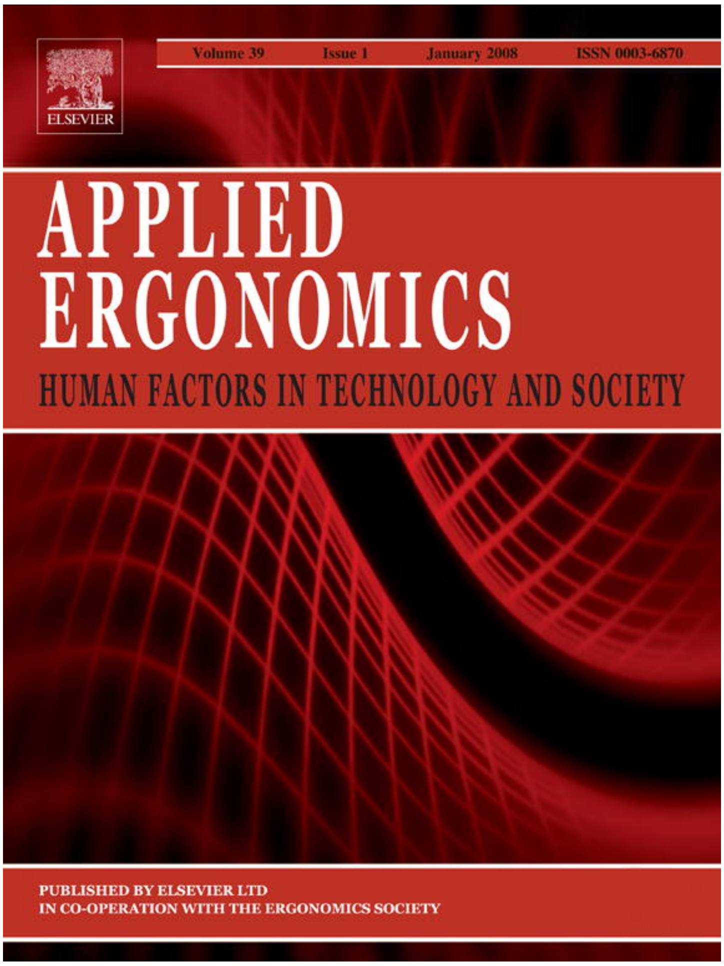
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Effects of working conditions and sleep of the previous day on cognitive performance

D. Ansiau[a], P. Wild[b], M. Niezborala[c], I. Rouch[d], J.C. Marquié[a,*]

[a]CNRS, University of Toulouse II, Work & Cognition Laboratory, 31058 Toulouse Cedex 9, France
[b]INRS (French National Research and Safety Institute for the Prevention of Occupational Accidents and Diseases), Department of Epidemiology, Vandoeuvre, France
[c]AMST (Occupational Health and Medicine Association), Toulouse, France
[d]CHU (University Hospital), Department of Neurology, Saint Étienne, France

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Abstract

The study examined the consequences of working conditions on the previous day on cognitive performance the following day. It also addressed the issue of whether this relationship was mediated by sleep and whether it differed as a function of age. The data were taken from the VISAT study (aging, health and work) and concerned the participant's general work schedule, general sleep quality, working conditions on the previous day (content, duration, load and schedule), subsequent sleep length and quality, and cognitive performance. Results showed that both physical activity and working before 6 am or after 10 pm on the previous day were significantly associated with poorer cognitive performance. Significant effects of working conditions on the previous day were also observed on subsequent sleep, but these effects did not mediate the relationship between working conditions and cognitive performance. The observed effect on cognitive performance of atypical work hours on the previous day was similar for all ages, probably because of the healthy worker effect.

