WORK & STRESS, APRIL–JUNE 2003, VOL. 17, 2, 123–137

The impact of rest breaks upon accident risk, fatigue and performance: a review

PHILIP TUCKER*

Department of Psychology, University of Wales Swansea, Singleton Park, Swansea SA2 8PP, UK

Keywords: *Rest breaks; Accidents; Fatigue; Performance.*

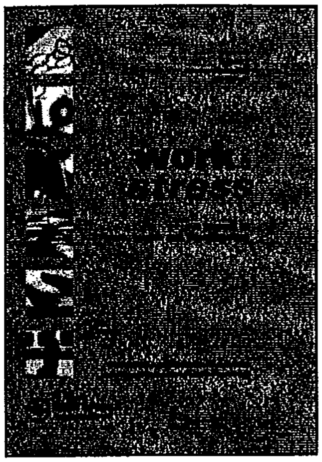
This review's primary objective is to identify research examining the impact of rest breaks upon accident risk in industrial settings. In the absence of much directly relevant research, the focus is broadened to consider the impact of rest breaks upon performance and fatigue, as well as epidemiological evidence, in both transport and non-transport settings. Relevant studies are identified from a range of electronic sources. In general, regular rest breaks can be an effective means of maintaining performance, managing fatigue and controlling the accumulation of risk over prolonged task performance. While two-hourly breaks are common in many industrial settings, the scheduling of additional micro-breaks can be beneficial under at least some circumstances. While some evidence supports allowing workers to take rest breaks that coincide with periods of heightened fatigue, workers sometimes fail to take adequate breaks when they are needed. There is little hard evidence concerning the optimum length of rest breaks (other than for heavy physical work), or to support the contention that increased rest-breaks can off-set the negative impact of extending shift durations, or to suggest that rest breaks counteract the negative impacts of circadian variations in alertness, unless they involve taking a nap or caffeine. The scarcity of epidemiological evidence in this area highlights the need for more research.

1. Introduction

A substantial body of research has examined the effects of different types of shift schedules on accident risk (Folkard & Hill, 2002; Frank, 2000). However, little attention has been paid to the impact upon risk of the way in which work activities, and in particular rest breaks, are scheduled within a shift. Some of the earliest research into the effects of rest breaks was conducted in the UK by the Industrial Fatigue Research Board. The primary focus of these studies was productivity and error rates. More recently, research has examined the impact of rest breaks upon stress and fatigue. Much of this work has examined the impact of different rest schedules on muscular fatigue (McLean, Tingley, Scott, & Rickards, 2001; Van Dieen & Vrielink, 1998; Wood, Fisher, & Andres, 1997). Where measures of mental fatigue or stress are included, these studies have tended to focus upon computer work (Boucsein & Thum, 1997).

*Author for correspondence. e-mail: p.t.tucker@swansea.ac.uk

Work & Stress ISSN 0267-8373 print/ISSN 1464-5335 online
http://www.tandf.co.uk/journals/
DOI: 10.1080/0267837031000155949



Work & Stress
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713697904

The impact of rest breaks upon accident risk, fatigue and performance: a review

PHILIP TUCKER [a]
[a] Department of Psychology, University of Wales Swansea, Singleton Park, Swansea SA2 8PP, UK.

To cite this Article TUCKER, PHILIP(2003) 'The impact of rest breaks upon accident risk, fatigue and performance: a review', Work & Stress, 17: 2, 123 — 137
To link to this Article: DOI: 10.1080/02678370310001559 49
URL: http://dx.doi.org/10.1080/0267837031000155949

This review focuses upon three aspects of the impact of rest breaks. First, evidence is examined to establish whether rest breaks influence accident risk. Second, consideration is given to optimizing rest break schedules within the duty period (i.e. the timing, frequency and duration of breaks). Finally, we reflect on whether rest breaks can be used to address other problematic work scheduling issues (i.e. extended shifts and night working).

The discussion centres around concepts that are notoriously difficult to define and/or measure, i.e. fatigue, risk and performance. Perhaps the most slippery of all is the notion of mental fatigue. Researchers variously define and measure fatigue in terms of both physiological and psychological reactions. In his scholarly review, Brown (1994) emphasizes the latter, defining fatigue as 'the subjectively experienced disinclination to continue performing the task at hand'. In addition, performance is sometimes used by researchers as an index of fatigue. However, as Murrell (1962) points out, this becomes a circular argument if fatigue is then used to account for decrements in performance. Epidemiological studies usually express risk in terms of the relative frequency of accidents and/or near misses under varying conditions. In practice, measuring the risk associated with a particular factor is complicated by the problems of controlling for influential confounds, e.g. experience and exposure. There are no necessary or logical associations between the phenomena of fatigue, performance and risk. However, in practice researchers often assume such associations, either explicitly or implicitly.

Relevant papers for this review were identified from 7 databases—namely, Social Science Citation Index, PsycLIT, NIOSHTIC, CISDOC, RILOSH Index, MEDLINE OEM and Web of Science. Only those papers that referred to intra-shift rest breaks or rest pauses were included. The issue of napping is largely outside the scope of this review and so only a limited number of illustrative studies are included, focusing on naps taken during the night shift. Given the relative scarcity of research that falls within the scope of the review, studies are not filtered on the basis of an evaluation of methodologies. However, where methodological problems were apparent, they are identified in the course of the review.

