experimenter has left the room: the anticipatory strategy. This indicate that fewer changes have to be made, resulting in a more immediate reaction. The fact that subjects' well-being, emotions, and arousal level are lower, compared to the neutral condition, confirms this idea. As expected, the effects are mainly found in the second session, when the interruption-related emotions are evoked for the first time. The fact that the influence of the interruption-related emotions has disappeared by the end of the experiment, concurs with findings of cognitive emotion theories (e.g., Mandler, 1975; Manstead and Wagner, 1981; Frijda, 1988). These results suggest that the unexpectedness and relevance of the interruption in the third session have lost their arousing influence (no action tendency).

The results confirm our conclusion drawn from the first experiment, that compensating for negative performance effects is achieved at the expense of a changes in the personal state. This effect is mainly found in the emotional conditions because here information about subjects' performance was given. The

results indicate that achieving positive work outcomes has a higher priority than having a positive personal state. In terms of Lazarus (1993), subjects use a problem-focused, rather than and emotional- way of coping, with interruption-related emotions. The suggestion in Chapter 5, that regulation processes are perhaps activated in order to prevent further negative personal effects, is not confirmed. If this suggestion was correct, larger performance effects would have been found with smaller effects on the personal state.

The fact that dealing with emotions was not a goal in itself, but that dealing with the negative effects on performance was, is in agreement with the design of our study. As mainly weak emotions are involved in work, the effects on both performance and personal state are rather weak, as expected. In a situation where stronger (e.g., in terms of relevancy, arousal, physiological reactions, etc.) emotions are investigated, the effects might have been differently. But the problem lies in the activation of these emotions in an experimental setting. And, we must not forget that those strong emotions are not common in a normal work situation. But despite these problems, we can conclude that this experiment has been worthwhile. Besides, as this experiment gives some confirmations of some of the important results of our first experiment, we have found some interesting supplements as well.

Furthermore, we suspect that there is a maximum level involved in dealing with experienced emotions. A relation between emotions and performance has often been suggested (cf. Yerkes Dowson law): an increase in emotions leads to an increase in performance, up to a certain point (Frijda, 1988). When the increase in emotions becomes too great (for instance with a strong emotion like anger), this can lead to a decrease in performance. So, it is conceivable that the interruption loses its stimulating effect when the influence of interruption-related emotions become too strong. This can lead to more after-effects, and may even lead to disorganisation. It is also conceivable that regulation processes may not compensate for the negative effects. As a result, stress and stress-related diseases can occur (e.g., Johansson and Aronsson, 1984; Kanfer and Stevenson, 1985).

Finally, we have to make some remarks concerning the physiological variables used in our experiment. The data on emotional arousal, i.e., the cortisol level and the NS_EDR are not completely in agreement with each other. This might be caused by the unreliable cortisol measurements. Between both cortisol (split-half) measurements of each sample, 36% of the cases showed a deviation of more than 25%, whereas a deviation of 5% was expected (Meuwissen and Sijbers, 1996). It was also found that the levels in our subjects were much higher than the levels reported in the literature. Frijda (1988) mentioned the influence of high temperature on the release of cortisol.[45] Furthermore, because the time spent on a task was not fixed, it was

[45] The experiment was executed in July and August of 1996. According to the weather reports of the national weather institute (KNMI), that summer was third on the list of hottest summers of the century, so far. July, with a mean temperature of 20.1 °C was the second hottest month of this century. The mean daily temperature was 18.2 °C, whereas 16.2 °C is the average temperature. Subjects often arrived warm

often not possible to take the cortisol sample within 20 to 30 minutes following the interruption was introduced when subjects were still working (as was suggested by Kugler and Kalveram, 1989). The time the sample was taken varied between 20 to 45 minutes following the interruption was introduced. Together with the fact that the samples in our training session could not be used as a control measurement, and because inter-individual differences exist at the moment of maximum cortisol release, we must conclude that it was impossible to gather reliable cortisol samples. We have tried to resolve these difficulties by comparing our data to the data of a large group of people without mental or physical activity in order to find the influence of the interruption-related emotions. In a similar experimental situation, we do not recommend using the saliva cortisol level as an indicator of emotional arousal. It requires a much more controlled experimental situation, with more measurements as controls, and more measurements during the experiment. This last solution was undesirable in our situation, as unwanted interruptions would have been introduced.

From our second experiment, we can conclude that interruption-related emotions can affect performance and the personal state. We have seen that dealing with interruption-related emotions requires some additional cognitive processing, resulting in some negative performance effects. Dealing with (first-time) interruption-related emotions also requires some psycho-physiological regulation processing, as subjects become generally and emotionally aroused.

In the next chapter, we will discuss the results of both our experiments in relation to the general ideas formulated in Chapters 3 and 4.

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and sweated; one subject almost fainted (of course, this subject was not included in our experiment). Also, July and August are very busy periods for students as examinations take place. Subjects may have been occupied with other mental activities, which could have influenced the cortisol level and which could not be controlled for.

CHAPTER 7 ***CONCLUDING REMARKS***

In this chapter, we return to the aims of our project and consider whether they have been achieved. Furthermore, we discuss our results in relation to the literature. We also discuss the practical implications of our study and finish with some recommendations for future research on (interrupted) mental information work.

7.1 The research goals and the set-up of this study

With the developments of new equipment and new, more mentally oriented tasks, a new type of work has been defined: mental information work. As mental information work places high demands on the cognitive system, it is likely that this type of work is sensitive to interruptions. Although several studies have acknowledged that interruptions can affect mental task performance, its effects were hardly ever studied, let alone that we find studies on the types of interruption that occur in normal working situations.

The first aim of our project was to find out which everyday interruptions occur in mental information work and how they (can) affect performance. In research, attention has been paid to possible negative effects. But we know that interruptions can have positive effects as well, for example, when they are experienced "as a nice break". Several task- and person-related factors, like the frequency and complexity of the interruptions, or feelings of fatigue, are important for this distinction.

Moreover, we felt that insufficient light had been shed on the role of emotions in work. Researchers (e.g., Frese, 1990; Frese and Zapf, 1994; Mandler, 1988) had reported that emotions occur in work, also in relation to interruptions. But the role of emotions was often acknowledged only theoretically. This defined the second goal of our research, i.e., to analyze the role of interruption-related emotions in mental information work in an empirical way.

We first collected data from real-life situations on the type of interruptions that occur, how they can affect performance, whether emotions are involved, which interruption and task related factors are important etc. This survey information was also used to enhance the ecological validity of the two experiments. By means of these two experiments, we tried to achieve the goals of our project.

In our investigation on the influence of interruption(-related emotions) in work, we have based ourselves on an integrated view of work-related theories, information-processing theories and cognitive emotion theories. Various cognitive and psycho-physiological regulation processes have also been taken into account.

7.2 Are our goals achieved?

The data of our survey study were, first of all, used to find out which interruptions occur in daily mental work. It was also used for the description of our research area, and to outline some important factors that influence daily, interrupted, mental information work. In evaluating our survey results, we find that an interruption can be characterized by its form (telephone call, face-to-face), its content (urgent orders or just a chat) and its source (colleague, client, etc.). The formal characteristics of these types of interruptions, for example the predictability and being used to the interruptions, are not significantly different from each other. In general, effects are found on the performance process (e.g., longer resumption times), the work outcomes (e.g., working faster) and on the personal state (e.g., fatigue, changes in subjective effort and emotions). It seems that these interruption effects are influenced by both work and task characteristics, as we found (small) differences between three groups of mental information workers. Clerical workers execute less mental tasks, which require less concentration and are executed under less time pressure than business workers. Furthermore, clerical work is regulated by standard rules and procedures. Our survey study shows that clerical workers were affected most by interruptions. For example, they often started doing something else, changed their priorities and experienced the interruptions as both positive and negative.

Although the effects were small, four interruption-related factors are found to influence the performance effects: the length of the interruption (e.g. questions from others lasted longer than question from colleagues), the frequency (e.g., clerical workers are interrupted more frequently than business workers), the moment (both interruptions at the beginning and in the middle of the task performance are mentioned as disturbing), and the complexity of the interruptions (more complex interruption tasks result in longer change-over times). An interesting finding is that interruptions seem to have greater effects on the performance process and the personal state while the work outcomes hardly seem to have been affected at all.

How interruptions affect performance was further investigated in our experimental studies. In our first study, we interrupted well-trained secretaries with a telephone call and found that interruptions can have both negative and positive effects, depending on the number, the complexity, and the moment at which the interruption takes place. These effects may have to do with the work characteristics of the clerical profession. (Complex) interruptions bring more variety in clerical work. We found that when one is interrupted, the working and interrupting times increase, that more subjective effort is invested and that more negative emotions are experienced. Interruptions can have positive effects as well. When interruption are more frequently introduced, or are more complex, they lead to stimulating effects. Similar results were found in our second experiment. Here, during clerical work, some entered the room. Again, we found that interruptions affected the performance process and the performance outcomes, both negatively and positively. The personal outcomes were mainly negatively affected as subjects' well-being reduced, more subjective effort was invested etc. In both experiment, we concluded that the

positive work outcomes are achieved at the expense of subjective costs.

When we look at the factors influencing these effects we see that the frequency of the interruptions results in (more) negative (e.g., increase in execution and resumption times) and stimulating (relatively shorter completion and change-over times) performance effects. A complex interruption results in greater negative performance effects than a simple interruption (e.g. longer change-over times). But a complex interruption can have a positive effect on the personal state (e.g. less subjective effort is invested). The influence of the moment of the interruption on performance and personal state is rather small. Overall, we can conclude that the general ideas, that were formulated after the survey study and investigated in our first experiment, have helped us to achieve the first goal of our study. And, as the data of our first experimental study are in line with the data of our survey study, we are inclined to conclude that our first experiment does simulate a real-life situation.

The question was raised - our second research aim - to what extent interruption-related emotions influence performance. Based on the results of our survey study, we investigated whether both positive and negative emotions are experienced after an interruption. Indeed, both types of emotions are found in our first experiment. In our second experiment, we investigated how both types of induced emotions affect performance. Effects are primarily found when the emotions are introduced for the first time. When the emotions are evoked for a second time, we find no effects on performance and cognitive and psycho-physiological processes. So, our idea that interruption-emotions influence performance is only confirmed when the situation is new, that is, when the interruption is not integrated into the activated working plan. We can conclude that we have achieved the second goal of our study as well.

In summary, the conclusions concerning the characteristics and effects of interruptions are as follows:

1• Five main types of interruptions occur in daily mental work: urgent calls, questions from colleagues, questions from clients, telephone calls and someone entering the room (survey study).

2• The formal characteristics of these five interruptions, e.g. interruptions are unpredictable, interruptions are part of the job, do not differ from each other significantly (survey study).

3• When these interruptions, i.e., a telephone call or some entering the room, is introduced during clerical work, we find negative effects on performance (for example, longer execution and resumption times in the first experiment and longer main intervals in the second experiment) and on the personal state (for example more invested subjective effort in both experiments).

