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The effects of pause software on the temporal characteristics of computer use

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The study investigated the natural work–pause pattern of computer users and the possible effects of imposing pause regimes on this pattern. Hereto, the precise timing of computer events was recorded across a large number of days. It was found that the distribution of the pause durations was extremely skewed and that pauses with twice the duration are twice less likely to occur. The effects of imposing pause regimes were studied by performing a simulation of commercially available pause software. It was found that depending on the duration of the introduced pause, the software added 25–57% of the pauses taken naturally. Analysis of the timing of the introduced pauses revealed that a large number of spontaneous pauses were taken close to the inserted pause. Considering the disappointing results of studies investigating the effects of introducing (active) pauses during computer work, this study has cast doubt on the usefulness of introducing short duration pauses.

Keywords: Computer use; Pause software; Exposure variability; Work–pause pattern

1. Introduction

It is commonly acknowledged that physical load factors such as excessive force, frequent bending and twisting, repetitive motions and static posture contribute to the occurrence of musculoskeletal disorders. Consequently, guidelines (Comité Europeen de Normalisation 1995, Fallentin *et al.* 2001), standards (Comité Europeen de Normalisation 1995) and national legislation (European Communities 1990, Swedish National Board 1998) have been implemented to promote variation in loading patterns.

However, recent reviews of the literature by Burdorf *et al.* (2003) and Mathiassen and Christmansson (2003) indicate that the effects of increasing variation are only supported by vague or indirect empirical evidence. These authors argue that there are only few

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studies explicitly addressing variation and musculoskeletal disorders and that there are insufficient methods for quantifying variation.

For example, one of the most frequently recommended interventions against musculoskeletal disorders is the introduction of more rest breaks (Sundelin and Hagberg 1989, Kopardekar and Mital 1994, Genaidy *et al.* 1995, Mathiassen and Winkel 1996, Henning *et al.* 1997, Galinsky *et al.* 2000, Dababneh *et al.* 2001, McLean *et al.* 2001). A reason why the effects of short organized rest breaks on fatigue and discomfort have been shown to be only weak might be that the additional rest breaks are not sufficient to significantly alter the work–pause pattern. That is, the additional breaks might not contribute significantly compared to the large amount of variation already obtained through natural and regulatory breaks present in the job, and through exposure variability associated with the task(s).

In recent years, several innovations have been developed to adjust break schedules to the actual work load, taking into account the breaks that users take naturally. In particular, during computer use, work can be regulated by pause software, which can administer additional pauses depending on the actual computer use of an individual user.

Such pause software works by administering a pause of a particular length when a period of continuous computer use (without pauses) has been exceeded (computer use limit). A threshold (pause definition) is used to define how far two recorded computer events are allowed to be separated in time to be classified as continuous work. For instance, a pause definition of 30 s would mean that the time between all recorded computer events larger than 30 s is classified as a pause. When a particular pause regime is implemented, several computer use limits are often used simultaneously, after each continuous period of use a corresponding pause of a particular duration is administered (pause duration). So, computer users receive both micro pauses (5–30 s) after a relatively short period of computer use and macro pauses (5–30 min.) after longer periods of use.

From studies using both self-administered questionnaires and external observers, it is known that users tend to overestimate the time they work behind the computer (Faucett and Rempel 1996, van der Beek and Frings-Dresen 1998, Burdorf and van der Beek 1999, Homan and Armstrong 2003, Heinrich *et al.* 2004). Some studies (Homan and Armstrong 2003, Heinrich *et al.* 2004) have therefore investigated whether work times, as measured by pause software or by external observers, correspond. Results indicate that a pause definition between 20 and 30 s yields work times in reasonable correspondence with the work times reported by observers.

The choice for the specific values of pause duration, computer use limit and pause definition that make up the pause regimes seem arbitrarily chosen. That is, no research has been published on how these regimes alter the total number of pauses that computer workers take. This is surprising since this software is used by over 1 million computer users worldwide (i.e. www.workpace.com), forms an important method for regulating the amount of time spent behind the computer and is used to guide (inter)national legislation (European Communities 1998, 1990) regarding workload during computer use.

Since pause software developers claim that their software reduces the risk of developing complaints of the upper extremity, the authors were interested as to what extent the implementation of additional breaks can alter the work–pause pattern of computer users. Whether the administration of additional pauses has possible health benefits is beyond the scope of the current study.

In order to precisely determine the time-pattern of computer use during a working day, a new software tool was developed. This software records, during normal computer use, the times at which the mouse and the keyboard are used. This enables the authors to reconstruct time traces over extensive periods of time for a variety of computer users.