Keywords: Age; Shift work; Cognitive performance

1. Introduction

The goal of the present study was to examine, in a large sample of wage earners and for several age classes, the consequences of working conditions on the previous day and of subsequent sleep characteristics, on cognitive performance the next day. Cognitive efficiency (efficacy of basic cognitive processes such as working memory, processing speed, and attentional processes) is a very important resource in a growing number of work situations. A decrease, even temporary, of mental efficiency may have serious human and material consequences in some circumstances, especially in critical phases of the work process where rapid and accurate responses are required. It is thus important to identify which factors may, separately or in combination, affect the availability of processing resources at work.

Sleep is one of the factors that may affect alertness and cognitive performance in work situations, as suggested by studies on sleep deprivation. Total or partial sleep deprivation is sometimes associated with a subsequent decrease in cognitive performance (e.g., Blissit, 2001; Drummond and Brown, 2001; Drummond et al., 2001; Harrison and Horne, 1998; Jones and Harrison, 2001; Pilcher and Huffcutt, 1996). Field studies have shown that, in turn, sleep is altered in its structure as well as in its duration by working conditions, especially night and shift work (Åkersted et al., 2002a, b; Folkard, 1996a; Foret, 1994; Härmä et al., 1998; Monk and Carrier, 2003). This may explain the impaired performance observed during successive night shifts (Folkard, 1996b; Folkard and Åkerstedt, 2004; Folkard and Tucker, 2003; Vidacek

*Corresponding author. Tel.: +33 5 61 27 08 68; fax: +33 5 61 50 35 33.
E-mail addresses: dansiau@monaco.edu (D. Ansiau), marquie@univ-tlse2.fr (J.C. Marquié).

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et al., 1986). Earlier studies also suggest that other job characteristics such as work content, duration and load may moderate the effects of atypical work schedules on sleep. For instance, Pavard et al. (1982) found in journalists doing word-processing activities a negative correlation between the mental load measured during the late evening shift and the length of subsequent sleep. Marquié et al. (1999) have shown that rather than specific job requirements, it was the perceived difficulty or stress associated with any job requirement that was related to sleep troubles. It is thus possible that these job characteristics affect cognitive efficiency the next day through their effects on sleep or, alternatively, through other mechanisms (e.g., fatigue). Unfortunately, few studies simultaneously addressed the effects of atypical work schedules and other working conditions both on sleep and cognitive efficiency. We have, therefore, little evidence concerning the joint effects of several working conditions on cognitive performance and the possible mediating role of sleep on this relationship. The reason for this lack of evidence is the variety of the factors in play, which requires large samples representative of a wide set of different work situations to be addressed (see Fig. 1).

In the current study, the main variable of interest was cognitive performance. Sleep was considered as an intermediate variable, namely as a possible mediator of the effects of working conditions on cognitive performance on the next day. One may consider, indeed, that shift work impairs cognitive functioning within the subsequent 24 h through the sleep troubles it induces, as indicated above. However, other studies suggest that the deleterious effects of shift work on performance, especially cognitive performance, may not necessarily be mediated by sleep troubles, but rather by other factors such as stress. For instance, evidence in this respect comes from studies of the effects of the desynchronization of circadian rhythms associated with transmeridian flights, especially eastward (e.g., Cho, 2001; Cho et al., 2000; Preston, 1978; Winget et al., 1984). In our study, hypothetical direct relationships (not mediated by sleep) between atypical work schedules on the previous day and some aspects of cognitive functioning the following day were assessed.

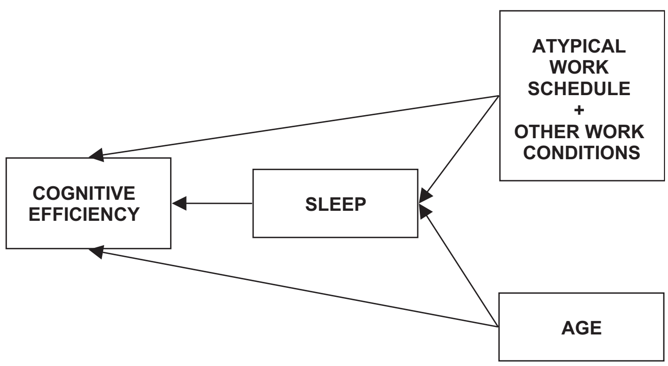

Fig. 1. Relationships between main variables in the current study.