4• Interruptions can also have a stimulating effect on performance (for instance, the completion and change-over episodes in the first experiment, and the planning episode in the second experiment become shorter).

5• Interruptions can have a negative impact on the emotional state and activation. Also more effort is invested when being interrupted, probably because subjects are getting tired (first and second experiment).

6• Interruptions can have positive effects on the personal state as well, e.g., more positive emotions are experienced and less subjective effort is invested after a complex interruption when the task is not challenging (first experiment).
7• Both the frequency and the complexity of the interruptions are factors of influence on task performance (first experiment).
8• The impact of interruption-related emotions on performance is rather small and is mainly found when (negative) interruption-related emotions are experienced for the first time (second experiment).
9• Interruptions are handled with a delay and "in series" with the main task (first experiment). When negative emotions are involved (second experiment), the task execution restarts later than when positive or no emotions are involved.
10• Relatively more cognitive processing is required when interruptions occur (first experiment).
11• Also more cognitive processing is required when (negative) interruption-related emotions are involved (second experiment).
12• Positive work outcomes are achieved at the expense of psychological costs as the personal state decreases (more negative emotions, reduced well-being; both experiments). This indicates the activation of certain cognitive and psycho-physiological processes, especially when negative emotions are experienced (both experiments).
13• The results suggest that a strategy choice has to be made to maintain the level of performance when interrupted. The achievement of the goals, set by the organisation and translated into more personal goals, is more important than possible negative personal effects (survey study and both experiments).

7.3 Results discussed in relation to the literature

For the theoretical discussion of our study, we integrated work-related theories, information-processing theories and cognitive emotions theories. Action Theory describes people's (cognitive) work behaviour. This theory is also linked with some theories of human information processing. Concepts of Action Theory, such as the phases of action preparation and action execution (such as orientation and planning, the use of strategies, and the activation and execution of plans) are also found in mental information work. Also, concepts from information-processing theories (such as activation and effort, and automatic and controlled processing), have been useful for understanding (interrupted) mental information work, for example for understanding the interruption effects at various regulation levels. We also found that cognitive regulation takes place at different levels. When one is interrupted once, the interrupting task is processed sequentially and more capacity is required. Less capacity is then available, resulting in longer execution, resumption, and change-over episodes. Thus, more effort is also needed here. Regulation, therefore, seems to take place at the intellectual level. When one is interrupted more than once, the occurrence of an interruption has been incorporated into the activated plan. More capacity is available for dealing with the interruption. Regulation seems to take place at the rule- or skill-based level, with shorter time intervals, and more parallel

processing with the main task. No additional effort was invested, compared to interrupted only once. Our results are in agreement with the suggestion made in Chapter 3, that interruptions, introduced at the intellectual level, are experienced as more disturbing then when they occur on the skill-based level (Britton and Glynn, 1989). Later, with more experience, fewer changes are needed in the (re)activated plans. The results from a Russian study, executed as part of the cooperation between Tilburg University and Moscow University (Roe et al, 1995), are in agreement with our results, and show that interruptions lead to more cognitive processing. In this study, it was found that interruptions lead to greater velocity of information processing and to a better attention. Here it was found that with complex interruptions, the accuracy increased and more effort was needed.

In line with Kirmeijer's (1988) and Eyrolle and Cellier's (1995) results, we find that workers who react to the interruption with a delay - rather than with an immediate reaction (i.e. dropping everything they are working on) - have less negative performance and personal state effects. The fact that workers execute the interruptions more sequentially, especially when the frequency increases, indicates that controlled processing is required. Some subjects try to gain some control over the moment of intrusion of the interruption. This may have to do with our subjects. They are well-trained secretaries who are experienced in handling with interruptions in such a way that the impact on performance and personal state is low (e.g., Kolish et al. 1991). Subjects prefer to postpone the interruptions in order to complete a particular part of the action that is executed at that moment (see also Zijlstra et al., 1999). This idea is related to the Gestalt principle of 'closure', which has also been used to explain the 'Zeigarnik effect'. "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" (Zijlstra et al., 1999; p. 180-181).

When we look at the three interruption-related factors that were investigated in this study, we see longer change-over and resumption times and an increase in the subjective effort when the number of interruption increases. More interruptions are handled serially and with a delay. But we also see that the main task is executed relatively faster, with no changes in the quality of performance when interrupted. These results suggest that people change their work strategy with multiple interruptions in order to achieve the (organizational) goals. This is not what we had hypothesized. It does show that other - more personal-related - factors have an influence on performance. Quite contrary to our expectation, we found large standard deviations in the performance variables. Although subjects in our first experiment worked with WordPerfect at least a couple of hours a day, during a normal working day, we found a considerable variety in subjects' skills. This was one of the reasons why we introduced a training session in our second experiment. Besides the differences in skill, Van den Berg et al. (1996) found that the (interrupted) tasks are also influenced by temperamental factors. They found that the resumption and the execution times in our first experiment were related to the temperament traits of strength of excitation and mobility, respectively. Secretaries,

who are high on excitation and mobility, needed less time to resume the tasks after being interrupted than subjects who were low on excitation and mobility. These results indicate that more is involved in work than the theories describe. Certainly, more research is needed on the influence of personal factors involved in interrupted work (see our conceptual model) as they seem to have an impact on performance.

Moreover, the results on the complexity of the interruptions are not as we expected. We expected to find greater performance and personal state effects when the interruption was more complex. We found that more complex tasks lead to higher performance, i.e., the total time spent on the task was not affected and a more positive personal state (positive emotions, less subjective effort invested) than easy tasks. This finding has mainly been attributed to a motivational effect, i.e., the interruption is seen as a pleasant distraction.[46] The results show, contrary to, for instance, Gillie and Broadbent's (1989) results, that a more complex interruption does not necessarily lead to negative effects. Again, the results suggest that situational and personal factors must be taken into account as well.

Unfortunately, the results on the various moment of interruptions were rather small. This may have to do with the subjects being well-trained. The interrupted situation is already familiar to them (incorporated into the activated plan). Both Mandler (1964) and Van Dusen et al.'s (1992) idea that an interruption at the beginning of the task performance is more disruptive than at the end, was neither confirmed nor contradicted.

Indeed, interruptions have been found to influence the personal state. But the effects are not as negative as theorized. Besides negative emotions and increased mental effort, positive emotions and a decrease in the mental effort were found as well. When we look at the influence of the personal state on performance, in particular at the influence of the interruption-related emotions, the results are in line with our general ideas. We found that interruption-related emotions affect both action preparation and action execution - as we see (relatively) longer planning and change-over episodes - and the strategies used - as we see more delayed processing of the main task. The results indicate that interruption-related emotions require additional cognitive processing. Less capacity is available for the main task, followed by some effects on performance. We also do find that the stimulation effect of being interrupted, which was found in both our experiments (i.e. a decrease in the execution time and the planning episode), is smaller when interruption-related emotions are involved. All these results are in agreement with concepts of cognitive emotion theories. First of all, more controlled processing is needed when interruption-related emotions are introduced. Mandler's idea, that negative emotions require more cognitive processing than positive emotions, is also confirmed by the results of our experiments. In Mandler's cognitive emotion theory, both arousal and

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[46] This effect is in some ways similar to other positive interruption effects like the results on problem solving or on the incubation effect discussed in Chapter 1 (when an interval is imposed, people remember things better).

an emotional experience are necessary conditions in the emotion process. When we look at our data, we do indeed see an increase in the emotional arousal level (NS_EDR) when interruption-related emotions are involved. However, this increase only occurs when the interruption-related emotions are evoked for the first time. The fact that emotions mainly affect performance when introduced for the first time is in line with Frijda's (1988) theory. The second time the emotions are evoked, no action tendency is activated as the situation is no longer relevant. Subjects' performance is not hindered by the interruptions; there is no mismatch situation because the interruption is incorporated into the activated plan. Also, the achievement of the goal is not threatened as worker have options available for dealing with the interruption effects (for example, workers can speed up the task execution). In this experimental situation, only weak emotions occur. When the situation is more serious, for example, when being interrupted again while trying to achieve a dead-line, the situation will be more a threat, as the goal achievement is hindered. Then, action tendency and emotions would occur. And, because of the seriousness of the situation, the emotions might even be more intense than the first time.

So, we have to expand our general idea that emotions can affect performance and personal state with the idea that the effects in work are likely to occur only when the emotions are novel. And, because (additional) cognitive and psycho-physiological processes are found to be activated for dealing with the interrupted emotional situation, in order to diminish negative performance effects, we can conclude that the influence on personal state in this situation is not as important as we suggested. What the effects will be when being interrupted is a more serious threat to the goal achievement (e.g. more often interrupted, under time pressure), is something that must be investigated in future research.

Our conceptual model of how interruptions can affect activity, has shown its applicability. We have found that an interruption affects work outcomes (e.g., longer working times), and activity (e.g., people work harder). We also found that personal outcomes (e.g., lower well-being) and activity (relatively less supportive operations) are affected by the interruptions. The personal state is also affected (changes in emotions). We see that interruption-related emotions influence activity (longer change-over episode), work outcomes (smaller decrease in execution time) and personal state (more aroused, more mental effort invested). Also interesting is the suggested relation between work and personal outcomes. Indeed, we found that such a relation exists as the negative performance effects are diminished (or do not arise) at some psychological costs. Indeed, the various psycho-physiological processes, that are activated, can be considered as 'regulation processes'.

The results further indicate that, when interrupted, workers are more work-oriented (to achieve positive work outcomes) than that they are focused on emotions (to achieve positive personal state). Work oriented people make an estimation of what would be an appropriate amount of time for executing the task. 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 requires the activation

of psycho-physiological resources (arousal, effort) as we find effects on emotions, effort and physiological processes involved. Henning et al. (1989) speak of 'avoiding loss of adaptation to the task'. Although they used this term in relation with microbreaks, it is also useful for explaining the stimulating effects of interruptions. In a study among data entry operators, Henning et al. found that these workers restarted work on the main task before the (allowed duration of) rest break was over. They tried to avoid loss of adaptation to the task ("If I stop too long, I'll never get going again") as this can lower the work output in the subsequent work period (i.e. longer change-over times are needed, see Chapter 5 and 6). But, as long as we have no detailed information on how people deal with an increase in negative (performance or personal state) effects (inverted U level) after being interrupted, we are not completely sure about our conclusion.