In order to determine the computer user's natural working behaviour, a detailed analysis on the recorded time traces was performed. To study the effect of different pause regimes on worker's pattern of computer use, this study performed a simulation of how this pattern, as measured by the registration software, would be altered under the influence of different pause regimes. That is, based on the criteria and thresholds that make up a pause regime, pauses of specific durations were inserted in the recorded time traces. Using a simulation, instead of administering different pause regimes to different users in a controlled trial, made it possible to estimate the potential effects of a whole range of changes in the work–pause schedule without being influenced by non-compliance of the users, compensation for non-work periods (speeding-up) and other confounding factors that might influence users' working behaviour.

The current study posed the following specific questions regarding the temporal variability of computer use and the influence of imposing different pause regimes:

1. What are the natural pause patterns that users display?
2. How many pauses would pause software administer to the users and how do these numbers compare to the number of pauses taken spontaneously?
3. Is the timing of the inserted pauses appropriate, that is, how long would it take before a computer user would take a similar pause spontaneously?

2. Methods

Custom-built registration software was installed on the computers that were used by 20 healthy employees of the academic hospital in Rotterdam, the Netherlands. Participants signed informed consent before entering the study. Before the start of the study participants filled in a small questionnaire, in which they were asked about their computer use. The participants (mean age 33.9 (SD 8.7) years) performed a variety of computer-intensive tasks; eight had an administrative job, six were researchers and six had managerial or other functions. The male ($n = 9$) and female ($n = 11$) participants estimated that they worked for 5.5 ($\pm$1.1) h/d behind the computer and spent 22.4% ($\pm$15.9) of their time doing other work. They also reported taking on average 1.5 ($\pm$1.3) scheduled rest breaks (lunch, coffee etc.) during a working day. Of the participants, 14 worked behind a single computer while six worked with two computers. According to the participants, they worked on average for 36.4 ($\pm$7.7) h per week.

The software registered with a frequency of 10 Hz the position of the cursor (x, y coordinates in pixels), whenever this position changed. Additional events that the software recorded were key presses, mouse clicks and mouse wheel use (temporal resolution 0.1 s). The software logged these data in the background in order not to interfere with the regular work of the participants. Participants could view daily statistics on their computer use, such as number of keyboard strokes, mouse clicks, mouse moves, etc. Participants were made aware that their computer usage was monitored as part of a study investigating computer usage patterns. Participants were not told that their pause behaviour would be studied. The unobtrusive nature of the installed monitoring software ensured that they quickly forgot that they were being monitored. It is therefore highly unlikely that participants altered their working behaviour as a consequence of participating in the study.

Data were collected centrally and processed offline. A sample of 50 workdays of each participant was selected to ensure the data files (for each participant for every day) contained sufficient data. Data files containing less than 15 000 events were not selected.

2.1. *Data processing*

For each of the 1000 recorded files, the times were extracted at which an event (a mouse movement, mouse click, mouse wheel use or keyboard stroke) was recorded. These time series, in which no distinction was made between the different types of events, were used to calculate the distributions of pause durations for each participant and day. In order to compare these distributions across participants and days, coefficients of variation (CV) were calculated, across participants and days, for a range of pause durations.

Additionally, the obtained time traces were used to simulate the effects of pause software. To this end, the standard regimes administered by the most commonly used (approximately 800 000 user-licences) pause software in the Netherlands were implemented; Workpace (Wellnomics Ltd., Christchurch, New Zealand).

These pause regimes vary in the level of altering the natural pause behaviour of computer users. Table 1 shows the settings for all the regimes. The regimes consist of implementing micro pauses (durations varying from 5 to 30 s) and macro pauses (5 to 30 min pause) after a specific duration of computer use has been exceeded (computer use limit). On top of this, a daily limit on the total amount of computer use could be imposed (table 1). In accordance with the Workpace software, a pause definition of 30 s was used. During the simulation the appropriate pause was inserted after the computer use limit was reached (see table 1). Since the duration of the micro pauses was always smaller than the pause definition, the insertion of macro and micro pauses could be done in subsequent steps. This yielded simulated time series of days with pauses imposed according to each of the regimes. As can be seen in table 1, the last seven regimes are only used for people

Table 1. The pause regimes* used by the Workpace software.