Because consistent relationships have been found between aging and the main variables considered in this study, age effects were also examined. There is evidence from a variety of sources that substantial changes occur in sleep throughout adult life. These changes are already apparent in early adulthood (Bliwise, 1994; Monk, 2003). Various sleep characteristics seem to be affected, including time of day, duration, internal structure, continuity, and restfulness. Partly because of such increased sleep difficulties, but also for other biological, social and economical reasons, shift work is reputed to be less well tolerated by older workers (Åkersted and Torsvall, 1981; Brugère et al., 1997; Foret et al., 1981; Härmä et al., 1994; Härmä and Ilmarinen, 1999; Quéinnec et al., 1998). Finally, we have accumulated substantial evidence to date concerning the age-related decline of several aspects of cognitive functioning (e.g., Craik and Salthouse, 2000). Due to the growing proportion of aging workers, it is likely that they will be more exposed to shift work in the years to come. Thus, investigating the extent to which the effects of working conditions on job performance vary as a function of age has become an important issue.

A direct study of the delayed, but short-term consequences of working conditions, including atypical work schedules, on an individual's real job performance is complicated because of several methodological difficulties. One source of such difficulties is the great variability in the worker's characteristics (age, sex, qualification), in the work schedules (various shift systems), and in other working conditions (content, duration and stress). Because of this variability, it is very difficult to design experimental studies that compare selected and control groups by simultaneously controlling for all these individual differences and working conditions. Epidemiological studies based on large samples may help to overcome some of these methodological problems. They can do so by providing more statistical power for examining both the combined effects of the various factors and their separate effects after adjustment for a variety of possible confounding factors. Another difficulty is obtaining relevant performance measures in situations where, fortunately, incidents and accidents are scarce. In order to estimate such risks, it may be useful to assess the disruptive effects of recent working conditions on basic cognitive processes such as memory, speed, and attentional processes, which are involved in many aspects of daily work behavior.

In the present study, we assessed the short-term consequences, namely those arising the next day, on cognitive performance of (i) abnormal work schedules and (ii) other aspects of working conditions in the previous 24 h work period, and (iii) of subsequent sleep (duration and quality). These short-term consequences were examined for several age classes in a large sample of wage earners, which was varied in terms of occupational status and working conditions. Cognitive performance was assessed through memory, speed, and attention tests.

2. Method

2.1. Participants

The data were collected during the first phase of the VISAT study (to find out more about the goals and methodology of this study, see Marquié et al., 2002). The original sample consisted of 3237 current and former wage earners of both genders born in 1964, 1954, 1944, and 1934. They were exactly 32, 42, 52, and 62 years old at the time the data were collected (1996). Only the group born in 1934 included retirees (83%). Participants were randomly drawn from among the patients of 94 occupational physicians in three southern regions of France, who volunteered for VISAT. The participation rate was 76%. Data were collected during the yearly medical examination, which is part of the health-screening program that takes place within the company. Retired workers who were no longer being monitored by the occupational physicians were invited specially for the purpose of the study. For our analyses, we excluded retirees ($n = 395$), current workers who were not working the day before data collection ($n = 438$), and participants with missing data ($n = 67$). Thus, the sample used for our analyses consisted of 2337 participants. Their characteristics regarding age, gender, years of schooling, work, and sleep characteristics for the previous workday and the subsequent night, plus cognitive performances are displayed in Table 1.

2.2. Material and procedure

2.2.1. Atypical work schedule in general

The current general work schedule was also assessed. An atypical work schedule was defined according to the following three criteria: (i) activity which does not allow workers to go to bed before midnight (more than 50 days per year), (ii) activity resulting in workers waking up before 5 am (more than 50 days per year), and (iii) activity preventing night sleep (more than 50 days per year). Participants concerned by at least one of these three items were considered as working in an atypical work schedule.