What are the theoretical implications of our study? From our study, we can conclude that the basic ideas of Hacker's Action Theory, which was mainly investigated with respect to production work, can also be used in (interrupted) mental information work. For example, in our study, work can be recognized as goal-directed behaviour since subjects work towards the goals derived from the tasks given. And, the three cognitive regulation levels have helped us to understand why certain effects of being interrupted occurred. Our study shows that Action Theory needs some adaptations when mental information work is involved. In mental information work, there is more emphasis on cognitive processes and attention (see also Meijer, 1990), and a larger demand is made on memory. And, although acknowledged, the influence of interruptions on performance needs more attention. To understand the effects of interruptions more clearly, one also has to pay attention to the job level, the task involved, the cognitive level people are working, etc. Task-related factors, such as the complexity and the frequency of the interruptions, and personal-related factors (see Van den Berg, et al., 1996) should be included as well. As our study shows, these factors can result in effects which were not expected. For example, the fact that workers try to work (relatively) more efficiently after being interrupted as they make up for the possible reductions by working harder, changing strategies, etc. On the other hand, Action theory is not a fully developed and well-tested theory (Frese and Zapf, 1994). But since Action Theorists are keenly interested in the issues of new technologies, more research is undoubtedly underway. At least, more research on the developments of methods, techniques and instruments for analyzing and designing mental information work, based on the theoretical framework of Action Theory, is needed. One of these methods has recently been developed by Meijer and Roe (1995).

The second implication of our study is that we suggest always to incorporate the activation of emotions when investigating mental work, and especially when investigating interruptions. Our study shows that the idea of a relation between action regulation and emotion mechanisms, as suggested in Chapter 3, has been found. This relation has, indeed, helped us to explain the influence of interruptions in work in more detail. Only when more information is gathered on the role of emotions, and on the regulation processes involved in work, the theories of

emotions and work can be further developed. ".. to construct a theory of work and emotions is a difficult task. Today there is no consensus on the causes of human emotions on which one might build. Furthermore, there is no consensus about relevant characteristics of jobs and tasks. Any comprehensive attempt to link work and emotions is therefore forced to build on assumptions eclectically derived from current theories and from rudimentary knowledge about work, achievement and emotions" (Pekrun and Frese, 1992, p. 49). Hopefully, our study will contribute to the eventual development of a general theory of work and emotions.

7.4 Practical implications

This study has proven that interruptions can indeed affect performance. As mentioned in Chapter 1, interruptions are often associated with a decrease in productivity. For example, interruptions lead to longer working times. But, we have shown that interruptions do not necessarily lead to worse performance. People tend to work more efficiently when interrupted. And, interruptions can be experienced as a nice distraction as well. When (negative) emotions are involved, the stimulating effects of the interruptions become smaller. At the same time, we have seen that trying to achieve the set goal, requires more of the worker, i.e., increased and sustained effort, emotional responses, and growing fatigue.

With the expected increase of pervasive and horizontal communication within the next few years, and the increasing use of communication technology such as pagers, mobile phone, and e-mail, it will be more and more likely that workers will be interrupted more frequently. In this study, we found that being interrupted can have harmful effects on task performance as interruptions place additional demands on the cognitive and psycho-physiological regulation processes, especially when negative emotions are involved. In particular with respect to jobs in the domain of mental information work, it is important that the potential risk of stress is acknowledged. Organizations tend to pay little attention to the effects on workers' well-being and health. Organizational goals, regarding productivity, are (still) more important. But eventually, the higher workload and stress can result in illness and in incapacitated workers.

This brings us to the practical implications of our study. How can we prevent the negative effects and how can we enhance the positive effects when interruptions occur? Suggestions for job (re)design depend on the tasks involved. It seems that jobs, that are affected most by (many) interruptions, involve routine tasks, and are carried out by standard procedures. Here, positive effects can be enhanced by varying the complexity of the interruptions. On the other hand, harmful effects of interruptions on performance and personal state are found in jobs that involve mental tasks with less organisational rules, because they do not occur that often. Here, interruptions are more likely to be prevented. But, removing all interruptions during task performance does not seem to be very useful. Research (see Chapter 1) has shown that placing the main task aside for a while can enhance performance.

This study shows, that being interrupted once in a while may improve efficiency, especially during a non-stimulating task. We recommend to alternate periods of interrupted and non-interrupted work.

To improve work conditions can also be used to prevent negative effects of interruptions, depending on the tasks that are executed. An example of a work condition that can impair performance, and lead to a decrease in well-being, is the open-space office (Johansson and Aronsson, 1984). Here, we think that interruptions during mental work that is not standardized, have a large impact on performance, as workers are not only interrupted by questions they themselves are asked, but also by questions asked to others in the room. This suggests that people should work with a limited number of colleagues in one room. Two or three people in a room seems alright. The number of interruptions will not be overwhelming as there is always someone else in the room who can ask for a halt when it becomes too much. On the other hand, the chance of being interrupted once in a while (resulting in positive effects) is always present. Recently, modern "flex" workers have been introduced. These workers do not have a desk or computer in their own office as they do not come to the office every day. When they come to work, they take their personal belongings and choose a desk, a computer, etc. Only a small group of workers share the room, the telephone, the fax machine, etc. But what happens in practice? The offices with only one desk, one telephone etc. get taken first. This was not what the designers had in mind when they designed only a few single rooms. One reason why workers choose the single desk room is that being away from the office often means collecting information. This information has to be dealt with later when back at the office. Workers probably prefer to do this uninterrupted and without sharing telephones, etc.

Another recommendation is to guarantee workers at least a few uninterrupted working hours a day during which they can reduce the work that has piled up because of the interruptions earlier that day. The use of an answering machine/ voice mail can help in reducing stress (although its usage is not common in customer-oriented organizations). It can be switched on or off, whenever convenient. But, in order to prevent stress, not only interruption-free-working periods are needed (which in turn can lead to time pressure), also periods during which the worker can recover[47] from the effects of interruption-related emotions are needed. For example, taking a break or starting to work on something else. These recovery periods should be longer when interruptions occur more frequently, are more complex, when the worker has less control over his work, or when he is less experienced. When these periods are not externally provided for, workers tend to create them themselves. This idea was also mentioned by the subjects of our survey study. Business workers take more rest breaks, while secretaries may go to the toilet or have a chat with a colleague. Some organizations have put a limit on the recovery time (for instance, a visit to the toilet cannot take longer than 5 minutes and only a few times a day;

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[47] Company fitness programs can help people successfully deal with psycho-physiological complaints and stress (Wientjes and Opmeer, 1992).

or a limit of 45 minutes for personal care during the working day), with the aim of controlling workers' performances. But limiting the recovery breaks can be counter-productive, especially for those workers who work for long hours on non-interrupted tasks, at the skill-based level, or for workers who are interrupted quite often. These workers might need extra recovery time. And, Henning et al. (1989) found that experienced workers will not take excessively long recovery times in order to prevent loss of adaptation to the task. When workers are not free in choosing their recovery periods, the level of productivity aimed for will only be achieved on the short term. In the longer run, the organization can gain more profit when the length and the number of recovery breaks are not limited, as lower subjective costs are more likely to result in a better prospective of better performance. So, instead of limiting recovery periods, an adequate personnel selection and/or training program seems more efficient.

In this training program, interruptions, when they are a common occurrence in a particular job, must be incorporated into the training plan. Many organizations also provide time-management skill training (MaST). Workers are advised to use "telephone-interruption free time", and "key action points" such as "don't call us, we'll call you". In addition, advice is given on the use of body language and on the design of the working room. The aim is to make the environment less friendly for the interrupter and to reduce possible (mental) strain and stress for the worker.

Personnel selection, in line with the job demands on knowledge and skills, can also help to prevent interruption-related stress. Kirmeijer (1988) found that Type-A subjects experienced interruptions as more taxing than Type-B subjects. Van den Berg et al (1996) suggested to use the temperament traits of strength of excitation and mobility as predictors for task performance in relevant jobs. "Applicants low on excitation can be expected to have problems in resuming their task when interrupted. With a high number of interruptions, these applicants will not get round with their tasks. Besides, they will experience less positive affect during task performance than applicants high on excitation. It is predicted that applicants low on mobility will be slow in task performance and need more subjective mental effort to do the same job. They are also slow to resume a task after interruptions" (Van den Berg et al, 1996, p.248).

As for the work tools, the use of visual clues can be stimulated. Wiethoff et al. (1995) found that these clues can diminish some of the negative performance effects. In their research, Wiethoff interrupted the execution of various secretarial computer tasks by telephone calls and found that subjects, whose work was more supported by visual cues (MS Windows versus MS DOS), worked faster and needed less help (browsing through help functions, reading the manual, etc.) after the interruption had occurred than workers who were less supported by visual cues. It was suggested that a visual cue, such as marking the text at the moment of the interruption, can facilitate or take over the function of memory storage. This can facilitate the resumption of the main task, resulting in smaller performance effects. Unfortunately, no information was given on the effects on the personal state. But, as fewer psycho-

physiological regulation processes need to be activated to achieve the goal, the personal state will be less affected than when no visual cues are used. In the long run, this will lead to less stress.

More research on the effects of interruptions on performance and personal state may indeed be helpful for understanding the relation between personal and environmental factors that are critical for the improvement of the work environments. More recommendations for future research are given in the next section.

7.5 Suggestions for future research

In designing our research, we chose a combination of psycho-physiological and behaviour research methods. When we look at the results of our studies, we see that this integrated method has proven its usefulness. If only one research method had been used, for example, behaviour variables, we would not have acquired detailed information on how subjects dealt with, for instance, interruption-related emotions. Other strengths of this study are the high ecological validity of the experiments, and the theoretical and empirical based hypotheses. The combination of subjective and more objectively gathered data, using a survey study and two experimental studies, has proven useful. For future studies on this topic, we would certainly recommend using a similar combination. However, a limitation of this study is the fact that a relatively small number of subjects was involved in all three studies. Because of the somewhat explorative character of our experimental studies, only a small number of subjects were observed. Using a reminder can increase the response percentage in a survey study. In future studies, a larger number of (different groups of) subjects must be observed. Then, the results will certainly more clear.

Our study has also shown that not all variables, proposed by researchers, can be used to investigate computer work. For example, the change in cortisol level, used as an indicator of emotional arousal, shows a large variance, even within the same person. Therefore, we do not recommend using this variable in future research. More research must help us to find out which variables can be used effectively and which not.

Why are some workers more successful in dealing with interruptions than others? For understanding more about work performance in general, and about the influence of interruptions in particular, more research is definitely needed. Only then can existing and new models be further developed to understand modern mental work. "We believe that we can only understand work performance well if we know how executing a work task, mobilizing effort, coping with emotions, staying alert, and maintaining a positive self-image interact" (Roe, 1998, p.71). Our conceptual model (Figure 1.2) on the influence of interruptions in mental work, in which several components are integrated, must be broadened in future research (for example, the influence of achieving the set goals despite negative personal effects). A wider range of conditions will have to be investigated in order to test the validity of our findings.

Identifying the conditions that lead to changes in personal state and performance outcomes would be an important objective for future research. We have investigated only a very small part of a very large, almost unexplored, field: the influence of interruptions in mental (information) work. We investigated only three interruption-related factors. It is not difficult to assume that, for instance time pressure, influences the work process, especially when interruptions are introduced. Workers may reduce the orientation phase, which may result in more negative work outcomes. Indeed, time pressure was mentioned by the respondents in our survey study. The degree of time pressure can be indicated by the speed of the work necessary for achieving the work goal: "If a high rate of work is continuously required, the action regulation capacity of the worker is overtaxed; the worker cannot adjust his performance to normal fluctuations of capacity" (Greiner and Leitner, 1989; p. 58). A relation between interruptions, time pressure, and feeling of stress has been found by many researchers (e.g., Ben Zur and Breznitz, 1981; Gaillard, 1992). And what about social interaction? Is the work process influenced when someone else is in the room? Do workers indeed need more recovery periods? Do interruptions also have an stimulating effect when they are not related to the work? All these factors need to be investigated in future research before detailed conclusions on the effects of interruptions in mental information work can be drawn.