Pause regime	Pause definition (s)	Computer use limit micro pause (min)	Inserted micro pause (s)	Computer use limit macro pause (min)	Inserted macro pause (min)	Day limit (h)
1 (normal prevention)	30	8	5	60	5	–
2 (normal prevention)	30	7.5	8	50	5	7
3 (normal prevention)	30	6	8	45	6	6.5
4 (past complaints)	30	5	9	45	7	6
5 (past complaints)	30	4.5	10	45	6	6
6 (past complaints)	30	4	10	40	8	5.5
7 (recovery complaints)	30	3.25	12	30	10	4.5
8 (recovery complaints)	30	3	15	20	10	4
9 (recovery complaints)	30	2.5	20	18	15	3
10 (recovery complaints)	30	2	30	10	20	2
11 (recovery complaints)	30	2	30	10	25	1.5
12 (recovery complaints)	30	1.75	30	10	25	1
13 (recovery complaints)	30	1.5	30	10	30	0.5

*Regime 1 administers a 5 s pause after 8 min of consecutive computer use (i.e. without pauses larger than 30 s) and a 5 min pause after 1 h of computer use. No limit on the amount of computer hours per day is imposed for this regime. Regimes 7 to 13 are recommended when computer users are recovering from complaints. Since the participants were healthy volunteers, only regimes 1 to 6 were used in the simulation analysis.

recovering after upper extremity complaints and have extreme limitations on the work that can be performed during a day. As all the participants were without complaints during the period of recording and worked considerable hours behind the computer, simulation of the data for these last regimes would therefore yield results beyond what is normally expected from a working person (i.e. working hours >12 h). The results from the simulations of these regimes are therefore not reported.

3. Results

3.1. *Natural computer pauses*

On average, 50 618 events were recorded for each participant every day (range 17 772–97 000, SD between participants averaged across days: 14 742; mean SD over days, within participants: 9430). Considering that these events could be as close as 0.1 s apart, the total number of the events corresponds to less than 85 min of continuous computer use each day. In contrast, the total time participants worked with the computer, that is, the time from the first recorded event until the last one for a particular day was on average 8 h and 33 min (SD 1.19 h).

Participants exhibited a great number of natural computer pauses of different duration during the day. Figure 1 shows the number of events for every 30 s interval during a

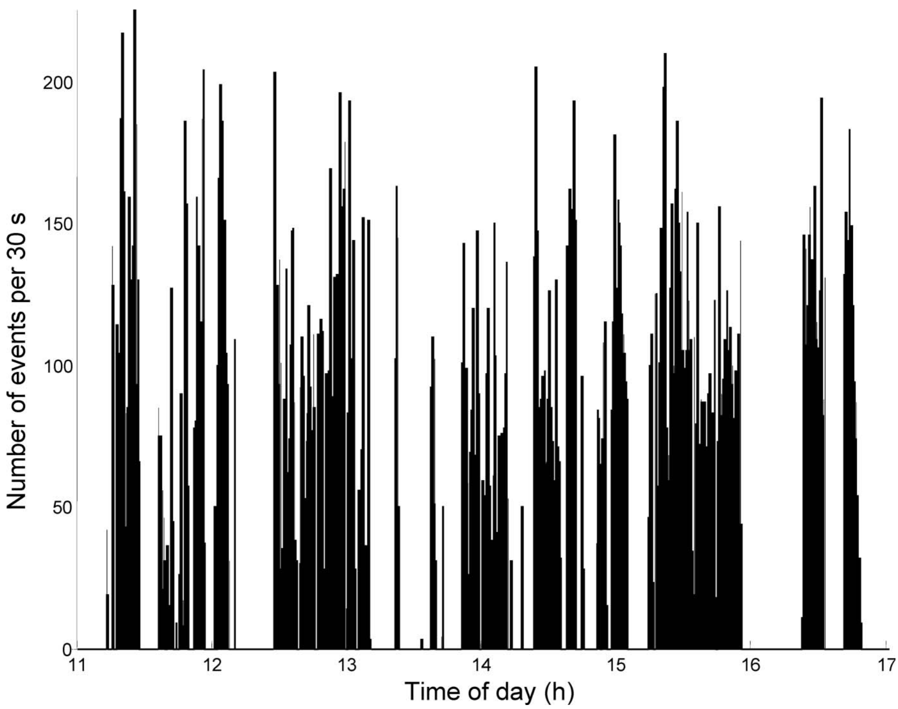

Figure 1. Histogram of the number of events per 30 s for a participant during one particular day. The empty bins (white) show the distribution of pauses over the day. This participant, a research scientist, started working behind the computer at 11.10 hours and stopped just before 17.00 hours on 2 March 2005.

working day of one of the participants. As can be seen, both the duration and timing of the (natural) pauses taken by a participant can vary considerably.

To gain insight into the distributions of pause durations, the number of pauses per hour was counted for a range of pause durations. The short duration pauses occur more frequently than the longer duration pauses. For instance, the majority (96.2%) of all pauses are shorter than 1 s. For pauses larger than 0.5 s, as can be seen in figure 2, a two-fold increase in pause duration leads to a decrease in the number of pauses by a factor of approximately two. The straightness of the curves in the log-log plot of figure 2 indicates that the pause distribution follows a power law.