2. The impact of rest breaks upon accident risk

2.1. *Rest breaks and driving fatigue*

The majority of evidence concerning the effect of rest breaks on accident risk has come from studies of driving behaviour and flight simulation. Even then, the majority of such studies have inferred a relationship between rest breaks and risk, from the study of driving performance and fatigue. Fatigue is most effectively managed when drivers are able to arrange the timing of rest breaks to coincide with periods of fatigue (Feyer & Williamson, 1995). For example, Stave (1977) reported that taking a 4-min break from a 3-h journey at the point at which gross errors began to occur led to an almost complete eradication of errors following the break. By contrast, pre-planned rest break schedules may be a less effective means of counteracting the accumulation of risk over prolonged periods behind the wheel. For example, Drory (1985) reported that while the incorporation of a pre-planned 30-min break 3 h into in a 7-h simulated driving task resulted in improved fatigue levels, performance was unaffected.

While the above evidence appears to suggest that taking sufficient rest breaks may be an efficient means of avoiding fatigue-related decrements in driving performance, evidence from laboratory studies suggests that the nature of the activity undertaken during the rest breaks may be crucial in determining the amount of recovery afforded. Lisper and Eriksson (1980) found that, compared to a rest break that involved doing nothing, one that incorporated food intake reduced subsequent deterioration in driving performance. Recent evidence suggests that taking a short nap (< 15 min) and/or drinking coffee (150 mg of caffeine) are more effective as countermeasures against sleepiness when driving, compared to just taking a break alone (i.e. doing nothing) or undertaking physical exercise (Horne & Reyner, 1996; Reyner & Horne, 1997). On the basis of such evidence, drivers are advised to take rest breaks at the point where they become sleepy, and to incorporate a short nap and the taking of a caffeinated drink within the break (Horne & Reyner, 1999). The role of naps within rest breaks will be considered in further detail later.

2.2. *Rest breaks and the occurrence of accidents*

Direct epidemiological research in transport settings has tended to focus on the overall amount of rest taken within a duty period. In a study of transit operators, Greiner, Krause, Ragland, and Fisher (1998) reported that accident risk was predicted by the amount of time an operator was able to detach from the work task, e.g. by taking rest pauses. However, Pokorny, Blom, van Leeuwen, and van Nooten (1987) found no association between total rest duration within the shift and accident risk, in a study of bus drivers in The Netherlands. In the latter study, it was suggested that the absence of significant effects of total-rest times might have been obscured by some more subtle effects, e.g. the effects of particular rests at particular times, or by individual differences in reactions to resting time. However the dataset was of insufficient size to allow such a fine-grained analysis. It would appear that the overall picture of the relationship between rest breaks and accident risk in transport settings has been muddied by methodological difficulties. For example, in a study of taxi drivers in Sydney, Australia, Dalziel and Job (1997) found a significant negative correlation between length of total rest time and number of accidents, although they noted that the relationship was confounded by the employment status of the drivers (i.e. drivers who worked unusual shift combinations took shorter breaks than owner-drivers). Hamed, Jaradat and Easa, 1998 reported a study of minibus drivers in Jordan, in which they found that drivers who took regular rest breaks were at reduced risk of having an accident. However, no operational definition of what constituted regular rest breaks was given.

The extent to which we can extrapolate from transport research to industrial settings is open to question. Driving is a highly sedentary task, involving relatively low levels of physical activity and a relatively high degree of vigilance monitoring. Moreover, drivers often have more flexibility and choice in the timing of their rest breaks, in comparison with many industrial workers, particularly those in traditional assembly line settings. However, relatively little attention has been paid to the effect of rest breaks on accident risk in industrial settings. In a recent study conducted within the New Zealand forestry industry, Lilley, Feyer, Kirk, and Gander (2002) concluded that workers working for short intensive periods without adequate rest breaks were at higher risk of accidents. However, while their analysis indicated that the taking of regular rest breaks and the number of tea breaks taken were both significantly associated with decreased fatigue, there were no direct associations reported between rest breaks and accident risk.

In a recent study conducted in a large manufacturing engineering plant, Tucker, Folkard, and Macdonald (2003) examined the trends in risk over the duration of an 8.55-h shift, in which rest breaks were taken after every 2 h of continuous work. A linear increase in risk was observed in 2 h of continuous work, such that an accident was more than twice as likely to occur in the last half hour, compared to the first half hour. Risk immediately following a break was reduced to a level close to that observed at the start of the preceding period of work. The same trends were shown across all three, 2-h periods within a shift, on both day and night shifts. The findings provided the first direct evidence that regular rest breaks are an effective means of controlling the accumulation of risk during prolonged performance of repetitive and largely machine-paced work.

In summary, research suggests that rest breaks are an effective means of managing fatigue and maintaining performance (see Table 1 for a summary of the main studies concerning the impact of rest breaks cited in this section). However, there is only limited direct epidemiological evidence that rest breaks reduce accident risk. This may be attributed, at least in part, to a failure of epidemiologists to take into account the way in which rest breaks are scheduled within a duty period (e.g. frequency, timing and duration of breaks). The majority of research that has examined the detailed scheduling of rest breaks, given below, has focused upon fatigue and performance outcomes, rather than accident risk *per se*.