When we look at the factors influencing performance, we would advise researchers to concentrate on the frequency of the interruptions. It is questionable whether the frequency of interruptions in our experiments was high enough to evoke responses as strong as those found in daily work. It was noted that the pressure, created by the interruptions, was less than commonly experienced. In future research, the influence of a greater number of interruption, and more demanding interrupting tasks, must be investigated. One could also opt to investigate subjects that are accustomed to less interruptions than the subjects in the present study. The greater and the longer the expenditure of effort needed for dealing with the interruptions, the more likely it is that stronger effects on the person's psycho-physiological state and his performance occur.

In this study, we have shed some light on the role of emotions in mental work. We have already questioned the induction of the interruption-related emotions in Chapter 6. Most often, emotion research utilizes films for evoking emotions. But this method is not applicable to our realistic work environment. In our experimental set-up, we introduced positive and negative feedback during task executions in order to evoke positive or negative emotions (see Baron 1988; 1990). Our experiment shows, similar to Baron's studies, that the manipulation of the evoked emotions was more or less successful, especially when the feedback was introduced for the first time. Our results also indicate that, for future research on the influence of work-related emotions, a similar method can be used, especially because the use of giving

feedback appears to be far from rare in actual work settings (Baron, 1988; 1990).[48] For future research on the influence of work-related emotions, we can only suggest evoking stronger emotions, for example, anger, during a more goal-threatening situation, that will also show its effects the second (or more) time(s) they are introduced.

Although not much research has been done on the role of different kinds of emotions, a great deal of literature exists on the influence of anger. Anger can arise when an unexpected event occurs. It calls for action (action tendency) and requires effort (Frijda, 1988). It has been suggested that anger relates to social concerns in the workplace and is a key to work-related stress (see Pekrun and Frese, 1992). But, again, we can only speculate about the relation between interruptions and anger, and how anger influences mental information work as no research has been found on this topic. The results of our study cannot give us more information as we found no significant increase in negative emotions (such as anger). We know even less about the influence of emotions like frustration, irritation, or boredom in relation to work. Must these emotions, similar to anger, be avoided, or can they also contribute to more efficient performance? We do not know yet. One problem with research on emotions is that the same emotion can have different meanings for the same person in a different situation, or for a different person in the same situation (Frijda, 1988). And, some people are afraid to fail, while others are afraid to succeed. The social environment is important as well: whether one is angry at his boss or at his neighbour makes a difference for the task execution. Some emotions have a stimulating effect, while others have a negative effect. For example, one can start to work hard or one can resign from his work because one is angry. It is too simple to say that negative emotions lead to negative performance and positive emotions to positive performance. Many other factors influence these processes. But the extreme complexity of emotions should not hold back the investigation of an integrated approach of both task and emotion regulation processes when investigating mental work.

With the increased usage of computers (for example, Internet), we suspect that more work will be mentally oriented than is now the case. This study demonstrates that interruptions affect mental information work on a short time scale. What will happen when interruption effects (e.g. the related emotions) are experienced over a long(er) time scale? In our research, we found that interruptions did not cross the point after which the positive work outcomes effects turn into more negative effects (inverted U curve). But when does the influence of interruptions(-related emotions) becomes

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[48] Negative emotions, evoked after receiving negative feedback, has been found to undermine individuals' confidence in their own ability to perform various task, to affect motivation and task performance, and to initiate or intensify organizational conflicts (e.g., competition for scarce resources and reward structures or systems and disputes over jurisdiction). An apology and information suggesting that the negative information stemmed from external causes can counter the negative impact, but only when used once or perhaps infrequently. Training managers and others how to deliver negative information about past performance seems more effective (Baron, 1988 and 1990).

so great that workers can no longer compensate for the negative effects, or when does a more positive personal state become more important? Profound and long lasting interruption effects may cause exhaustion and stress in a person. Or, when does the additional effort turn into a state of de-motivation to execute the main task? What will happen when workers are (not) interrupted during a long time? Will the achievement of the organizational goals then still be more important than high psycho-physiological costs? Research on the effects of computer breaks on behaviour and stress among secretaries (e.g., Henning, et al., 1989) showed that the tasks were executed less efficiently when workers executed mental tasks for two hours without any breaks. In addition, more physical complaints, like headache and pain in the shoulder and eyes, were mentioned after hours of uninterrupted work (Johansson and Aronsson, 1984). Are similar effects found when no interruptions occur during mental information work?

These are only a few of the questions that can be asked. There are many more. What about age, for example? Norman, Kemper, Kynette, Cheung, and Anagnopoulos (1991) found that elderly adults were less able to simultaneously process remaining and new information when they were interrupted (no action required) while listening to a text. On the other hand, Erber (1986) found that exercise can compensate for the decrements found in elderly. According to these results, it seems that elderly workers deal with interruptions differently than young workers. All these questions indicate that more research is needed on the longer term effects. At this point, we can only speculate about the (cumulative) long-term effects. When no plans, useful strategies, or recovery breaks are available, all kinds of psychological and physiological reactions, such as cortisol, adrenaline, etc., cannot return to their baseline level (e.g., Van Ouwerkerk et al., 1994). In the long run, heart rate, blood pressure regulation, and the immune system will then be affected, not only during but also after working hours (Johansson and Aronsson, 1984). This can, eventually, lead to stress, with all its consequences of stress-related diseases (De Sitter, 1990; Frankenhaeuser, 1993; Gaillard, 1992; Kanfer & Stevenson, 1985; Meijman, 1989; Van Ouwerkerk et al., 1994).

Another question is to what degree the results of this study can be generalized to other settings. Our survey study has shown that differences exist in the tasks of different mental information workers. The type and the effects of interruptions differ as well. So, by using the same experimental setting, adjusted to the characteristics of another category of mental information workers, different effects may be found. The effects will also differ when individual factors, like skills or the amount of control, differ within the same occupation or in the same experimental setting. We can assume that subjects, who have little experience with the (interruption) task, and have less control, will show stronger responses than those who are familiar with many interruptions. But apart from the difference in these personal-related factors, we predict little variance in performance and its outcomes. One assumption of work is that workers receive a reward when the goal of the organisation has been achieved. Therefore, workers are more oriented to the achievement of the goal than to a better personal state, despite all negative influences. This will probably be the

case for most workers. But, we suspect that this will be true only up to a certain point. When the demands of the goals of the organization become too high, the negative personal effects will reach a critical point where worker may fall ill or resign from their jobs. But before we describe, or even design and investigate, the optimum mental information work environment, it is necessary to gain more information on the issue of mental information work in which the influence of daily occurring interruptions are considered.

SUMMARY

Interruptions are a common phenomenon in our daily work. Aren't we all interrupted in our work by a telephone call or by someone asking a question? These interruptions often lead to feelings of irritation, to a decrease in performance, or to additional effort. Researchers have found a relationship between time pressure, interruptions, and stress (BenZur and Breznitz, 1981; Gaillard, 1992). But interruptions do not always have negative effects on performance and personal state. They can also have positive effects, for example, during monotonous work. Therefore, it is necessary to understand when interruptions can affect performance and the personal state. But no research has addressed daily occurring interruptions and their effects on modern work. Also, no information exists on how workers deal with these interruptions, i.e., the activation of regulation processes. This dissertation investigated how daily occurring interruptions affect performance and why this happens. An interruption is defined as an external event which results in the temporary cessation and suspension of an ongoing activity. The activity is resumed after a certain amount of time. An example is a telephone call that occurs while writing a letter on the computer. After answering the call, the worker continues writing.

The increasing use of computerized information systems in modern societies has contributed to the spread of new types of work. 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 on 'knowledge work' such as planning and designing. Roe and Meijer (1990) identified a new kind of work, designated as "Mental Information Work". The assumption is that the performance of mental tasks is affected by interruptions as they place high demands on the cognitive system of the worker. For example, one has to remember where the interruption has occurred in order to carry on. Both the performance and the personal state can thus be affected. We also suspect that interruption-related emotions can affect performance, as dealing with these emotions requires cognitive processing. For example, more errors may be made because one is irritated. Not much research has been done on the influence of emotions on work.

Hacker's Action Theory (1973; 1978; 1986; 1998), described in Chapter 3, describes how workers regulate their goal-directed work at different levels, based on cognitive structures. The regulation of work involves the following phases. Based on the worker's interpretation of the task, the external goal is redefined into a personal goal. Then, plans are made or activated, and executed to achieve the goal. Action Theory uses information-processing theories. These theories are based on structures, such as memory and schemes. Cognitive processes transfer information from one structure to another. These processes are automatic or controlled processed, serial or parallel processed, depending on the experience with the task.

According to cognitive emotion theories (e.g. Mandler, 1964; 1975; Frijda, 1988), described in Chapter 4, emotions arise when an unexpected event occurs (for

example, an interruption) and when an internal process judges the situation as relevant (appraisal). This is followed by the generation of a plan for action. Cognitive and psycho-physiological processes are activated for dealing with the (interruption-related) emotions with the aim to adapt to the demands of the (work)situation. Cognitive regulation involves processes such as arousal, appraisal, activation, and effort. Both automatic and controlled processing occurs. Since emotions require the activation of similar structures and processes, we suggest that interruption-related emotions affect work as well. In our study, we look at the influence and effects of both negative and positive emotions.

The study consists of three parts. Besides the theoretical discussion (see above), a survey study is performed to investigate which interruptions occur in daily work. We also investigate which factors influence the effects of the interruptions. In the third part, the results of the survey study are experimentally investigated; these two experiments are executed in the Laboratory of Information Work of Tilburg University.

The survey study, described in Chapter 2, was executed among 79 mental information workers. We found that "telephone calls" and "a person entering the room" are the most frequent interruptions in daily work. The interruptions are characterized as unpredictable and vary in content. They require some skills for dealing with them. The effects of the interruptions differ between the professional groups. Clerical workers, mainly secretaries, experience the interruptions as both negative ("the interruption is useless") and positive ("the interruption brings a change"). Business workers perceive the interruptions mainly as negative ("the interruption means extra work"). The effects also differ: clerical workers avoid the interruptions (they use time management strategies), while business workers block their telephones or start working somewhere else where they can not be interrupted. Besides personal-related factors, like fatigue and additional mental effort, interruption-related factors, like the frequency, the length, the moment, and the complexity of the interruptions, are reported to influence the performance effects.