The variability between participants, as shown in the spread of the different lines in figure 2, can partially be explained by the intensity with which participants worked during each of the 50 days of recording. That is, the more intensely a user works, the more events are recorded each hour, thereby increasing the number of pauses between those events. The lines of the different participants run in a band. This was reflected in CV across participants that were independent of the pause duration (0.29 ± 0.06). The CV for variability across days (within participants) for the different pause durations was somewhat lower (0.22 ± 0.03).

When a pause definition of 30 s was applied, it was found that on average (across days and participants) a working day consisted of 64 working periods, with a mean duration of

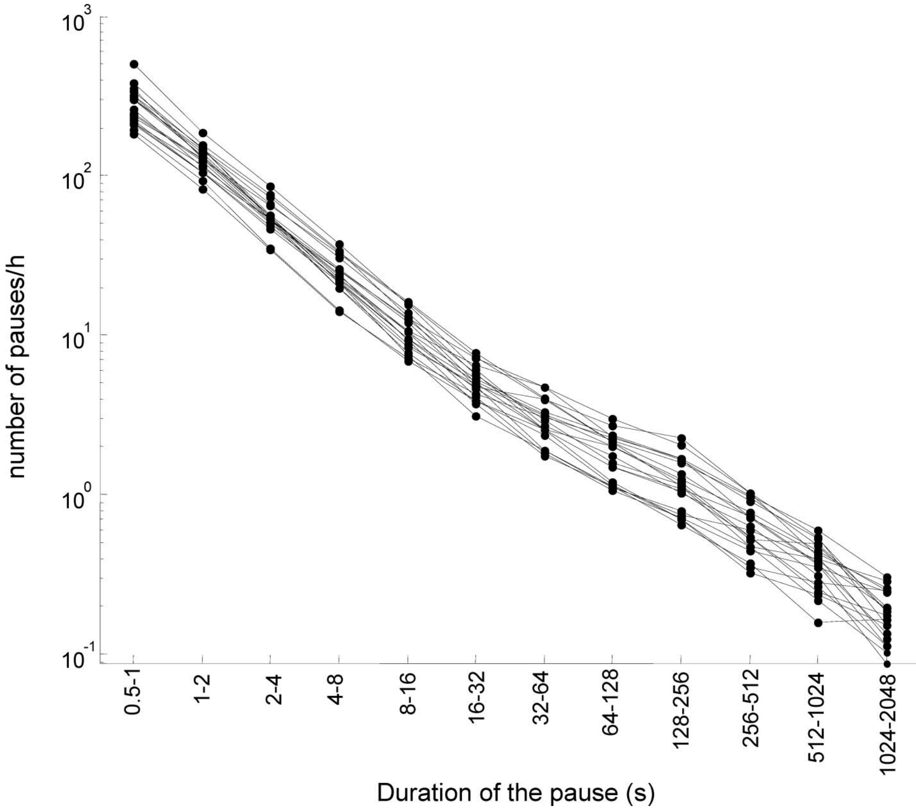

Figure 2. Histogram of pause durations for the different participants (the different lines), across all days. Both axes are on a log scale. 512 to 1024 s is approximately 8.5 to 17 min.

4 min (see table 2). The longest period of continuous computer use (mean over all participants and days) lasted almost 0.5 h. The average duration of the pauses in between the working periods was somewhat longer, with the longest pause lasting on average 1 h and 14 min. Note that the pause duration is much more variable than the duration of the working periods. This was reflected in a 42% smaller CV for the working periods.

3.2. *Artificial computer pauses*

During the simulation, pauses were inserted every time the computer use limit was exceeded. In figure 3 the number of inserted pauses is shown for the first six pause regimes across all participants and days. It should be noted that the majority (89%) of pauses that are administered are micro pauses and that the more stringent the regime becomes, the more pauses are administered. The daily limit of computer use is not taken into consideration in the analyses.

In addition to the additional pauses introduced by the simulation, participants took a great number of natural pauses of similar duration as the introduced pauses during each workday (as already shown in figure 2). Using figure 4, the number of pauses before and after the implementation of the pause regime can be compared. For each pause regime, the number of pauses with a length corresponding to the duration of the inserted pause or larger is shown. It should be noted that the number of pauses given on top of the ones that occur naturally is rather small, especially for the micro pauses. For the micro pauses, on average 25% more pauses are inserted across the six pause regimes. This percentage increases with the stringency of the pause regime (from 9 to 39). For the macro pauses, the number of additional pauses is larger; for regime 1 there are 32% more pauses added while for the last regime 83% more pauses are administered than occur naturally. On average 57% more macro pauses were inserted.

3.3. *Changes in the duration of the working day*

The inserted pauses in the simulation lengthened the working day by an amount equal to the summed duration of all inserted pauses. For the six pause regimes studied, the working day increased on average by 37 min (7.2%). If the workers had been working with pause software on their computer, they would most likely reduce the number of spontaneous pauses, having a pause already administered by the software. The above increase in working day should therefore be seen as an upper limit. Based on a pause

Table 2. Characteristics of the working day* averaged across participants and days.