2.2.2. Working conditions on the previous day

Information was obtained about the participant's working conditions on the day preceding the data collection: (i) time spent working (<8, 8–10, or ⩾10 h), (ii) atypical work schedule (whether at least part of the work activity had taken place before 6 am or after 10 pm: yes/no), (iii) self-assessed workload (high/low), and (iv) prevailing activity type (physical, mental, social).

2.2.3. Sleep

Participants were required to report their actual bedtimes for the previous night in hours and minutes (base 24). Sleep length (in minutes) and sleep quality during the previous night (night preceding the data collection) were also recorded. Sleep quality during the previous night was assessed through: (i) the number of awakenings during the night (none/one or more), (ii) difficulty getting back to sleep once awakened (yes/no), and (iii) sleep dissatisfaction (yes/no; no meaning fully satisfied). A general sleep quality score (range 5–20) was obtained for a broader period (the previous month) by adding up the frequency ratings (never = 1, seldom = 2, sometimes = 3, and often = 4) of five sleep complaints: (i) difficulty initiating sleep, (ii) difficulty remaining asleep, (iii) difficulty getting back to sleep, (iv) early morning awakening, and (v) use of hypnotic medication. The higher the score, the poorer the general sleep quality.

Table 1
Participants' characteristics

		n (%)	Mean (SD)
Age	32 years	736 (31.49)	
	42 years	803 (34.36)	
	52 years	731 (31.28)	
	62 years	67 (2.87)	
Gender	Male	1152 (49.29)	
	Female	1185 (50.71)	
Years of education			10.96 (3.4)
Atypical work schedule in general	Yes	426 (18.23)	
	No	1911 (81.77)	
General sleep quality score			11.01 (3.39)
Working conditions on the day before:			
Atypical work schedule[a]	Yes	258 (11.04)	
	No	2079 (88.96)	
Time spent working	< 8 h	1511 (64.66)	
	8–10 h	669 (28.62)	
	> 10 h	157 (6.72)	
Workload	Low	1911 (81.77)	
	High	426 (18.23)	
Prevailing activity	Physical	679 (29.05)	
	Mental	956 (40.91)	
	Social	702 (30.04)	
Sleep on the night preceding the tests			
Sleep length (mn)			411.23 (91.52)
Awakenings (number)	⩾1	1182 (50.58)	
	0	1155 (49.42)	
Difficulty getting back to sleep	Yes	424 (35.87)	
	No	758 (64.13)	
Sleep dissatisfaction	Yes	1169 (50.02)	
	No	1168 (49.98)	
Time of day of cognitive tests (hour)			13:21 (3 h)
Cognitive performances			
Immediate free recall (nb words)			8.21 (2.04)
Delayed free recall (nb words)			7.84 (2.82)
Processing speed (score)			52.18 (14.58)
Selective attention (score)			205.27 (93.66)

[a]Working before 6 am or after 10 pm.

2.2.4. Time of day

The time of day when the cognitive tests were administered was controlled in multivariate analyses because of possible chronobiological influences on cognitive performance. Hours and minutes of the day were transformed into a single variable assessed in minutes. As the tests were administered between 8:00 and 19:00, values ranged between 480 ($8^{*}60$ mn) and 1140 mn ($19^{*}60$mn).