The subjective information from the survey studies was investigated in a more controlled, objective situation. Two experiments were carried out in a simulated work office. In the first experiment, described in Chapter 5, the influence of the frequency, the moment, and the complexity of the interruption on performance and personal state was investigated. Forty secretaries were interrupted, at set moments, by a telephone call during the execution of a computer task. The results show that, although subjects need more time for the execution of the whole task (including the interruption), the time needed for the execution of the main task decreases. The quality of performance is not affected by the interruptions. When interrupted more often, subjects answer the telephone with a delay. A complex interruption seems to affect performance negatively. On the other hand, we see that a complex interruption is experienced as positive perhaps because it brings more variation during dull work. The moment of the interruption does not seem to have an impact on performance or on the personal state. Overall, the results indicate that people's

work behaviour becomes more efficient when one is interrupted more often. This is achieved at the expense of the personal state such as reduced well-being, more negative emotions, more mental effort invested, etc.

The second experiment, described in Chapter 6, was also conducted in the simulated work office. The purpose of this experiment was to determine how interruption-related emotions affected the work of 30 students. During the execution of a series of computer tasks, three interruptions were introduced: the experimenter entered the room and gave neutral information during the first interruption, and positive, negative, or neutral information about the subjects' performance during the second and third interruption, respectively. It appears that interruption-related emotions do influence performance, especially when negative emotions are involved. The effects occur mainly the first time the emotions are introduced. Similar to the first experiment, we see that workers compensate for possible negative performance effects: no influence of the interruptions on the total working time is found. Again, we find that efficient work behaviour is achieved at the expense of negative personal outcomes. This happens mainly when interruption-related emotions are involved.

The results of our study show that daily occurring interruptions affect work behaviour and the personal state of the worker. Interruptions do not only mean that extra activities have to be executed, or that cognitive and psycho-physiological regulation processes are activated, the results also show that interruptions can affect the performance process and the personal state. From our study, we can also conclude that interruption-related emotions require additional cognitive and psycho-physiological processing, resulting in more performance effects. Workers choose a strategy that ensures that the interruption will not, or only slightly, affect the work outcomes. Achieving this positive (work) goal seems more important than the psychological costs. We suggest that there is a point after which the mental information worker can no longer compensate for the performance effects of the interruptions by, for instance, additional mental effort. Also, at a certain point, the achievement of a more positive personal state can become more important than the achievement of the organizational goals. This study does not indicate whether or when workers achieve these points. More research, preferably longitudinal, might give more information.

In the last chapter, suggestions are given for future research. Given the increase use of information technologies and communication (e.g., Internet), we would recommend to investigate the effects of interruptions during mental information work in greater detail. The influence of factors like the frequency, the moment, and the complexity of the interruption should also be investigated in other professional groups. Other factors, like time pressure, do need to be investigated as well. Our study shows that Action Theory can be very helpful for these investigations. We would suggest incorporating the activation of emotions when investigating mental work, and especially, when investigating interruptions. Only when more information is gathered on the role of emotions and on the regulation processes involved in

work, can the theories of emotions and work be further developed.

Our study shows that interruptions do not necessarily have a negative influence on performance. Workers compensate for possible negative work outcomes. However, this has an adverse effect on their personal state. We suggest an adjustment of the work environment, such as a few uninterrupted working hours a day, or working only with a few colleagues in one room, in order to reduce the possible negative effects on the personal state when interruptions occur too frequently. On the other hand, uninterrupted working-periods should not be too long. As our study shows, interruptions can have beneficial effects as well, especially during tedious work. In short, periods of interrupted and uninterrupted work should alternate. More research needs to be conducted before all aspects of interruptions are elucidated. Eventually, this knowledge may be put to use to the advantage of the worker and his performance.

SAMENVATTING

Onderbrekingen tijdens het werk zijn een veel voorkomend en welbekend verschijnsel. Hoe vaak wordt men niet gestoord door een telefoontje of door iemand die iets komt vragen? Vaak zorgen deze onderbrekingen voor irritatie, extra inspanning, en verminderen zij de prestaties etc. Onderzoek heeft uitgewezen dat er een verband bestaat tussen het voorkomen van onderbrekingen en het ontstaan van tijdsdruk en stress (BenZur en Breznitz, 1981; Gaillard, 1992). Echter, onderbrekingen kunnen ook een positief effect hebben, bijvoorbeeld doordat de onderbreking voor enige variatie zorgt tijdens monotoon werk. Het is dus van belang om te weten wanneer onderbrekingen voorkomen, en wat de effecten daarvan kunnen zijn. Tot nu toe is er echter nauwelijks onderzoek gedaan naar het voorkomen en de effecten van dagelijkse onderbrekingen. Ook onderzoek naar de wijze waarop mensen omgaan met dergelijke onderbrekingen, d.w.z. de achterliggende reguleringsprocessen, heeft nauwelijks plaats gevonden. In dit proefschrift wordt onderzocht hoe dagelijks voorkomende onderbrekingen het werk kunnen beïnvloeden, en waarom dat zo gebeurt. Een onderbreking is daarbij gedefinieerd als een (externe) gebeurtenis die leidt tot een tijdelijke opschorting van de activiteit, zoals bijvoorbeeld het beantwoorden van de telefoon tijdens het schrijven van een artikel.

Met het toenemend gebruik van computers en andere ontwikkelingen op economisch en technisch gebied, heeft zich een verschuiving in de arbeid voorgedaan, waarbij mentale componenten een belangrijker rol zijn gaan spelen dan fysieke componenten. Men kan spreken van een nieuwe vorm van arbeid: mentaal informatie werk (MIW). In mentaal informatie werk wordt voornamelijk een beroep gedaan op de mentale capaciteiten van de werker. Er worden hoofdzakelijk bewerkingen uitgevoerd op informatie of gegevens (Roe en Meijer, 1990). In ons onderzoek veronderstellen we dat onderbrekingen een extra beroep doen op de mentale capaciteiten van de persoon. Zo moet bijvoorbeeld worden onthouden waar men mee bezig was op het moment van de onderbreking. Dit kan een extra belasting betekenen voor het geheugen van de werker,
waardoor zowel de uitvoering en het resultaat van het werk, als het welbevinden van de werker worden beïnvloed. Tevens wordt verondersteld dat emoties opgewekt worden, die eveneens het werk beïnvloeden. Zo zou men bijvoorbeeld minder nauwkeurig kunnen gaan werken omdat men geïrriteerd is geraakt. Er is echter weinig onderzoek verricht naar de invloed van emoties op het werk.

De Handelingstheorie van Hacker (1973; 1978; 1986; 1998), beschreven in hoofdstuk 3, legt de nadruk op de cognitieve processen die een rol spelen bij het uitvoeren van werk. Deze processen zijn gerelateerd aan een aantal (hiërarchische) niveaus. De regulering van arbeid omvat globaal de volgende stappen. De arbeidsopdracht dient te worden vertaald in een persoonlijke arbeidsopgave. Daarna worden plannen gemaakt (of aangepast), en vervolgens uitgevoerd, om het doel te bereiken. De handelingstheorie maakt gebruikt van informatietheorieën. In deze informatietheorieën gaat men uit van een aantal structuren, zoals het geheugen en

het bestaan van schema's, waarin informatie is opgeslagen. Cognitieve processen zorgen er voor dat de informatie wordt omgezet van de ene structuur naar de andere. Deze processen verlopen automatisch of bewust, serieel of parallel, en op verschillende niveaus van ervaring.

Volgens cognitieve emotietheorieën (o.a. Mandler, 1964; 1975; Frijda, 1988), beschreven in hoofdstuk 4, ontstaan emoties wanneer een persoon een onverwachte situatie, zoals een onderbreking, als relevant waardeert (appraisal). Cognitieve en psycho-fysiologische reguleringsprocessen worden geactiveerd en zorgen dat (alsnog) aan de eisen van de (werk)situatie kan worden voldaan. Deze processen kunnen zowel onbewust als bewust verlopen. Hierbij spelen arousal, appraisal en inspanning een belangrijke rol. Omdat de ontstane emoties eveneens een beroep doen op de geactiveerde informatie-structuren en processen, veronderstellen wij dat onderbreking-gerelateerde emoties het werk zullen beïnvloeden. Wij kijken in ons onderzoek dan ook naar de invloed en de effecten van zowel positieve als negatieve onderbrekings-gerelateerde emoties.

Het onderzoek bestaat uit drie delen. Naast een bespreking van de achterliggende theorieën (zie boven) wordt, middels een veldonderzoek, de vraag onderzocht welke onderbrekingen voorkomen in het dagelijks werk. Daarnaast wordt onderzocht welke factoren van invloed zijn op de effecten van onderbrekingen. In het derde deel van het onderzoek worden de resultaten van het veldonderzoek nader onderzocht. Hiertoe worden een tweetal experimenten uitgevoerd in het Laboratorium voor Informatie Arbeid (LIA) van de Katholieke Universiteit Brabant.
In het veldonderzoek, beschreven in hoofdstuk 2, werden 79 mensen ondervraagd die mentaal informatie werk verrichten. De enquête wijst uit dat "telefoontjes" en het "binnenlopen van een collega/cliënt" de meest voorkomende onderbrekingen zijn. De onderbrekingen kunnen worden gekarakteriseerd als onvoorspelbaar en variërend van inhoud. De meeste ondervraagden zijn gewend aan het voorkomen van onderbrekingen. Daarnaast zijn enige vaardigheden vereist om met de onderbrekingen om te gaan. De effecten van onderbrekingen blijken af te hangen van het soort werk dat men uitvoert. Zo trachten administratieve werkers, bijvoorbeeld, de onderbrekingen te vermijden door het maken van afspraken (time management), terwijl commercieel gerichte werkers de telefoon blokkeren of ergens anders gaan werken waar ze niet gestoord kunnen worden. Daarnaast ervaren administratieve werkers, waaronder een grote groep secretaresses, onderbrekingen zowel positief ("geeft variatie in het werk") als negatief ("de onderbreking is nutteloos"). Commercieel gerichte werkers ervaren onderbrekingen vrijwel altijd als negatief ("een onderbreking betekent extra werk"). Naast persoonlijke factoren, als bijvoorbeeld ervaring, vermoeidheid en extra inspanning, blijken ook de frequentie, de lengte, het moment, en de complexiteit van de onderbreking de effecten te beïnvloeden.

De gegevens van deze enquête werden in een gesimuleerde kantooromgeving nader onderzocht. In het eerste experiment, beschreven in Hoofdstuk 5, werd de invloed van de frequentie, de complexiteit en het moment van de onderbreking op het werk

en het welzijn van de werkers onderzocht. Als proefpersonen fungeerden 40 secretaresses. Tijdens de uitvoering van bepaalde taken werden de proefpersonen, op een vooraf vastgesteld moment in de taakuitvoering, onderbroken door een telefoontje van de proefleider. Uit de onderzoeksgegevens blijkt dat de proefpersonen weliswaar meer tijd nodig te hebben om hun taak af te ronden naarmate zij vaker worden onderbroken, maar dat de tijd die nodig is voor het uitvoeren van de primaire taak afneemt. De kwaliteit van de arbeidsprestatie wordt niet beïnvloed door de onderbreking. Tevens blijkt dat proefpersonen de telefoon later opnemen naarmate zij vaker worden gestoord. Aan de andere kant blijkt een complexe onderbreking (d.w.z een meer ingewikkelde opdracht) naast negatieve effecten op de uitvoering van het werk, ook een stimulerend effect te hebben op het persoonlijk welbevinden van de proefpersonen. Blijkbaar zorgt de onderbreking voor enige afwisseling tijdens het, toch wat, saaie werk. Het moment van de onderbreking blijkt het werk en het welbevinden van de persoon nauwelijks te beïnvloeden. Algemeen kan worden gesteld, dat de proefpersonen efficiënter gaan werken wanneer zij (vaker) in het werk worden onderbroken. Dit brengt echter psychologische kosten met zich mee, in de vorm van een afname van positieve emoties en een toename van de benodigde mentale inspanning.