Pause definition (s)	1	10	30	100
% workday classified as 'work'	26.7 (7.1)	40.4 (8.9)	45.6 (9.2)	52.7 (9.2)
Number of work periods	1839 (424)	158 (37)	64 (16)	26 (7)
Pause duration (min.)	0.2 (2.3)	2.2 (7.8)	5.1 (12.1)	11.2 (17.3)
Longest pause (min.)	74.0 (42.0)	74.0 (42.0)	74.0 (42.0)	74.0 (42.0)
Work time duration (min.)	0.1 (0.1)	1.4 (2.1)	4.0 (5.7)	11.1 (13.6)
Longest work time (min.)	1.3 (0.4)	13.2 (4.5)	27.5 (9.1)	50.8 (13.4)

*How many events are classified as work, depends on the pause definition used. Calculated here is the number and duration of the (longest) working periods and pauses under four different pause definitions (1, 10, 30 and 100 s). Standard deviations across participants are shown between parentheses.

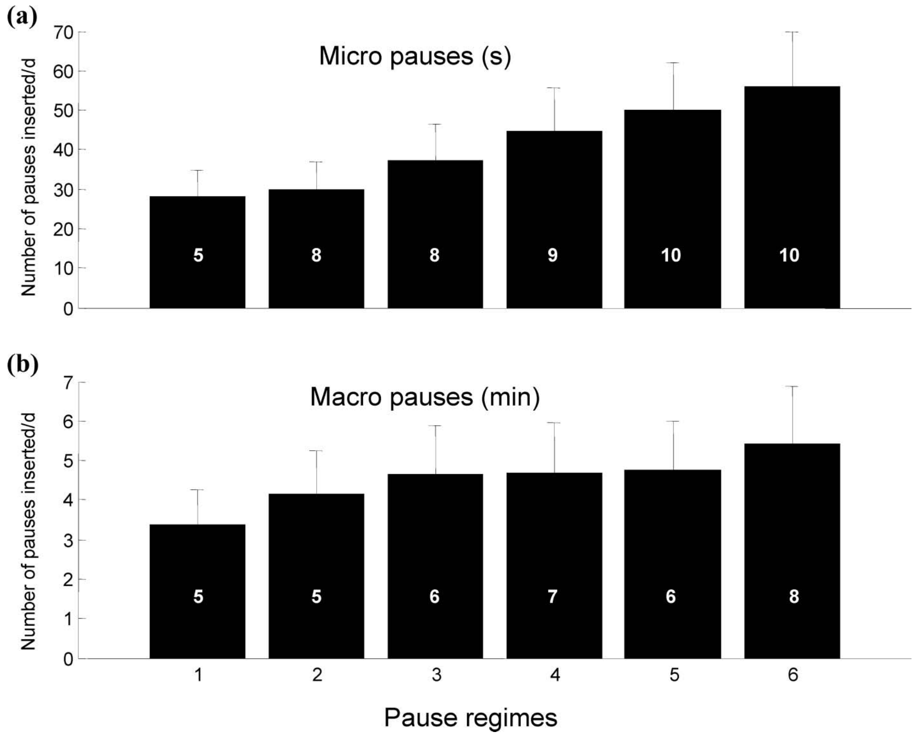

Figure 3. Mean number of micro (a) and macro pauses (b) per day inserted for all pause regimes across participants and days. Error bars are standard deviations for variability across participants. The numbers in the bars are the durations of the pauses for that regime. Note the different scales on the y-axis.

definition of 30 s, on average 46% of the total time the computer was on was classified as 'work', this would come down to approximately 4 h of computer use per day. Since this amount of time was far below the daily limit of computer use, only in 3% (range 0–11.7%) of the days this limit was reached during simulation of the six pause regimes. The total amount of time classified as 'work' hardly increased for the six pause regimes studied (maximally 8 min for regime 6). Because 'work' is defined by the pause definition of 30 s, pauses smaller than 30 s will lead to an increase of the total amount of 'work' performed. Counter intuitively, this means that by adding micro pauses, work time is increased.