2.2.5. Cognitive efficiency

Three types of cognitive test were administered to the participants: (1) a memory test adapted from the Rey verbal learning test (Rey, 1964). The participant was read a list of 16 words and then immediately asked to recall the words. Three consecutive learning/recall trials were given. After a delay of 15 min, spent performing other tests, participants were submitted to a delayed free recall test. Four verbal memory measures were thus recorded: three immediate free recalls and one delayed free recall, (2) the digit–symbol substitution test, a sub-test of the Wechsler adult intelligence scale (WAIS, 1970), which is considered to be highly loaded by cognitive processing speed component and very sensitive to aging effects (Salthouse, 1992). The test consists in assigning the correct symbol to digits ranging from 1 to 9 according to a code table displaying pairs of digits and symbols. Participants had to copy as many symbols as possible in a 90 s time period, and (3) a selective attention test derived from the Sternberg test (Sternberg, 1975) which consisted of two sub-tests. The first was a task consisting in looking as quickly as possible through a line of 58 alphabetic characters to find a target letter shown in the margin, then crossing it out. This task was repeated six times, on six lines with a different target located in a different place each time. The second sub-test also had six lines of 58 alphabetic characters, but this time the memory load was greater because the target to be located was one of the four letters shown in the margin.

Results are given as the mean number of words correctly recalled across the three learning/recall trials for the immediate free recall; and as the mean number of words correctly recalled for the delayed free recall. Results concerning processing speed (digit–symbol substitution test) are given as a mean score. Results concerning selective attention initially coded as the time spent to perform the two sub-tests were recoded as a score ($x_{\max}$–x_i). Thus, for every cognitive test, higher values reflected higher cognitive performance.

3. Results

We first assessed the possible effect of age and several of the previous day's work characteristics on subsequent sleep length by means of multiple linear regressions (see Table 2). Being 52 years old (compared with participants who were 32 years old; $p \leqslant 0.0001$), having worked more than 10 h on the day before (compared with those who worked less than 8 h; $p \leqslant 0.002$), with an atypical work schedule for the day before ($p \leqslant 0.0001$) and reporting a higher workload for the day before ($p \leqslant 0.003$) were significantly associated with a decrease in sleep length ($R^2 = 0.08$). Then, we investigated the effects of the same factors on the number of awakenings, difficulty getting back to sleep and sleep dissatisfaction concerning subsequent sleep. This was done by means of multiple logistic regressions, as the dependent variables were dichotomous (see Table 2). Being 52 ($p \leqslant 0.0001$) or 62 years old ($p \leqslant 0.0001$), having worked between 8 and 10 h on the previous day ($p \leqslant 0.044$), and reporting a higher workload ($p \leqslant 0.014$) were significantly associated with awakenings during subsequent sleep (Cox and Snell $R^2 = 0.04$). Concerning the difficulty getting back to sleep once awakened, being 42 years old or more (all p's $\leqslant 0.006$) and reporting a high workload ($p \leqslant 0.002$) were significantly associated with experiencing greater difficulty getting back to sleep (Cox and Snell $R^2 = 0.02$). Lastly, sleep dissatisfaction results indicated that being 52 years old ($p \leqslant 0.039$), reporting a higher workload ($p \leqslant 0.0001$), and primarily mental and social activity (respectively $p \leqslant 0.033$ and 0.002) compared with those who had a primarily physical activity type for the day before were significantly associated with greater overall sleep dissatisfaction (Cox and Snell $R^2 = 0.02$). To examine whether the effects of working conditions on sleep differed as a function of age and gender, we introduced interaction parameters between age and the work-related variables; and between gender and the same variables. No significant interaction was found. This means that the observed effects on sleep of working conditions on the previous day were similar for all age groups and for men and women.

After having checked that sleep was affected by recent working conditions, we focused on the effects of working conditions on the previous day on cognitive performance. We did so while examining simultaneously the hypothetical mediating role of sleep in this relationship. Relationships between age, working conditions on the previous day, subsequent sleep, and cognitive performances were assessed using backward multiple linear regressions. In these analyses, we also controlled the effect of general sleep quality and general work schedule assessed over a broader period, the time of day of the cognitive assessment, as well as individual characteristics such as years of schooling and gender which may have confounding effects.