3. Optimizing rest break schedules

3.1. *Frequency of rest breaks*

Under some circumstances, the overall amount of rest taken within a duty period may be less important than the precise manner in which rest breaks are scheduled, i.e. the manner in which the overall rest time is distributed throughout the shift. Optimum rest schedules are likely to be specific to the nature of the work activity being undertaken (e.g. task demands, worker's control of pacing, consequences of failure) as well as differences in both the individual's state (e.g. ability, motivation, sleep debt) and trait (e.g. circadian type). Nevertheless, common practice across a wide variety of modern industrial settings tends to reflect the view propounded by Grandjean (1969, p. 82) that:

> From a medical point of view, for the majority a midday break of 45–60 minutes is sufficient for recovery from fatigue, provided that breaks of 10–15 minutes exist in the morning and afternoon for rest and light refreshments.

Similarly, NIOSH (Dooley, 1981) recommend a break of 15 min every 2 h for VDU work under moderate demands and after 1 h for operators under high visual demands, high work loads and/or for those engaged in repetitive tasks. However, such recommendations tended not to be based upon systematic investigations (Kopardekar & Mital, 1994).

Evidence from a range of industrial settings appears to suggest that fatigue and productivity can benefit from relatively frequent short breaks. Early studies conducted by the Industrial Fatigue Research Board found that by dividing the total rest time within a work period into more frequent shorter breaks, productivity was increased (Jones, 1919; Wyatt & Fraser, 1925). Latterly, a series of field studies conducted within a factory manufacturing book covers found that a schedule of 10-min breaks each hour was more productive and less fatiguing than one of 15-min breaks every 90 min (Bhatia & Murrell, 1969). However, it was noted that in this particular situation, the former arrangement was more compatible with the job routine.

More recent research has tended to focus on the scheduling of rest breaks in computer-based occupations. For example, in a study of computer operators, Boucsein and Thum (1997) compared a schedule of short frequent rest breaks (7.5 min after 50 min of work) with one of longer less frequent breaks (15 min after every 100 min). Physiological strain indices indicated that short frequent breaks were more beneficial until the late afternoon, when the effects became reversed. Kopardekar and Mital (1994) found that incorporating short hourly or half hourly breaks into 2 h of otherwise continuous work resulted in fewer errors being made by participants in a simulated directory operator task. Galinsky, Swanson,

Table 1. Summary of the main studies concerning the impact of rest breaks on accident risk.

Relevant aspect of rest breaks studied	Author	Sample	*N*	Main outcome measure(s)	Summary of findings
Driving fatigue	Drory, 1985	Truck drivers	60	Subjective fatigue, driving performance	Breaks are most effective when taken to coincide with periods of fatigue. Breaks incorporating food, caffeine and/or naps are more effective than rest alone. Combination of nap and caffeine especially effective.
	Feyer & Williamson, 1995	Long-distance truck drivers	989	Subjective fatigue	
	Lisper & Eriksson, 1980	Car drivers (students)	8	Reaction time	
	Horne & Reyner, 1996	Car drivers (students)	10	Driving performance, physiological & subjective sleepiness	
	Reyner & Horne, 1997	Car drivers (students)	12	As above	
	Stave, 1977	Helicopter pilots	15	Errors	
Occurrence of accidents	Dalziel and Job, 1997	Taxi drivers	42	Accident risk	Conflicting findings as to whether *amount* of rest predicts risk. Methodological problems associated with some studies. Nevertheless, rest breaks appear to be an effective means of controlling accumulation of risk during industrial shift work.
	Greiner *et al.*, 1998	Transit operators	170	As above	
	Hamed *et al.*, 1998	Minibus drivers	438	As above	
	Lilley *et al.*, 2002	Forestry workers	367	As above	
	Pokorny *et al.*, 1987	Bus drivers	990 accidents	As above	
	Tucker *et al.*, 2003	Car assembly workers	526 accidents	As above	

Sauter, Hurrell, and Schleifer (2000) reported that short breaks (5 min in each hour which did not otherwise contain a break) in addition to the standard scheduled rest breaks (of two, 15-min breaks and a 30-min lunch break) resulted in reduced discomfort and eyestrain. Moreover, the introduction of additional rest breaks did not harm productivity levels. Other evidence suggests that additional rest breaks may even enhance productivity under certain conditions. For example, in a study conducted in a meat-processing plant, Dababneh, Swanson, and Shell (2001) reported that inclusion of short frequent rest breaks (3 min every 27 min in one condition and 9 min every 51 min in the other condition) prevented a decline in performance that was observed in the fourth quarter of the day when there were no such mini-breaks. However, it was noted that micro-rest breaks at a frequency greater than once per hour may not be desirable, as they tended to cause excessive disruption to the flow of work.

We will return to the issue of rest breaks disrupting the flow of work in the next section, in which we consider the optimum timing of rest breaks (i.e. when should breaks be taken?). For the purpose of the current discussion, this is considered separately from frequency of rest breaks (i.e. how many rest breaks should be taken during a shift?), although it is likely that the two parameters will be somewhat inter-related in practice.