3.4. *Pause software intervention*

For each of the pause regimes, a certain amount of computer use needs to be exceeded (computer use limit) before a pause is administered. The time differences were calculated between the moments an artificial pause would have been administered and the subsequent moment a natural pause of equal or greater length occurred. This time difference is a measure of the amount of time participants would be stopped using the computer earlier than they would naturally do (or the amount of time participants continue to use the computer while the software would have stopped them). These data, averaged across all participants and days and for the six pause regimes, are shown in

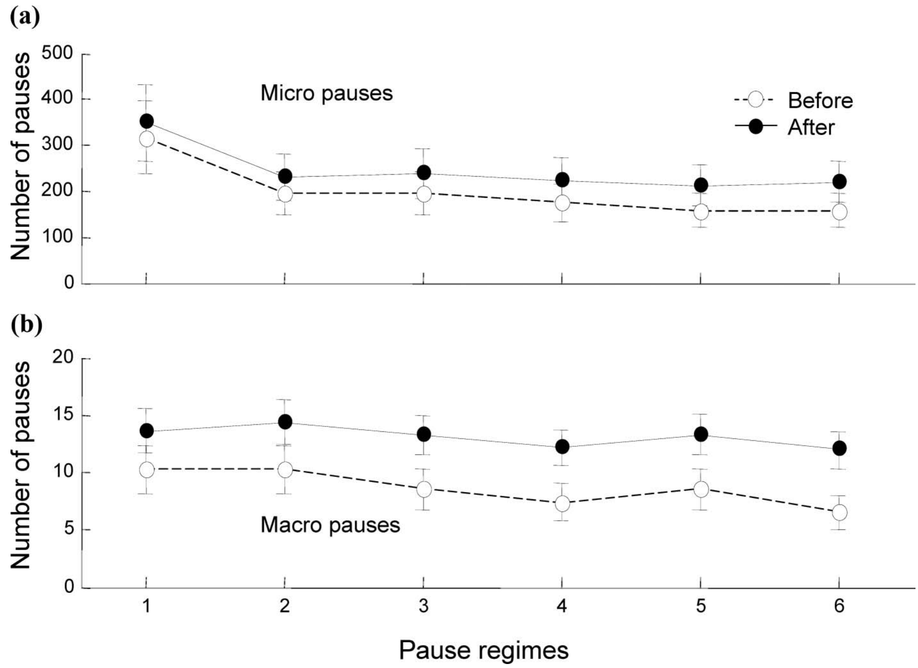

Figure 4. Number of micro (a) and macro (b) pauses before and after pause insertion for six pause regimes across participants and days. Error bars are standard deviations for variability across participants. Note the different scales on the y-axis.

figure 5. Figure 5(a) (compare the top two lines) shows that for short duration pauses the software administered the pause only shortly (45 s (=8%)) before the natural pause would occur and that this time increases with the stringency of the imposed pause regime (up to 2 min or 32% earlier). In contrast, figure 5(b) shows that this time difference is much larger for the macro pauses. Participants are stopped much earlier (on average 53 min (=52%)) than they would naturally do. Dependent on the stringency of the regime this effect becomes even larger (from 45 to 64 min earlier (=43 to 61%)).

Since the administered micro pauses have a duration that is shorter than that of the pause definition, micro pauses of the same length could also have occurred in the 'work-period' prior to the administration of the micro pause. It was calculated at what time before the insertion of the micro pause the last spontaneous micro pause occurred. These time points, averaged across participants and days, are shown in figure 5(a) in the bottom line. As can be seen in this graph the time difference between the spontaneous pauses before and after the inserted micro pause are quite similar (due to the random distribution of the pauses).

Additionally, the number of micro pauses, with a length larger than the administered pause, was calculated in the computer use period prior to the administration of the pause. These numbers are indicated in figure 5(a) by the number (rounded off to integers) of open circles below the line of inserted pauses. The actual values for the six regimes were: 8.76; 4.15; 3.27; 2.22; 1.65; 1.44 pauses. The timing of these pauses was not calculated.