Het tweede experiment, beschreven in Hoofdstuk 6, vond eveneens plaats in de gesimuleerde werkomgeving. In dit experiment werd onderzocht hoe een onderbreking-gerelateerde emotie het werk van 30 studenten beïnvloedt. Hiertoe werden tijdens de uitvoering van een reeks computer-taken een drietal onderbrekingen geïntroduceerd, op vaste tijdstippen. Tijdens de eerste onderbreking werd neutrale informatie gegeven. De twee andere onderbrekingen bevatten positieve, negatieve of neutrale informatie over de prestatie van de proefpersoon. Uit de resultaten blijkt, dat emoties inderdaad het werk ongunstig kunnen beïnvloeden, vooral wanneer er sprake is van negatieve onderbreking-gerelateerde emoties. De effecten zijn vooral zichtbaar na de eerste onderbreking die emoties oproept. Evenals in het eerste experiment compenseren de proefpersonen de negatieve effecten van een onderbreking: er wordt geen effect gevonden op de totale werktijd, terwijl de psycho-fysiologische kosten hoger zijn. Deze situatie ontstaat vooral wanneer er onderbreking-gerelateerde emoties in het spel zijn.

De resultaten van dit onderzoek geven aan, dat dagelijks voorkomende onderbrekingen het werk en het welbevinden van de werker beïnvloeden. Duidelijk wordt dat een onderbreking niet alleen betekent dat er extra activiteiten dienen te worden uitgevoerd, en dat bijbehorende cognitieve en psycho-fysiologische processen worden geactiveerd. De resultaten geven eveneens aan dat onderbrekingen de verdere taakuitvoering en het welzijn van de werker beïnvloeden. Uit het onderzoek blijkt tevens dat onderbreking-gerelateerde-emoties het werk nog eens extra negatief kunnen beïnvloeden. Daarbij kiezen de werkers een zodanige strategie dat de uiteindelijke prestatie niet of nauwelijks wordt beïnvloed. Het bereiken van dit "positieve" werkresultaat is blijkbaar belangrijker dan een (mogelijk) negatief welbevinden. Wij veronderstellen echter, dat "mentale informatie werkers" niet altijd de negatieve effecten op de prestatie (zullen kunnen)

compenseren met bijvoorbeeld extra inspanning. Eveneens veronderstellen we dat er een moment zal zijn waarop de negatieve effecten op het persoonlijk welbevinden belangrijker zullen worden dan het bereiken van het gewenste werkdoel. Dit onderzoek geeft echter geen antwoord op de vraag waar dit punt ligt of wanneer dit punt bereikt wordt. Meer, en eventueel longitudinaal, onderzoek zal hierop wellicht een antwoord op kunnen geven.

Verdere suggesties voor vervolgonderzoek worden gedaan in het laatste hoofdstuk. Met de toename van het gebruik van informatica en communicatie (Internet) lijkt verder onderzoek naar mentaal informatie werk zeer zinvol. Zo is meer onderzoek nodig naar, bijvoorbeeld, de invloed van de frequentie van de onderbrekingen en naar de effecten van onderbrekingen bij andere beroepsgroepen. Ook een factor als tijdsdruk dient onderzocht te worden. Uit ons onderzoek blijkt dat de Handelingstheorie hierbij behulpzaam kan zijn. Tevens lijkt het goed om de rol van emoties tijdens het werk hierbij te betrekken, zodat theorieën over emoties en werk zich verder kunnen ontwikkelen.

De meer algemene conclusie van ons onderzoek is, dat onderbrekingen niet noodzakelijk een negatieve invloed hebben op het werk. Werkers compenseren eventuele negatieve effecten, maar dit gaat ten koste van het persoonlijk welbevinden. Aanpassingen van de werkomstandigheden, zoals een aantal uren ongestoord kunnen werken of met niet teveel mensen in dezelfde ruimte werken, zouden negatieve effecten terug kunnen dringen. Daarbij dient niet te worden vergeten dat, juist wanneer het werk niet uitdagend is, onderbrekingsvrije periodes niet te lang mogen duren. Zoals uit ons onderzoek blijkt, kunnen onderbrekingen dan juist positieve effecten teweeg brengen. Onderbrekings-vrije werkperiodes dienen dan ook afgewisseld te worden met periodes waarin de werker gestoord kan (en mag) worden. Verder onderzoek is noodzakelijk voordat alle aspecten van onderbrekingen duidelijk zijn. Wij hopen dat zowel het werkresultaat als het persoonlijk welbevinden van de werker voordeel van dergelijk onderzoek zullen ondervinden.

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APPENDIX A: *QUESTIONNAIRE OF THE SURVEY STUDY*

Deel 1. Persoonlijke gegevens

1.1 Wat is de hoogst genoten opleiding die U heeft afgerond?
lager onderwijs/middelbaar onderwijs/lager beroepsonderwijs/
middelbaar beroepsonderwijs/hoger beroepsonderwijs/wetenschappelijk onderwijs
1.2 Wat is Uw leeftijd?
1.3 U bent vrouw/man
1.4 Hoe lang bent U in dienst bij Uw huidige werkgever?
1.5 Wat is Uw beroep/functie?

Deel 2. Algemene werkzaamheden

2.1 Hoe lang vervult U dit beroep/deze functie bij dit bedrijf?
2.2 Wat zijn Uw belangrijkste dagelijkse werkzaamheden?
2.3 Met hoeveel mensen werkt U in één ruimte?
2.4 Geeft U leiding? nee/ja, aan ..... mensen
2.5 Kunt U omschrijven hoe U Uw werk aanpakt, bijvoorbeeld wat betreft planning, het stellen van prioriteiten e.d. (werkstrategie)?

Kunt U op onderstaande 5-puntsschaal aangeven in hoeverre de volgende kenmerken op Uw werkzaamheden van toepassing zijn? Omcirkel het cijfer van Uw keuze, waarbij antwoordcategorie **1 nooit/geen** betekent: de bewering is absoluut niet op U of Uw werkzaamheden van toepassing; antwoordcategorie **5 altijd/veel** betekent: de bewering is geheel op Uw of Uw werkzaamheden van toepassing; de antwoordcategorieën **2, 3 en 4** geven aan dat de bewering bijna nooit, soms en bijna altijd op U of op Uw werkzaamheden van toepassing is.

1	2	3	4	5
nooit	bijna nooit	soms	bijna altijd	altijd

2.6 In hoeverre bent U voor het uitvoeren van Uw werkzaamheden afhankelijk van overleg met anderen?
2.7 Ik ben tevreden met mijn werk
2.8 Ik ben vrij in het kiezen van mijn eigen werk methode
2.9 Ik heb veel variatie in mijn werkzaamheden
2.10 Ik ben vrij in het bepalen van de volgorde van mijn werkzaamheden
2.11 Mijn werk bestaat veelal uit routinematige werkzaamheden
2.12 Het uitvoeren van mijn werk vraagt veel concentratie
2.13 Voor het oplossen van problemen bestaan standaardprocedures
2.14 Ik ben vrij in het bepalen van de hoeveelheid tijd die ik aan een taak besteed
2.15 Mijn werk bestaat hoofdzakelijk uit lichamelijke arbeid
2.16 Mijn werk bestaat hoofdzakelijk uit denktaken
2.17 Ik heb veel te maken met het werken onder tijdsdruk

2.18 Mijn werk bestaat steeds uit nieuwe (niet met elkaar samenhangende) werkzaamheden
2.19 In mijn werk heb ik te maken met voorgeschreven regels/procedures
2.20 Wanneer ik in mijn werk word gestoord is het moeilijk om mijn geplande werk af te maken
2.21 Het werk dat ik doe boeit mij
2.22 Ik bepaal mijn eigen onderbrekingen/ pauzes

Deel 3. De omstandigheden van onderbrekingen in Uw werkzaamheden en Uw reacties hierop.

3.1 Door welke onderbreking wordt U zodanig gestoord dat U Uw werk moet onderbreken?
3.2 Hoe vaak gebeurt dit per dag
3.3 Hoe lang duurt deze storing gemiddeld?
3.4 Kunt U aangeven hoe lang het duurt (in minuten) voordat U weer op Uw oude functioneringsniveau terug bent?
3.5 Op welk moment tijdens de uitvoering van een taak ervaart U een onderbreking als het meest storend? begin, midden of eind van de taak
3.5b De reden hiervoor is...

Kunt U weer op onderstaande 5-puntsschaal aangeven in hoeverre de volgende kenmerken op Uw werkzaamheden van toepassing zijn? Omcirkel het cijfer van Uw keuze, waarbij antwoordcategorie **1 nooit/geen** betekent: de bewering is absoluut niet op U of Uw werkzaamheden van toepassing; antwoordcategorie **5 altijd/veel** betekent: de bewering is geheel op Uw of Uw werkzaamheden van toepassing; de antwoordcategorieën **2, 3 en 4** geven aan dat de bewering bijna nooit, soms en bijna altijd op U of op Uw werkzaamheden van toepassing is. Bij sommige vragen wordt U gevraagd het antwoord toe te lichten.