3.2. *Timing of rest breaks*

The timing of intra-shift rest breaks is related to the amount of control that a worker has over the pacing of their job. In situations where the individual has little control over the pacing of their job (e.g. on a traditional assembly line, where the work may be machine paced), then the scheduling of rest breaks usually has to be planned in advance. These scheduling decisions will often be taken by management, perhaps in consultation with the workforce. The requirement for pre-determined rest schedules means that rest periods will not necessarily coincide with the individual's perceived need for a break (i.e. at times of heightened fatigue). By contrast, self-paced work allows the individual a degree of autonomy in determining their optimum rest strategy. There is no direct evidence linking machine pacing with accident risk. However, compared to self-paced work, performance of machine-paced tasks declines after shorter durations of continuous work (Broadbent, 1953). Machine pacing and a lack of autonomy are also associated with higher levels of stress (Salvendy, 1981) and higher perceived accident risk (Harrell, 1990). Thus machine-paced jobs could potentially be more hazardous than self-paced work. Consequently, the ways in which rest breaks are scheduled may have particularly important implications for health and safety in machine-paced work.

Brown (1994), however, notes that few tasks are truly continuous in that they do not allow any temporary withdrawal of attention. Most permit voluntary or spontaneous rest pauses to be taken at well-chosen intervals (albeit with limited opportunity), and this is usually sufficient to prevent build up of spontaneous inhibition (e.g. blocks). Skilled individuals generally learn when and for how long they can withdraw their attention from a given task so that concentration can be maintained. Therefore, an important issue regarding rest breaks in most types of work is the individual's ability to monitor their own levels of fatigue. At the same time, the choice of rest strategy will be constrained by production targets, the demands of co-workers, other elements of the operation, etc. Therefore deciding when to rest will involve striking a balance between the need to counteract fatigue and extrinsic job demands.

Left to their own devices, individuals often tend to work beyond the point at which their performance begins to decline, perhaps continuing until subjective feelings of fatigue become intolerable. Rest breaks taken after the point at which performance has begun to decline are likely to be less effective in promoting recovery, with only temporary respite from the decline in performance being achieved (Murrell, 1962, 1979). Thus the self-regulation of rest pauses is a non-trivial decision-making process that may have important health and safety implications, both for the individual worker, and the public they serve (c.f. sleep-related vehicle accidents; Horne & Reyner, 1999). As with driving, problems associated with fatigue in computer-based work are often most effectively addressed when the individual is able to adjust the timing of their rest to coincide with periods of fatigue (e.g. Hahn, 1989), while rigid break schedules can be associated with disruption of the flow of work (Henning, Jacques, Kissel, Sullivan, & Alteras-Webb, 1997) and increased emotional strain (Boucsein & Thum, 1997). Such findings would appear to suggest that the greater the discretion given to a worker to control the pace of their work, the better able they will be to regulate both the effects of fatigue on their performance, and the experience of stress, by taking microbreaks. However, workers may not always be the best judges of the most appropriate rest schedules. This was demonstrated by recent research on computer work which found that self-timed microbreaks were less effective than scheduled breaks in reducing certain forms of muscular discomfort (McLean *et al.*, 2001).

In series of laboratory studies reported by Henning, Kissel, and Maynard (1994) and by Henning, Callaghan, Ortega, Guttman, and Braun (1996), a system was described in which short rest breaks were only administered when the user's discretionary rest breaks were inadequate. In later versions, users were provided with continuous feedback regarding their level of spontaneous rest taking, relative to the target standard for rest taking (i.e. the level of rest taking below which the computer administered compulsory rest breaks). Users were thus able to self-manage their discretionary rest breaks and avoid unnecessary task interruptions. In comparison with a control condition in which rest breaks were universally administered at regular intervals, levels of comfort were improved, although no evidence was provided that performance was improved.

While it may be argued that the majority of work tasks within modern industrial environments allow a degree of self-pacing and thus self-regulated rest scheduling, the extent to which a job is machine paced may have a greater impact on the length of the rest break that is taken.

3.3. *Length of rest breaks*

Henning, Sauter, Salvendy, and Krieg (1989) reported a laboratory study involving a self-paced data entry task in which it was demonstrated that degree of recovery (in terms of typing performance and heart rate) was proportionate to the length of the microbreak taken. They also reported that performance worsened following microbreaks and this was taken to imply that participants terminated their microbreaks before recovery could occur. However, Lisper and Eriksson (1980) found that length of rest break (15 min versus 60 min) had no effect on performance in a driving task. There is little other evidence on required length of individual breaks, other than for heavy physical work. In general, it seems unlikely that there could be hard and fast rules about the duration of rest breaks independent of either the task being performed or the type of schedule being worked. In practice, rest pauses seem to have been negotiated to allow sufficient time for completion of the rest break activity (Brown, 1994).

In summary, performance and fatigue may benefit from relatively frequent short breaks. Workers should ideally be allowed to take rest at the point when they experience heightened fatigue. However, they may need to be actively encouraged to monitor their own fatigue levels and take breaks accordingly. The effectiveness of a particular rest break schedule will be influenced by the nature of the work routine and will therefore vary from one working environment to the next. The findings of the main studies concerning the frequency, timing and length of rest breaks cited in this section are summarized in Table 2.