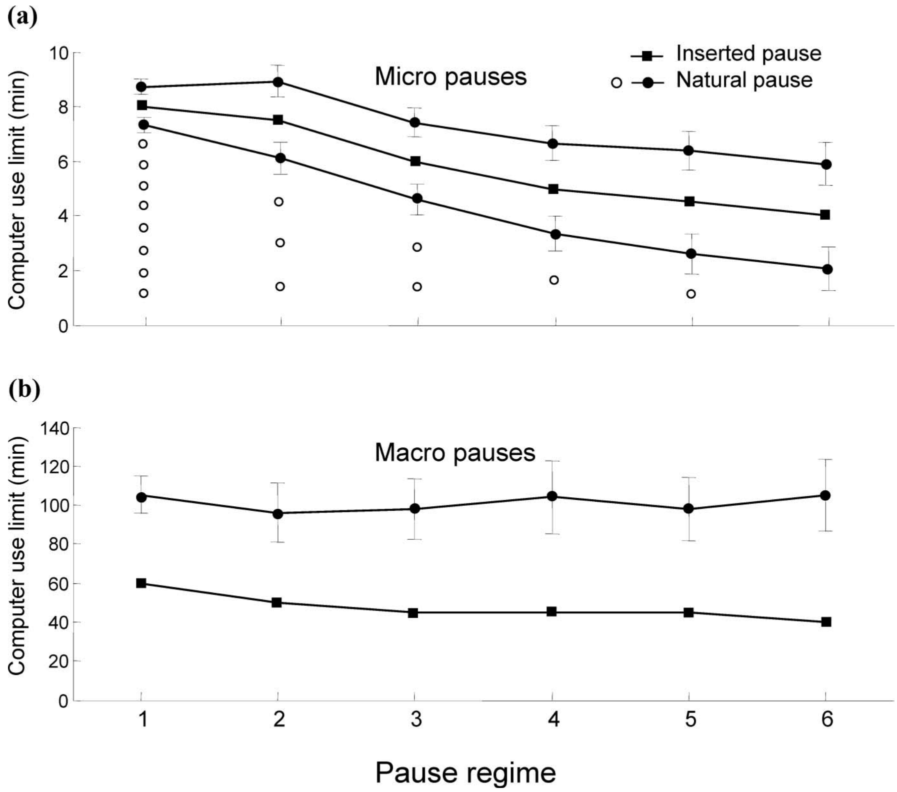

Figure 5. The amount of time after a pause of 30 s or more before the software would notify the user to pause (computer use limit) is shown as –■–. The top lines show the time it took participants to spontaneously take a pause of a length equal or greater than the one just administered. Since the pause definition is larger than the administered micro pauses, participants also showed micro pauses preceding the inserted pause. The lower line in (a) shows the time at which the previous pause of equal or greater length was spontaneously taken. ○ indicates the number of pauses of these durations taken in the period up to administration of the pause. Timing of these pauses is not taken into consideration and numbers are rounded off to integers (for actual values see text).

4. Discussion

In the Introduction, three questions were asked regarding the possible effects of pause software on computer use. The answers to these questions and the generality of the results will shortly be addressed. Subsequently, the following section will discuss how the current results should be interpreted in the light of possible health benefits of pause software.

What are the natural pause patterns that computer users display? The results show that the distribution of pauses, the time between two computer events, is extremely skewed. That is, the vast majority (96%) of pauses are shorter than 1 s and only a small number of pauses are of long duration. The distribution of pause duration follows a power law with a slope of approximately -2, meaning pauses with twice the duration are twice less likely to occur. Such distributions of waiting times have been found in the distribution of a large number of human activities, such as the times between sending emails, between telephone conversations, between words during speech production and other forms of communication (Barabasi 2005). The variability of the pause distributions, as expressed in the CV, was somewhat larger across participants than over days (0.29 vs. 0.22), which means that participants apparently show some personal trends (intensity of work) in how their pause durations are distributed. This indicates that it might be possible to identify computer users by their work–pause patterns.

When a pause definition of 30 s was applied, the work–pause pattern consisted of on average 64 short duration (4 min) work periods, interlaced with slightly longer pause periods (5 min). The duration of the work periods was less variable (a 42% smaller CV compared to that of the pauses; see table 2). Moreover, the longest pause lasted on average more than twice as long as the longest working period. The work–pause pattern of computer users can thus be described as a highly intermittent behaviour with short duration work periods being followed by slightly longer, and very variable, pauses.

How many pauses does pause software administer and how do these pauses compare to the number of pauses taken spontaneously? When the simulation of the pause software was applied, pauses of different durations were inserted when a computer use limit was exceeded. For an average working day of 8.5 h, 38 micro pauses (5 to 10 s) and 4 macro pauses (5 to 8 min) were administered, a nine-fold difference. Compared to the number of pauses taken spontaneously, an additional 25% micro pauses were inserted. For the macro pauses, an additional 57% pauses were inserted compared to the number of natural pauses with the same or longer duration. The inserted pauses add on average only 7.2% extra pause time to a working day. Only in a very small percentage (3) of the days a day limit would be imposed.

Is the timing of the inserted pauses appropriate? The number of pauses that the software would administer seems to be quite significant when compared to the number of pauses taken spontaneously. However, upon further examination into when these pauses were inserted, it was found that, specifically for the micro pauses, a large number of spontaneous pauses was taken just before and after the inserted pause (see figure 5). The spontaneous pauses just before and after the inserted micro pause occurred on average within 90 s. This means that pause software, through the administration of micro pauses, does not seem to alter the work–pause pattern of computer users to a large extent. For longer duration pauses (5–8 min), the software would administer a pause long before the computer user would take a pause of equal or a longer length, spontaneously. The administration of longer duration pauses, although they compromise only 11% of the total amount of pauses, seems therefore to be a method for altering the work–pause pattern.