3.6 In hoeverre kunt U het tijdstip van een onderbreking voorspellen, m.a.w weet U wanneer een onderbreking gaat optreden?
3.7 Is er sprake van overeenkomst in de inhoud van de onderbreking en Uw (oorspronkelijke) werk?
3.8 Verandert de strategie (planning, stellen van prioriteit e.d.) van Uw werk zoals U dat in vraag 2.5 hebt beschreven als gevolg van de onderbreking?
3.8b Kunt U aangeven hoe Uw strategie van werken verandert?
3.9 Reageert U emotioneel op een onderbreking?
3.9b Kunt aangeven hoe, en waardoor dit komt?
3.10 Verandert Uw werkwijze wanneer U vaak in Uw werk wordt onderbroken?
3.10b Hoe verandert Uw werkwijze dan?
3.11 Is er variatie in de inhoud van de onderbreking?
3.12 Ervaart U het voorkomen van onderbrekingen in het algemeen als positief of als negatief? positief, ga door naar vraag 3.13/ negatief, ga door naar vraag 3.14

3.13 Hoe vaak ervaart U het voorkomen van onderbrekingen als positief?
3.13b Waarom ervaart U de onderbreking als positief?
3.14 Hoe vaak ervaart U het voorkomen van onderbrekingen als negatief?
3.14b Waarom ervaart U de onderbreking als negatief?
3.15 Raakt U gewend aan het optreden van onderbrekingen?
3.16 Zijn er speciale vaardigheden vereist wanneer, door de onderbreking, een andere taak moet worden uitgevoerd?
3.16b Zijn dat vaardigheden in kennis/omgangsvormen/anders, en wel
3.17 In hoeverre bent U ervaren in het oplossen/beantwoorden van de onderbreking?
3.18 In hoeverre bestaan er regels/standaard procedures voor het beantwoorden/oplossen van de onderbreking?
3.19 In hoeverre raakt U vermoeid als gevolg van de onderbreking?
3.20 Heeft U moeite om de oorspronkelijke werkzaamheden weer op te pakken na de onderbreking?
3.21 Heeft U moeite om zich weer te concentreren op Uw oorspronkelijke taak?
3.22 Heeft U moeite om gemotiveerd verder te gaan werken?
3.23 In hoeverre ervaart U een onderbreking als een rustpauze in Uw werkzaamheden?
3.24 Gaat U na het einde van de onderbreking direct weer verder met de oorspronkelijke taak?
3.24b Indien U niet direct verder gaat met Uw oorspronkelijke taak, wat gaat U dan na de onderbreking doen?
3.25 Probeert U onderbrekingen te vermijden?
3.25b Hoe tracht U onderbrekingen te vermijden?
3.26 In hoeverre heeft U lichamelijke klachten als gevolg van de storingen?
3.26b Welke klachten zijn dit?
3.27 In hoeverre heeft U mentale klachten als gevolg van onderbrekingen?
3.27b Welke klachten zijn dit?
3.28 In hoeverre vraagt de onderbreking om lichamelijke inspanning?
3.29 In hoeverre vraagt de onderbreking om mentale inspanning?
3.30 Gaat U meer of minder fouten maken in de oorspronkelijke taak nadat Uw werk werd onderbroken? Of maakt het geen verschil?
3.31 Hoe vaak gaat het uitvoeren van de oorspronkelijke taak moeilijker nadat de onderbreking is beëindigd/beantwoord?
3.32 Bent u bang dat U, a.g.v. de onderbreking, de oorspronkelijke taak niet goed uitvoert?
3.33 Bent u bang dat U de onderbreking, wanneer deze de uitvoer van een andere taak inhoudt, niet goed uitvoert?
3.34 Voelt U zich gespannen nadat U weer met Uw (oorspronkelijke) werk verder gaat?
3.35 Voelt U zich gespannen tijdens de uitvoer/beantwoorden van de onderbreking?

APPENDIX B: *INSTRUCTIONS OF EXPERIMENT 1*

Instructie Experiment Kantoor gebruik

U doet mee aan een onderzoek naar het gebruik van moderne kantoorruimtes. U krijgt in dit onderzoek enkele eenvoudige kantoortaken. Wij zijn geïnteresseerd in hoe mensen in de moderne kantoren van tegenwoordig hun werk uitvoeren. Alle gegevens zijn alleen voor de onderzoekers toegankelijk. De verwerking is zoveel mogelijk anoniem: uw naam wordt in de gegevens niet genoemd.

De indeling voor vandaag is als volgt: Als eerste wordt de apparatuur klaargezet. U krijgt elektrodes opgeplakt om uw hartslag te kunnen meten (dit plakken mag u zelf doen, op aanwijzing van de proefleider). Hierna krijgt u **drie keer** een eenvoudige kantoortaak. Er zijn dus drie "sessies". Tussen deze taken in pauzeren we even (mogelijkheid om naar het toilet te gaan of gewoon om even bij te komen). Vóór elke sessie wordt een instructie met u doorgenomen. Hierna krijgt u steeds de gelegenheid om vragen te stellen. Tevens wordt u gevraagd een aantal malen vragenlijsten in te vullen. De proefleider zal hiervoor opdracht geven. Dan beginnen we nu met het aanbrengen van de elektrodes. Hierna bespreken de verdere instructies.

Instructie Dag 1

U bevindt zich in een kantoor met werkeenheden en computers, evenals stapels papier met nog uit te voeren opdrachten e.d. Uw collega's zijn vandaag niet aanwezig waardoor u de enige bent die vandaag werkt. De opdracht die u gaat uitvoeren is een kantoortaak: correcties in een tekst in de computer invoeren. De niet-gecorrigeerde tekst ziet u voor u op het scherm. De verbeterde tekst, die u moet invoeren, staat op papier. U moet alle correcties and opdrachten verwerken en uitvoeren.

Als u klaar bent met de gehele taak belt u de proefleider op 3343. Heeft u nog vragen? Dan mag u nu beginnen met het invullen van de vragenlijsten. Als u hiermee klaar bent kunt u meteen beginnen aan de correctie taak.

Dank voor uw medewerking en succes.

Instructie tweede onderdeel

Nu beginnen we met de tweede sessie. De taak die u krijgt is dezelfde als in de eerste taak: correcties in een tekst in de computer invoeren. De niet-gecorrigeerde tekst ziet u voor u op het scherm. De verbeterde tekst, die u moet invoeren, staat op papier. Wederom: U moet alle correcties en opdrachten verwerken en uitvoeren.

Als u klaar bent met de gehele taak belt u de proefleider op 3343. Ook na deze taak is er een pauze. Heeft u nog vragen? Dan kunt u meteen beginnen aan de

correctietaak.

Succes.

Instructie derde en laatste onderdeel

Dit is het laatste onderdeel van vandaag (begint u zich al thuis te voelen in dit kantoor?) De instructie voor dit onderdeel is gelijk aan die van de eerste twee onderdelen, in het kort: U bevindt zich in een kantoor en u bent vandaag de enige bent die werkt. Uw taak is een soort correctie taak. De niet-gecorrigeerde tekst ziet u voor u op het scherm. De verbeterde tekst, die u moet invoeren, staat op papier. U moet alle correcties en opdrachten verwerken en uitvoeren.

Als u klaar bent met de gehele taak belt u de proefleider op 3343. Heeft u nog vragen? Dan kunt u meteen beginnen aan de correctietaak.

Dank voor uw medewerking en succes.

Opzet experiment Kantoor Gebruik Dag 2

Dit is de tweede dag van het onderzoek naar het gebruik van moderne kantoorruimtes. De opzet van vandaag wijkt niet af van die van gisteren. U krijgt in dit onderzoek ook vandaag enkele eenvoudige kantoortaken. Zoals u weet zijn wij geïnteresseerd in hoe mensen in de moderne kantoren van tegenwoordig hun werk uitvoeren.

De indeling voor vandaag is als volgt: Als eerste wordt weer de apparatuur klaargezet. U krijgt weer elektrodes opgeplakt om uw hartslag te meten. Hierna krijgt u ook vandaag **drie keer** een eenvoudige kantoortaak. Er zijn dus weer drie "sessies". Tussen deze taken in pauzeren we even (mogelijkheid om naar het toilet te gaan of gewoon om even bij te komen). Vóór elke sessie wordt een instructie met u doorgenomen. Hierna krijgt u steeds de gelegenheid om vragen te stellen. Dan beginnen we nu met het aanbrengen van de elektrodes. Hierna bespreken de verdere instructies.

Instructie

U bevindt zich in een kantoor met werkeenheden en computers, evenals stapels papier met nog uit te voeren opdrachten e.d. Uw collega's zijn vandaag niet aanwezig waardoor u de enige bent die vandaag werkt. De opdracht die u gaat uitvoeren is een kantoortaak: correcties in een tekst in de computer invoeren. De niet-gecorrigeerde tekst ziet u voor u op het scherm. De verbeterde tekst, die u moet invoeren, staat op papier. Tevens wordt u verzocht een aantal vragenlijsten in te vullen De proefleider zal u hiervoor opdracht geven. U moet alle correcties en opdrachten verwerken en uitvoeren.

Als u klaar bent met de gehele taak belt u de proefleider op 3343. Heeft u nog

vragen? Dan mag u nu beginnen met het invullen van de vragenlijsten. Als u hiermee klaar bent kunt u meteen beginnen aan de correctie taak.

Dank voor uw medewerking en succes.

Instructie tweede onderdeel

Nu beginnen we met de tweede sessie van vandaag. De taak die u krijgt is inmiddels bekend: correcties in een tekst in de computer invoeren. De niet-gecorrigeerde tekst ziet u voor u op het scherm. De verbeterde tekst, die u moet invoeren, staat op papier. Wederom: U moet alle correcties en opdrachten verwerken en uitvoeren.

Als u klaar bent met de gehele taak belt u de proefleider op 3343. Ook na deze taak is er een pauze. Heeft u nog vragen? Dan kunt u meteen beginnen aan de correctietaak

Succes.

Instructie derde en laatste onderdeel

Dit is het laatste onderdeel van dit experiment. De instructie voor dit onderdeel is gelijk aan die van de eerdere onderdelen: correcties in een tekst in de computer invoeren. De niet-gecorrigeerde tekst ziet u voor u op het scherm. De verbeterde tekst, die u moet invoeren, staat op papier. U moet alle correcties en opdrachten verwerken en uitvoeren.

Als u klaar bent met de gehele taak belt u de proefleider op 3343. Heeft u nog vragen? Dan kunt u meteen beginnen aan de correctietaak.

Dank voor uw medewerking en succes.

APPENDIX C: *LIST OF INTERRUPTIONS EXPERIMENT 1*

Simpele onderbreking:

* Kunt u voor mij iets opzoeken in het **telefoonboek van Amsterdam**? Dit ligt naast de computer. Kunt u mij het telefoonnummer geven van: Nederlandse Spoorwegen (via Nederlands en Spoorwegen) station Sloterdijk? (020- 5578143). En ook van Boekhandel Allert de Lange op het Damrak (62) (tel 020-246744).

*In de tekst op pagina 3 staat een voetnoot. Op papier is deze weggevallen. Kunt u mij vertellen wat er in de tekst op de computer staat? Voor tekst A tot en met F:

A: ze zijn weggewist door de trend.

B: wij bouwden de welvaarts- en verzorgingsstaat en daarvan profiteerde iedereen.

C: uit: 'Politici en Informatie: gegevens van ons allemaal'. Van Stokkom: 1984.

D: Melvin Lerner: 'Geloof in een rechtvaardige wereld'. University of Waterloo, Canada.

E: hiermee wordt het CDA bedoeld

F: zoals het ingooien van ruiten

* Aan het einde van de tekst bevindt zich een korte literatuurlijst waarin nog een auteur mist. Kunt u dit nu direct invoeren? De auteur is **(vet invoeren)**: Voor tekst A tot en met F:

A: Derakhshan, F. & **Fatehi, K.** (1985).

B: Derrick, W.L. (1981): erbij **Wierville, W.W.**

C: Deal, T.E. (1985) erbij: **Jelinek, M.**

D: Martin, C. (1976) erbij: **Meyerson** D.