In the light of the forgoing, it is worth noting that the European Working Time Directive (EC Working Hour Directive, 1990) entitles adults who work for more than 6 h at a stretch to a 20-min rest break (workers under 18 years are entitled to 30 min rest if they work more for than 4.5 h). The timing of breaks is at the discretion of employers, although it may not be at the beginning or end of the shift. Employers are only required to ensure that workers can take a rest, but they do not have to ensure that a rest is taken.

In the third part of this review, we now turn now to consider rest breaks in relation to one particular aspect of the work routine, namely the type of shifts being worked.

4. Rest breaks and shift work

4.1. *Rest breaks on extended shifts*

In a review of the impact of extending the duration of shifts, Rosa (1995) recommends that rest breaks should be distributed liberally throughout the shift in order to provide temporary recovery from the task at hand. However, evidence is equivocal on whether rest breaks can mitigate the negative consequences of extending the length of shifts. Rosa cites evidence from a study of the implementation of extended (12 h) shifts for nurses, in which patient contact time actually declined because of an increase in the number of unofficial breaks being taken (Reid, Robinson, & Todd, 1993). Costa, Gaffuri, Ghirlanda, Minors, and Waterhouse (1995) concluded that the extension of nurses' night shifts to 10 h was acceptable, so long as the workload was reduced and sufficient rest pauses were introduced. However, no direct comparison with shorter night shifts was reported. In a study of bus and truck drivers Harris *et al.* (1972) found that the third, 3-h break did not aid physiological recovery, nor did it arrest an increasing trend in errors that occurred after 9 h of duty. Moreover, a decline in psychophysiological indexes of alertness continued unabated, after the break. Thus it remains unclear whether increasing the number of rest breaks will necessarily be sufficient to counteract the increase in risk associated with the latter stages of a long duty period.

4.2. *Rest breaks on the night shift*

A substantial body of evidence has identified the ways in which alertness varies as a function of time of day and, in particular, as a result of circadian rhythms (e.g. Folkard, Akerstedt, Macdonald, Tucker, & Spencer, 1999). Eilers and Nachreiner (1990) recommended that more rest breaks be provided to counteract more pronounced decrements in night-time performance, where jobs are safety critical. A recent laboratory study of flight crews found that hourly 7-min rest breaks during a 6-h night flight were an effective means of temporarily counteracting declines in physiological and subjective measures of sleepiness, with strongest effects occurring near the circadian trough (Neri *et al.*, 2002). However, the physiological effects were not sustained throughout the entire inter-break period. Moreover, there were no beneficial effects of rest breaks on vigilance performance. Brown (1994) concluded in his review of driving research, that while rest breaks that do not involve sleep may alleviate the declines in alertness that are experienced in the afternoon, they will be less effective as a lasting countermeasure to fatigue in the early hours of the morning.

Table 2. Summary of the main studies concerning the frequency, timing and length of rest breaks.

Relevant aspect of rest breaks studied	Author	Sample	*N*	Main outcome measure(s)	Summary of findings
Frequency of rest breaks	Bhatia & Murrell, 1969	Manufacturing workers	12	Productivity, fatigue	Frequent short rest breaks are associated with at least some positive effects, although excessively frequent breaks may be disruptive.
	Boucsein & Thum, 1997	Computer operators	11	Physiological strain	
	Dababneh *et al*., 2001	Meat-processing plant workers	30	Productivity, comfort, stress	
	Galinsky *et al*., 2000	Data-entry operators	42	Discomfort & eyestrain	
	Kopardekar & Mital, 1994	Computer operators (students)	8	Error rate, mood	
Timing of rest breaks	Boucsein & Thum, 1997	Computer operators	11	Physiological strain	Self-managed breaks often result in better fatigue management. However, workers may take insufficient discretionary breaks to avoid discomfort, e.g. in computer work.
	Hahn, 1989	Computer operators	6	Physiological, performance, self-report	
	Henning *et al*., 1994	Computer operators (students)	38	Mood, comfort, performance	
	Henning *et al*., 1996	Computer operators (students)	61	As above, heart rate	
	Henning *et al*., 1997	Computer operators	~ 44	As above	
	McLean *et al*., 2001	Computer operators	15	Physiological comfort	
Length of rest breaks	Henning *et al*., 1989	Computer operators	20	Performance, heart rate	Conflicting findings. Optimum length will depend upon task context.
	Lisper & Eriksson, 1980	Car drivers (Students)	8	Reaction time	

Few other studies have examined the impact of conventional rest breaks in relation to circadian rhythm effects. However, several researchers have examined the potential role of scheduled naps in helping workers to overcome troughs in alertness that are associated with certain times of day.

4.3. *Rest breaks incorporating naps*

We have previously noted driving research which suggests that the beneficial effects of rest breaks may be significantly enhanced if they incorporate a nap. A recent experimental field study of power-industry workers found that naps taken during the night shift were associated with increases in satisfaction with night working, self-reported vigilance, and quality of life (Bonnefond *et al.*, 2001). However, the findings were somewhat limited by the absence of data from a control condition. A series of studies of long-haul flight crews have shown that 40-min naps during both day and night flights had positive effects on vigilance performance and physiological measures of sleepiness (Rosekind *et al.*, 1995).