4.1. *Sensitivity analysis*

Because of the choice of simulating the effects of pause software, instead of comparing groups working with and without the software, it was necessary to ensure that the study was not hampered by non-compliance of participants, nor influenced by compensatory strategies that participants might use in response to an imposed pause, such as speeding up computer use. This means that the presented data are most likely an overestimation of the possible effects of pause software on the temporal characteristics of computer users. Since participants were not informed about the nature of the analysis and the monitor software was running unobtrusively in the background, participants were only minimally aware that they were being monitored. The authors are therefore convinced that the recorded time traces are representative of the natural working pattern of the participants.

In order to study the generality and robustness of the simulation results two sensitivity analyses were performed. First was the analysis of whether the choice of data, only selecting files with a large amount of recorded events, could have influenced the results. Therefore, the results were compared for analyses done on the 100 smallest files and on the 100 largest files of the dataset, which differed by a factor 3.44 in size (bytes). The results from this comparison showed that there were neither differences in the pause distributions nor differences in the ratio of spontaneous and administered pauses between the two groups of data files. This shows that although the total number of administered pauses might increase, there was no fundamental difference in work–pause patterns for short or long working days, nor would pause software have different effects.

Second, an analysis was performed to determine whether the results would be dependent on the pause definition used. The analysis calculated how much time would be classified as work when pause definitions of 1, 10, 30 and a 100 s were used (table 2). These results were obtained for both the natural pauses as well as for the six simulated pause regimes. As can be seen in table 2, the number of work periods decreased 70-fold when the pause definition was increased. The duration of the working periods increases more than 100 times, resulting in a two-fold increase in the time being classified as work. Note also that for all pause definitions the duration of the work period is consistently shorter than that of the pauses and that the variability of the pause durations is higher than the variability of each of the working durations.

When the effects of the pause software were simulated, it was found that working times were similarly affected under the different pause regimes, independent of the pause definition used (results not shown). This means that, although the amount of computer activity classified as work might be higher or lower, depending on the specific pause definition used, the way pause software affects the work–pause pattern is similar.

4.2. *Possible health benefits of pause software*

Variation in physical exposure is the result of the variation within and between all of the tasks performed in the job, including non-work activities. The recorded time traces that were used in the simulation of pause software therefore give only a rough approximation of the possible physical exposure during the working day. For example, similar computer activities can be performed using a variety of working postures and with different amounts of task variability (variability in movement repetitions). Also, the amount and the variability of muscle activity associated with the execution of computer work can vary considerably due to the mechanical redundancy of the muscles, for instance, by co-contracting muscles around a joint. Additionally, the time traces provide no insight into the exposure during pauses of longer duration, when the computer user is most likely engaged in non-computer work. For these reasons, it is important to be cautious when drawing conclusions whether alterations in work–pause pattern, as imposed by pause software, can lead to possible health benefits. Nevertheless, the recording of the timing of computer events forms the basis for pause software to impose pause regimes, which, according to the manufacturers, has health benefits.

In the literature, two possible mechanisms are described that explain how additional rest breaks could influence computer user's health (e.g. reduce fatigue, discomfort and other complaints of the upper extremity; Kumar 2001). First, rest breaks might lower the cumulative loading during a workday, which might in turn give muscles the chance to recover from fatigue, promote blood circulation or promote some other form of recovery (Helliwell *et al.* 1992, Galinsky *et al.* 2000). Second, rest breaks might introduce an increase in the variation of the physical exposure. By increasing variation, i.e. reducing stereotypy of the work, selective exhaustion of muscles, tendons and nerve tissue could be alleviated (Hagg 1992, 2000).

As stated in the Introduction, the benefits of additional rest breaks on fatigue and discomfort have found only marginal support in the scientific literature. One of the reasons for this modest effect might be that the additional breaks do not contribute to the decrease in cumulative loading. A review by Lötters and Burdorf (2002) concluded that a substantial (14%) reduction in physical load is needed to result in a corresponding decline in complaints. In the current study, it was found that the additional rest breaks added only 7.2% extra 'pause time' to the working day. This seems to suggest that, regardless of whether a changed work–pause pattern might influence workers' health, it is very unlikely that pause software contributes to reducing cumulative load.

For long-lasting work at low load levels, such as computer work, increases in exposure variation are thought to be better met by introducing more activity than by introducing more rest. Studies on active breaks, such as specific exercises or stretching, have shown, however, very disappointing results (van den Heuvel *et al.* 2003). The results of the current study suggest that with regard to introducing additional variability the effect of micro pauses is probably quite low considering the large number of spontaneous micro pauses taken just prior and after the administration of the pause (see figure 5). In all the analyses the authors did their best to verify possible effects of pause software on temporal characteristics of computer use. Despite this, it seems very unlikely that the introduction of micro pauses (those below 10 s) has a possible benefit. It therefore seems a logical step for computer users to switch off this functionality in their pause software.

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