E: Gabriel, S.S. & Dallos, V..,..... erbij: **Brill**, G.C.

F: Tanner, W.A. &Issa, M.M. erbij: **Inglis**, G.S.

* Aan het einde van de tekst bevindt zich een korte literatuurlijst. Er mist een deel van de titel. Kunt u dit direct invoeren? **(vet invoeren)** Voor tekst A tot en met F:

A: Podsakoff, P.M., Todor, W.D., Grover, R.A. & Huber, V.L. (1984) Situational moderators of leader reward and punishment behaviors: Fact or **Fiction**? Organizational Behavior and Human Performance, vol 34, 21-63.

B:Boxtel, A. van., & Jessurun, M. (in press). Amplitude and bilateral coherency of facial and jaw-elevator EMG activity as an index of **effort** during a serial choice reaction task. Accepted for publication in Psychophysiology (to appear in Sept. 1993).

C: Donaldson, D. & Lorsch, J.W. (1983) Decision making of the Top **of an organization**

D:Lewin, K., Lippitt, R., & White, R.K. (1939). Patterns of aggressive behavior in experimentally created 'social **climates**'. Journal of Social Psychology, 10, 271-299.

E: Fraser, A.R. Orthonyx-Theory and **practice**. British Journal of chiropody, 1968, November: 249

F: Pettine, K.A., Cofield, R.H., Johnson, K.A., Bussey, R.M. Ingrown Toenail: Results of surgical **treatment**. Foot & Ankle, 1988; 9, nr 3:130-4.

Complexe onderbreking:

* Kunt u van de stapel die naast de computer ligt, de dossiermap pakken waarop

staat **OPDRACHT 1. Wundt** Kunt u de tekst nalezen en corrigeren op typefouten (dus aangeven met pen). Kunt u dit nu direct doen dan kom ik de tekst zo meteen halen.
*Kunt u van de stapel die naast de computer ligt, de dossiermap pakken waarop staat **OPDRACHT 2. Frijda** Kunt u de tekst nalezen en corrigeren op typefouten (dus aangeven met pen). Kunt u dit nu direct doen dan kom ik de tekst zo meteen halen.
*Kunt u van de stapel die naast de computer ligt, de dossiermap pakken waarop staat **OPDRACHT 3. De VS** Kunt u de tekst nalezen en corrigeren op typefouten (dus aangeven met pen). Kunt u dit nu direct doen dan kom ik de tekst zo meteen halen.
*Kunt u van de stapel die naast de computer ligt, de dossiermap pakken waarop staat **OPDRACHT 4. De Vos** Kunt u de tekst nalezen en corrigeren op typefouten (dus aangeven met pen). Kunt u dit nu direct doen dan kom ik de tekst zo meteen halen.

APPENDIX D: *INSTRUCTIONS OF EXPERIMENT 2*

Algemene Instructie

Trainingsessie:
Allereerst willen we je hartelijk bedanken voor je deelname aan dit experiment. Je bevindt je hier in het Laboratorium voor Informatie Arbeid. Het experiment behelst de uitvoering van een aantal WordPerfect-taken ingebed in een grotere opdracht waarin enkele activiteiten worden georganiseerd.
Bij het werkelijke experiment krijg je nadere uitleg over de opdracht.
In deze trainingsessie worden enkele van de uit te voeren taken kort doorgenomen om je enigszins vertrouwd te maken met de opdracht en de gang van zaken in dit laboratorium. Tevens dient deze dag voor de afname van een viertal speekselmonsters, die op ieder heel uur zullen plaatsvinden. Na voltooiing van het werkelijke experiment vul je een declaratie-formulier in, waarna de beloning van *f* 10,- per uur zo snel mogelijk op je bank- of girorekening zal worden overgemaakt.

Werkelijke Experiment:
Gedurende het werkelijke experiment zullen diverse (fysiologische) maten worden geregistreerd, waarvoor enkele elektroden worden aangebracht. Tijdens deze fase (voorafgaand aan het experiment) krijg je drie vragenlijsten in te vullen.
Je krijgt hier bovendien een korte, algemene vragenlijst in te vullen. Het experiment bestaat uit drie sessies die ieder ± 45 minuten duren. Na elke sessie heb je een pauze, waarin een speekselmonster wordt genomen en twee vragenlijsten worden ingevuld. Tevens krijg je iets te drinken en heb je de mogelijkheid voor een sanitaire pauze.

Mocht zich gedurende de taak-uitvoering een noodgeval voordoen, dan kun je de proefleiders bellen onder nummer **2610**. Indien er na het lezen van deze instructie nog vragen zijn, kun je deze aan de proefleiders stellen.

Algemene opdracht

Stel je voor dat je lid bent van een studentenvereniging. Deze vereniging organiseert een internationale week in samenwerking met de KUB, waarbij een congres "Europe 2000" wordt afgewisseld met ontspannende en gezellige activiteiten. Deze internationale bijeenkomst zal eind augustus plaatsvinden en duurt 5 dagen. De eerste twee dagen (maandag en dinsdag) staan in het teken van gezelligheid. Door middel van sport en spel leren de deelnemers elkaar en elkaars talen en cultuur beter kennen. De twee daaropvolgende dagen wordt het congres "Europe 2000" gehouden. De laatste dag zal weer gevuld worden met ontspannende activiteiten. De meeste deelnemende buitenlandse studenten zijn reeds in Nederland, anderen komen rechtstreeks vanuit enkele buitenlandse steden. Ze komen allen met de trein naar Tilburg.

Voordat zo'n internationale week kan worden verwezenlijkt moet er van alles georganiseerd en geregeld worden. In dit experiment zal jij je bezig gaan houden met enkele van deze activiteiten.

In het kort zijn deze activiteiten als volgt:
-Een poster maken voor de werving van vrijwilligers.
-Telefoonnummers en postcodes opzoeken van een aantal reeds ingeschreven vrijwilligers.
-Adressenlijst aanvullen met opgezochte gegevens.
-Weekrooster met activiteiten aanvullen.
-Treinreizen opzoeken met behulp van de NS Reisplanner.
-Treinreisgegevens verwerken in een tabel.
-Introductietekst over Tilburg schrijven aan buitenlandse studenten.
-Optimale routes plannen voor het ophalen van studenten.
-Routes in kolommen zetten + afrondende handelingen verrichten.

Iedere taak bestaat uit een aantal gebundelde formulieren die in **postvak A** liggen. Hierin staan de specifieke instructies en worden, afhankelijk van de taak, invul-formulieren en help-informatie toegevoegd. Voorts liggen op het bureau een Basishandleiding WordPerfect 5.1 en enkele kopieën van een WordPerfect-handboek waarin belangrijke informatie met betrekking tot de gebruikte WP-functies wordt uiteengezet. Bij de WP-taken zal - indien nodig - worden aangegeven waar je help-informatie kunt krijgen. De instructies staan altijd op het formulier genaamd **Taak x: Instructie-formulier**. Dit formulier is steeds het eerste van de bundel. Nadat een taak is afgewerkt dienen de betreffende formulieren in **postvak B** dan wel **postvak C** te worden gelegd en kun je direct de formulieren van de volgende taak uit postvak A nemen. De aanwijzingen hiervoor staan onder aan de instructie- en invul-formulieren en beginnen steeds met --->.
Deze procedure herhaalt zich totdat je een formulier "**Einde Sessie - Pauze**" uit het postvak neemt. Op dat moment heb je enkele minuten rust. Ondertussen krijg je twee korte vragenlijsten in te vullen en wordt een speekselmonster afgenomen.
Bij de uitvoering van de taken is het gebruik van potlood en papier in principe toegestaan, tenzij anders wordt vermeld. Beschrijf de formulieren met uitzondering van de invul-formulieren in ieder geval nooit.

Belangrijk: Lees de taak-instructies steeds goed door. Daarin staat relevante informatie voor de specifieke opdrachten en eventuele verwijzingen naar hulp bij de uitvoering van de taken.

Let op: De opdracht is zodanig gedefinieerd dat iedere taak in 10 à 15 minuten kan worden afgewerkt. Probeer je aan deze richttijd te houden.

Als je deze instructie hebt gelezen kun je mogelijke vragen aan de onderzoeks-leiders stellen. Deze verlaten nadien de ruimte en geven je een teken dat je met de opdracht kunt beginnen. Op dat moment neem je de formulieren van Taak 1 uit postvak A en wordt het feitelijke experiment gestart. Leg dit formulier nu in Postvak B. Succes

APPENDIX E: *LIST OF INTERRUPTIONS EXPERIMENT 2*

Procedure Aanbieding Onderbrekingen

Neutrale Onderbreking:
* Proefleider klopt eenmaal en opent direct de deur. Proefleider kijkt proefpersoon aan en zegt tegen hem, terwijl hij naar de Nihon Kohden loopt: "Sorry, *Naam proefpersoon*, ik moet even de afstellingen controleren." Kun je even rechtop zitten? Proefleider bekijkt gedurende een aantal seconden de afstellingen, geeft de proefpersoon aan dat hij verder kan werken en verlaat dan de ruimte.

Negatieve Onderbreking:
* Proefleider klopt eenmaal en opent direct de deur. Proefleider blijft in de deuropening staan en zegt tegen proefpersoon: "Zeg, *Naam proefpersoon*, ik weet dat het maar een experiment is, maar wil je wel serieus mee blijven doen." Proefleider verlaat direct daarna weer de ruimte, zonder op een reactie van proefpersoon te wachten.

Positieve Onderbreking:
* Proefleider klopt eenmaal en opent direct de deur. Proefleider blijft in de deuropening staan en zegt tegen proefpersoon: "Hai, *Naam proefpersoon*, je bent heel erg serieus met dit experiment bezig. Prima zo!" Proefleider verlaat direct daarna weer de ruimte, zonder op een reactie van proefpersoon te wachten.

DANKWOORD

Na vier jaren van onderzoek bij de sectie arbeids- en organisatiepsychologie in Tilburg, was de voltooiing van dit proefschrift, thuis in Groningen, een eenzaam proces. Maar het is gelukt; het is klaar. Iedereen die, in welke vorm dan ook, heeft bijgedragen aan het tot stand komen ervan, wil ik hierbij bedanken. Een aantal mensen wil ik met name noemen.

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In Tilburg was er altijd wel een kamergenoot of mede-AiO in de buurt om een probleem mee te bespreken of om even koffie mee te drinken. Met name Titia Meijer, Joost Taggenbrock, Jos van der Wielen, Reinout de Vries, Charissa Freese, Christina Fernandes da Costa en Edith Josten hebben hierin een bijdrage gehad. Bij het oplossen van problemen tijdens het schrijfproces heb ik veel gehad aan de e-mailtjes en telefoongesprekken met Edith.

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Lieve Anne Cees en Jelle, het is gelukt, het is klaar. Het Groninger land, met zijn Onneres en Onnerpolder, een mooie boerderij, en een weiland met schapen, ligt op ons te wachten. Het is mooi.....

Groningen, 16 juli 1999

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