There are conflicting findings from laboratory studies of the impact of intra-shift naps on night-time performance. Sallinen, Harma, Akerstedt, Rosa, and Lillqvist (1998) found that naps (< 1 h taken at 01:50 and 04:40 h) were an effective means of counteracting late night decrements in reaction time and physiological sleepiness, although these effects were not sustained in the latter part of the shift. However, in an earlier laboratory study, Rogers, Spencer, Stone, and Nicholson (1989) reported that 1-h naps taken at 02:00 h resulted in improvements in performance in just two out of eight performance measures, when compared with a no nap condition. Gillberg, Kecklund, and Akerstedt (1996) reported that 30-min naps were insufficient to counteract low levels of alertness at night in a simulated truck driving task, although in a separate laboratory study the same researchers found that 30-min day naps had positive effects on sleepiness and vigilance performance (Gillberg, Kecklund, Axelsson, & Akerstedt, 1996). Saito and Sasaki (1995) also reported that 30-min naps taken at 03:00 h by participants in a laboratory study did not improve subjective feelings of sleepiness, compared with a no nap condition. However, they later reported that naps of 1 and 2 h did reduce sleepiness (Saito & Sasaki, 1996).

In summary, napping can be an effective means of counteracting troughs in alertness (for example, at night). However there are also potential negative effects of napping, such as the disruption of subsequent sleeps and also sleep inertia. Sleep inertia is characterized by a temporary degradation of performance in the immediate aftermath of sleep (Dinges, 1992). Thus the utility of naps appears to depend upon the interaction of a range of complex factors, such as the timing of nap (e.g. relative to the individual's circadian phase and the duration of wakefulness prior to the nap), the length and quality of the nap, the sleep stage preceding the awakening from the nap, the nature of the waking activity, and individual differences (e.g. circadian type). Moreover, further discrepancies between findings result from methodological differences between studies (Sallinen *et al.*, 1998). The findings of the main studies cited in this section are summarized in Table 3. More detailed reviews of napping are provided by Kogi (2000), Muzet, Nicolas, Tassi, Dewasmes, and Bonneau (1995), Rosekind *et al.* (1995), and Sallinen *et al.* (1998).

5. Conclusions

It is commonly assumed that rest breaks are a good thing, and that their incorporation enhances performance, well-being and safety. The original intention of this review was to explore evidence for such assumptions and, in particular, to consider the impact of rest

Table 3. Summary of the main studies concerning the role of rest breaks in shiftworking.

Relevant aspect of rest breaks studied	Author	Sample	*N*	Main outcome measure(s)	Summary of findings
As means of counteracting the effects of extended shifts	Harris *et al*., 1972	Bus and truck drivers	–	Physiological alertness, errors	Little direct empirical evidence that extra rest breaks counteract effects of increased shift length.
Waking rest breaks during night shifts	Neri *et al*., 2002	Airline pilots	14	Physiological & subjective alertness, vigilance performance	Rest breaks temporarily enhance alertness, especially around the circadian trough
Rest breaks incorporating naps during night shifts.	Bonnefond *et al*., 2001	Power-industry workers	12	Satisfaction, subjective vigilance, quality of life	Utility of naps to counteract circadian trough will depend on complex range of interacting factors; hence conflicting findings.
	Gillberg *et al*., 1996a	Truck drivers	9	Driving performance, physiological & subjective sleepiness	
	Gillberg *et al*., 1996b	–	8	Vigilance performance, physiological & subjective sleepiness	
	Rogers *et al*., 1989	–	6	Cognitive task performance	
	Rosekind *et al*., 1995	Airline pilots	21	Vigilance performance, physiological sleepiness	
	Saito & Sasaki, 1995	Students	12	Subjective sleepiness & fatigue	
	Saito & Sasaki, 1996	–	–	As above	
	Sallinen *et al*., 1998	Oil refinery workers	14	Reaction time, physiological & subjective sleepiness	

break schedules upon accident risk in industrial settings. However, it soon became apparent that directly relevant evidence is lacking. Thus it became necessary to draw upon a broader range of research, in order that inferences could be drawn in relation to the original focus.

There is only limited epidemiological evidence on the precise impact of rest break schedules upon risk. While several studies have demonstrated that rest breaks taken at the onset of fatigue are an effective means of restoring performance, until recently there appears to have been no direct epidemiological evidence of the impact of breaks upon risk as a function of time-on-task. Further research is now needed to establish whether the reduction in risk following rest breaks, as reported by Tucker *et al.* (2003) is observed in other types of working environment.