The optimal regression model (a parsimonious model minimizing risks of multicollinearity and explaining more variance) is displayed in Table 3 for every cognitive performance. All the variables which were introduced in the model as predictors at earlier steps in the statistical process and which turned out to have no significant relationship with at least one of the dependent variables are listed in the bottom part of the table. These variables were excluded from the regression models. Results showed, as expected that higher age was negatively associated with all cognitive performances (all p's $\leqslant 0.0001$). For variables related to working conditions on the previous day, the results showed that an atypical work schedule (working

Table 2
Relationships between working conditions on the previous day and four variables concerning subsequent sleep: duration (multiple linear regression), awakenings, difficulty getting back to sleep, and sleep dissatisfaction (logistic regressions; OR = Odd Ratio)

Variables (reference category in brackets)		Sleep length (mn)	Awakenings (⩾1/0)	Difficulty getting back to sleep (yes/no)	Sleep dissatisfaction (yes/no)
		β	OR	OR	OR
Age (32 years)	42 years	−6.8	1.02	1.53**	0.97
	52 years	−22.3**	2.05**	2.14**	1.24*
	62 years	−16.4	3.06**	2.56**	1.24
Working conditions on the day before:					
Time spent working (< 8h)	8–10 h	−7.0	0.82*	0.96	1.11
	> 10 h	−24.1**	0.81	1.12	1.27
Atypical work schedule[a] (No)	Yes	−64.1**	1.08	0.95	1.18
Workload (Low)	High	−14.2**	1.32*	1.58**	1.77**
Prevailing activity (Physical)	Mental	5.9	1.06	.88	1.24*
	Social	4.8	1.24	1.26	1.41**

Note.
β coefficients and OR are also adjusted for gender. Examples of how to read results displayed in the table are as follows. Sleep length (row 1) of the 52 years olds was decreased by 22.3 mn as compared with the 32-year olds who serve as a reference group. The probability of being awakened once or more during the nigh (row 2) was 3.06 higher in the 62-year-old workers than in the 32-year-olds.
[a] = Working before 6 am or after 10 pm.
*$p \leqslant 0.05$.
**$p \leqslant 0.01$.

before 6 am or after 10 pm) was significantly associated with poorer performances in immediate free recall ($p \leqslant 0.029$), delayed free recall ($p \leqslant 0.021$), and selective attention ($p \leqslant 0.032$). However, no interaction between age and working hours (working before 6 am or after 10 pm) was found (outside the models), thus indicating that the effect of an atypical work schedule did not differ across age groups. In the current study, the available item concerning atypical work schedules on the previous day lumped together work activity taking place before 6:00 and after 22:00. Because working after 22:00 on the previous day is more likely to be associated with a later bedtime, we also entered into the multivariate regression models information about bedtime on the previous night (recoded into two modalities: going to bed before or after 2:00). Controlling for this variable is a way of examining whether the observed effect on performance of an atypical schedule during the day before was due to only one of the working hours or to both. As can be seen in Table 3, bedtime was not significantly related to either cognitive performance. Similar results were further obtained by using midnight as a cutoff point to dichotomize the bedtime variable. It thus seems that both working hours have a deleterious influence on cognitive efficiency.

Compared with people who reported that their activity was mostly physical on the day before, those reporting primarily mental activity showed significantly better cognitive performances on the following day (all p's$\leqslant 0.02$). Performing a primarily social activity on the day before was also associated with better performances in processing speed, immediate and delayed free recall (all p's$\leqslant 0.04$). In other words, this result means that people who reported physical activity as prevailing on the previous day showed poorer cognitive performances on the subsequent day than those reporting primarily mental and social activity. In order to check whether this result was not due to the underlying effect of socio-professional category, the same analyses were performed by further adjusting for this variable (white and blue-collar workers, $n = 975$ and 1362, respectively). Analyses showed the same pattern of results for the prevailing activity variable as well as for an atypical work schedule.

We observed a counterintuitive negative relationship between sleep length the previous night and the selective attention score ($p \leqslant 0.001$). It means that longer sleepers were also poorer performers on this test.