We have noted contrasting evidence as to whether self-determined or pre-planned rest breaks are preferable. On the one hand, pre-planned rest breaks may not coincide with an individual's experience of heightened fatigue. On the other, individuals may not always be the best judge of when a rest break is needed. In many industrial settings, the distinction may be academic. Compared to drivers, many industrial operatives have relatively limited opportunity to take a spontaneous rest break of anything more than a matter of seconds, or possibly a minute or two. The nature of many industrial working environments requires that the timing of longer rest breaks be planned in advance. Therefore, the design of pre-planned rest break schedules is an important healthy and safety consideration in such environments. Rest breaks every 2 h are common in many industrial settings, and have been shown to act as an effective means of controlling the accumulation of risk as a function of time-on-duty. However, there is evidence from a range of settings that scheduling additional short rest breaks can be beneficial. Such arrangements will increase the likelihood of allowing the worker to rest at times of heightened fatigue that do not coincide with the conventional 2-hourly rest breaks.

Workers should not only be given the opportunity to take adequate rest breaks, but should also be encouraged to do so. Where practical, it may be desirable to combine a schedule of pre-planned rest breaks with the option for workers to take short breaks at the point at which they experience heightened fatigue. The optimum timing of rest breaks will be contingent upon the nature of the job routine (e.g. the period of the task cycle).

Rest break schedules should also take into account what effect 'starting-up' and 'shutting-down' procedures may have on efficiency and accident risk. In a study of injuries suffered by ore miners, Wagner (1988) reported that injury rates increased just prior to meal breaks or just prior to the end of the shift. According to Frank (2000), this pattern mirrors the commonly observed trends within the mining industry, of heightened injury risk during start-up and just prior to major shut-downs, when there appears to be an increase in external distractions. Overall safety levels may benefit from the appropriate redesign of such procedures, particularly if it allows for more frequent rest breaks to be taken without compromising safety.

A central premise of this review is that rest breaks are a potential fatigue countermeasure, and hence a means of controlling risk. It seems likely that their effects will be at least in part mediated by a reduction in the biological stress response (lower levels of catecholamines, cortisol, blood pressure, etc.). Moreover, they may have beneficial psychosocial effects, facilitating social relations within the workplace and enhancing work satisfaction, which may in turn have a stress reduction or buffering effect. Rest breaks also afford opportunities for a range of activities such as carrying out basic personal needs (e.g. going to the toilet) and the intake of food. Some of these activities may in themselves have significant alertness-enhancing effects. Indeed, we have noted evidence which suggests that simply taking a rest break may be relatively ineffective as a countermeasure to driver fatigue, unless it encompasses a nap and/or caffeine intake. Future research needs to examine not only issues of rest break scheduling as outlined above, but also the content of the break, in relation to the impacts upon accident risk, fatigue and performance.

Acknowledgements

The author is grateful to Simon Folkard, Celia Rutherford and the anonymous referees for their comments on an earlier draft of this paper.

References

Bhatia, N. & Murrell, K. F. (1969). An industrial experiment in organized rest pauses. *Human Factors*, *11*, 167–174.

Bonnefond, A., Muzet, A., Winter-Dill, A.-S., Bailloeuil, C., Bitouze, F., & Bonneau, A. (2001). Innovative working schedule: Introducing one short nap during the night shift. *Ergonomics*, *44*, 937–945.

Boucsein, W. & Thum, M. (1997). Design of work/rest schedules for computer work based on psychophysiological recovery measures. *International Journal of Industrial Ergonomics*, *20*, 51–57.

Broadbent, D. E. (1953). Noise, paced performance and vigilance tasks. *British Journal of Psychology*, *44*, 295.

Brown, I. D. (1994). Driver fatigue. *Human Factors*, *36*, 298–314.

Costa, G., Gaffuri, E., Ghirlanda, G., Minors, D. S., & Waterhouse, J. M. (1995). Psychophysical conditions and hormonal secretion in nurses on a rapidly rotating shift schedule and exposed to bright light during night work. *Work and Stress*, *9*, 148–157.

Dababneh, A. J., Swanson, N., & Shell, R. L. (2001). Impact of added rest breaks on the productivity and well being of workers. *Ergonomics*, *44*, 164–174.

Dalziel, J. R. & Job, R. F. S. (1997). Motor vehicle accidents, fatigue and optimism bias in taxi drivers. *Accident Analysis and Prevention*, *29*, 489–494.

Dinges, D. F. (1992). Adult napping and its effects on the ability to function. In C. Stampi (Ed.), *Why we Nap: Evolution, Chronobiology, and Functions of Polyphasic and Ultrashort Sleep* (pp. 118–134). Boston, MA: Birhauser.

Dooley, A. (1981). NIOSH issues, CRT guidelines. *Computerworld*, *15*, 1–8.

Drory, A. (1985). Effects of rest and secondary task on simulated truck-driving task performance. *Human Factors*, *27*, 201–207.

EC Working Hour Directive (1990). Council Directive concerning certain aspects of the organization of working time. Official Journal of the European Communities, No C254/4.

Eilers, K. & Nachreiner, F. (1990). Time of day effects in vigilance performance at simultaneous and successive discrimination tasks. In G. Costa, G. Cesana, K. Kogi, & A. Wedderburn (Eds.), *Shiftwork: Health, Sleep and Performance* (pp. 467–472). Frankfurt am Main: Peter Lang.

Feyer, A. M. & Williamson, A. M. (1995). Work and rest in the long-distance road transport industry in Australia. *Work and Stress*, *9*, 198–205.