4. Discussion

The present study provided evidence of a negative impact of an atypical work schedule and other working conditions on the previous day on cognitive efficiency the following day. Furthermore, it was found that sleep did not mediate these effects.

Not surprisingly, older age was found to be associated with sleep fragmentation, difficulty getting back to sleep and, especially for the 52 year olds, with shorter sleep length and greater overall sleep dissatisfaction. Several aspects of working conditions on the previous day also influenced sleep. For instance, in line with earlier work, decreased sleep length was associated with longer working days and higher workload (Dahlgren et al., 2005), as well as with working outside normal hours (Åkersted et al., 2002a, b). Participants reporting higher workloads also

Table 3
Results of multiple regression analyses

Variables (reference category in brackets)		Cognitive performances			
		Immediate free recall (nb of words)	Delayed free recall (nb of words)	Processing speed (score)	Selective attention (score)
		β	β	β	β
Age (32 years)	42 years	−0.52**	−0.56**	−1.86**	−0.50
	52 years	−1.03**	−1.40**	−6.84**	−35.19**
	62 years	−1.30**	−1.67**	−16.72**	−50.97**
Atypical work schedule on the day before[a] (No)	Yes	−0.37*	−0.55*	−0.01	−17.52*
Prevailing activity on the day before (Physical)	Mental	0.38**	0.55**	2.14*	23.69**
	Social	0.29*	0.45*	2.10*	11.97
Sleep length on the night preceding the tests (mn)		−0.001	−0.001	−0.003	−0.06*
R^2		0.27	0.26	0.33	0.20

Non-significant variables

- General work schedule (atypical work schedule: yes/no)
- General sleep quality (score)
- Time spent working the day before (< 8 h, 8–10 h, > 10 h)
- Workload on the day before (high/low)
- Bedtime on the previous night (before/after 2 am)
- Awakenings during the previous night (0, $\geqslant$1)
- Difficulty getting back to sleep during the previous night (yes/no)
- Sleep dissatisfaction concerning the previous night (yes/no)
- Time of day of the clinical examination (mn)
- Age × Atypical work schedule on the day before

Note.
β coefficients of regression (and significance level) are given only for the variables showing a significant relationship with at least one of the cognitive performances. Variables showing no significant relationship with any of the cognitive performances are listed at the bottom of the table. β coefficients are also adjusted for gender and education. Examples of how to read results displayed in the table are as follows. Reporting atypical work schedule on the day before was independently associated with a decrease of 0.37 word in the immediate free recall performance (row 1) as compared with workers reporting normal working hours on the previous day.

[a] = Working before 6 am or after 10 pm.

*$p \leqslant 0.05$.

**$p \leqslant 0.01$.

experienced difficulties remaining asleep, getting back to sleep, and were less satisfied by their sleep. These results are in line with those of earlier studies (e.g., Åkersted and Torsvall, 1981; Dahlgren et al., 2005; Folkard, 1996b; Foret, 1994; Foret et al., 1981). Concerning the effects of work content, primarily mental and social activity on the previous day, compared with primarily physical activity, were found to be related to a greater overall sleep dissatisfaction and difficulty remaining asleep (only for the mainly social activity type). The lack of any interaction between age and working conditions means that the latter had the same effect on sleep at all ages.

Due to the great number of possible combinations between several types of working conditions, it is usually very difficult to know their independent effect. Large samples of workers including a variety of occupations and working conditions provide an opportunity to shed light on this issue. In the present study, the deleterious effect of an atypical work schedule on the previous day was observed on cognitive performances the following day, which was especially significant for verbal memory (free recall) and selective attention. This effect was independent of the other working conditions that were also assessed in this study. In particular, statistically controlling for the effect of the general work schedule ruled out any confounding cumulative influence of regular shift or night work on cognitive efficiency (Rouch et al., 2005). The effect was also independent of work content (prevailing activity type) on the previous day, which was significantly associated with cognitive efficiency on the subsequent day. Further analyses allowed us to check that the negative effect of the primarily physical activity was not an artifact due to the socio-professional category. Thus, our results clearly suggest that both physical activity and working outside the normal hours on the previous day significantly increase the risk of impaired efficiency of some cognitive functions.

The finding that an atypical work schedule the previous day is associated with poorer performances in some cognitive tests is also independent of the participant's sleep characteristics the previous night. Indeed, none of the sleep quality measures (awakenings, difficulty getting back to sleep, and global sleep dissatisfaction) were significant predictors of cognitive performance. This was true for sleep length as well, since the latter was not significantly related to cognitive efficiency. Only one exception was observed with longer sleep length during the previous night being associated with poorer selective attention, a result which is paradoxical and difficult to explain. Alertness and cognitive performance of people working on atypical work schedules are under the influence of a large number of factors. Such factors are social factors, reduced physical health or psychological wellbeing, desynchronization of circadian rhythms, sleep deprivation, or the stress resulting from these combined factors. The present study does not allow us to say which particular mechanisms are involved in the observed effect of working conditions on performance. However, it enables us to rule out the independent effect of the worker's reported sleep characteristics during the recent (previous night) or less recent (previous month) period.

The lack of an interaction between age and atypical work schedule on the previous day, both for sleep and cognitive performance, suggests that older workers are not more affected by atypical work schedules than the young. Similar findings have already been obtained by Pavard et al. (1982) who showed that work content and work load had the same effect on subsequent sleep regardless of the worker's age. This does not allow us to conclude, however, that young and older workers are similarly affected by shift work. This is due to the so-called healthy worker effect, according to which workers with poorer sleep and health are most likely to leave workplaces involving job demands such as shift or night work (e.g., Gonon et al., 2004). Evidence of an interaction between age and atypical work schedule was obtained in earlier studies (e.g., Härmä et al., 1994), but it may have been masked here. Indeed, we have no information in the present study about at which phase of a shift work cycle (at the time of data collection) are the workers who reported atypical work schedules for the previous day. Yet, Härmä et al. (1994) found that young and older shift workers exhibited pronounced differences in their ability to cope with night work over successive night shifts. Older workers showed less fatigue than the young during the first two nights, while the opposite age-related pattern was subsequently observed. It may be that our results reflect an average situation, thus masking possible age-related temporal differences in the way workers cope with atypical work hours (De Zwart and Meijman, 1996).

In this study, because the item concerning atypical work schedule on the previous day combined working before 6:00 and after 22:00, it could be argued that the observed effects on cognitive performance might be due to one or other of these two, but not both. However, we controlled statistically for bedtime on the previous night in the multivariate regression models. This yielded no change in the pattern of results for any of the cognitive performances. As working after 22:00 is associated with a higher probability of going to bed later in the night or in the morning, this result suggests that the effects on cognitive performance were due to both working hours, not only one.

Performance measurements used in this study concerned cognitive performances. Although we argue that they are relevant to many occupational activities, cognitive performances are not direct measurements of job performance, the latter often being difficult to obtain in this type of study for several reasons (e.g., see Folkard, 1996b). Cognitive tests are something new for the participant, and usually yield a favorable (that is stimulating) effect on performance. The fact that, in spite of this possible favorable effect, some cognitive functions were impaired in this study as a result of atypical work hours and physical activity on the previous day, suggests that this finding is robust.

Cognitive efficiency is an increasingly sought-after resource in our information society. Even temporary decreases in the availability of cognitive resources may result in errors or accidents, or be compensated for at the cost of increased effort and mental strain. This especially raises a problem in critical phases of the work process or of daily activities such as driving, or crossing a road. The present study reveals the independent deleterious effects of physical activity and an atypical work schedule on cognitive efficiency on the following day. Though relatively moderate when considered separately, the effects of such factors may have significant effects on daily behavior when added to each other. Moreover, our study suggests that providing an effective environmental support (e.g., work design) is critical for individuals involved in irregular work schedules.

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