Folkard, S., Akerstedt, T., Macdonald, I., Tucker, P., & Spencer, M. (1999). Beyond the three-process model of alertness: Estimating phase, time on shift, and successive night effects. *Journal of Biological Rhythms*, *14*, 100–110.

Folkard, S. & Hill, J. (2002). Shiftwork: Body rhythm and social factors. In P. Warr (Ed.), *Psychology at Work*, 5th ed. (pp. 51–76). London: Penguin.

Frank, A. L. (2000). Injuries related to shiftwork. *American Journal of Preventative Medicine*, *18*, 33–36.

Galinsky, T. L., Swanson, N. G., Sauter, S. L., Hurrell, J. J., & Schleifer, L. M. (2000). A field study of supplementary rest breaks for data-entry operators. *Ergonomics*, *43*, 622–638.

Gillberg, M., Kecklund, G., & Akerstedt, T. (1996). Sleepiness and performance of professional drivers in a truck simulator—comparisons between day and night driving. *Journal of Sleep Research*, *5*, 12–15.

Gillberg, M., Kecklund, G., Axelsson, J., & Akerstedt, T. (1996). The effects of a short daytime nap after restricted night sleep. *Sleep*, *19*, 570–575.

Grandjean, E. (1969). *Fitting the Task to the Man: An Ergonomic Approach*. London: Taylor & Francis.

GREINER, B. A., KRAUSE, N., RAGLAND, D. R., & FISHER, J. M. (1998). Objective stress factors, accidents, and absenteeism in transit operators: A theoretical framework and empirical evidence. *Journal of Occupational Health Psychology*, *3*, 130–146.

HAHN, E. (1989). Erholungswirkungen ausgewaehlter Pausenorganisationsvarianten bei Routine-bildschirmarbeitstaetigkeiten [Recovery effects of some rest period variables in routine computer screen (CRT) operations]. *Zeitschrift-fuer-Arbeits-und-Organisationspsychologie*, *33*, 188–196.

HAMED, M. M., JARADAT, A. S., & EASA, S. M. (1998). Analysis of commercial mini-bus accidents. *Accident Analysis and Prevention*, *30*, 555–567.

HARRELL, W. A. (1990). Perceived risk of occupational injury: Control over pace of work and blue-collar versus white-collar work. *Perceptual and Motor Skills*, *70*, 1351–1359.

HARRIS, W., MACKIE, R. R., ABRAMS, C., BUCKNER, D. N., HARABEDIAN, A., O'HANLON, J. F., & STARKS, J. R. (1972). *A Study of the Relationships among Fatigue, Hours of Service and Safety Operations of Truck and Bus Drivers*. Final Report 1727-2. Human Factors Research Inc., Goleta, CA.

HENNING, R. A., CALLAGHAN, E. A., ORTEGA, A. M., KISSEL, G. V., GUTTMAN, J. I., & BRAUN, H. A. (1996). Continuous feedback to promote self-management of rest breaks during computer use. *International Journal of Industrial Ergonomics*, *16*, 71–82.

HENNING, R. A., JACQUES, P., KISSEL, G. V., SULLIVAN, A. B., & ALTERAS-WEBB, S. M. (1997). Frequent short rest breaks from computer work: Effects on productivity and well-being at two field sites. *Ergonomics*, *40*, 78–91.

HENNING, R. A., KISSEL, G. V., & MAYNARD, D. C. (1994). Compensatory rest breaks for VDT operators. *International Journal of Industrial Ergonomics*, *14*, 243–249.

HENNING, R. A., SAUTER, S., SALVENDY, G., & KRIEG, E. (1989). Microbreak length, performance and stress in a data entry task. *Ergonomics*, *32*, 855–864.

HORNE, J. A. & REYNER, L. A. (1996). Counteracting driver sleepiness: Effects of napping, caffeine, and placebo. *Psychophysiology*, *33*, 306–309.

HORNE, J. & REYNER, L. (1999). Vehicle accidents related to sleep: A review. *Occupational and Environmental Medicine*, *56*, 289–294.

JONES, E. D. (1919). *The Administration of Industrial Enterprises*. New York: Longman.

KOGI, K. (2000). Should shiftworkers nap? Spread, roles and effects of on-duty napping. In P. Knauth, G. Costa, & S. Folkard (Eds.), *Shiftwork in the 21st Century*. Frankfurt am Main: Peter Lang.

KOPARDEKAR, P. & MITAL, A. (1994). The effect of different work-rest schedules on fatigue and performance of a simulated directory assistance operator's task. *Ergonomics*, *37*, 1697–1707.

LILLEY, R., FEYER, A.-M., KIRK, P., & GANDER, P. (2002). A survey of forest workers in New Zealand: Do hours of work, rest, and recovery play a role in accidents and injury? *Journal of Safety Research*, *33*, 53–71.

LISPER, H.-O. & ERIKSSON, B. (1980). Effects of the length of a rest break and food intake on subsidiary reaction-time performance in an 8-hour driving task. *Journal of Applied Psychology*, *65*, 117–122.

MCLEAN, L., TINGLEY, M., SCOTT, R. N., & RICKARDS, J. (2001). Computer terminal work and the benefit of microbreaks. *Applied Ergonomics*, *32*, 225–237.

MURRELL, K. F. H. (1962). Operator variability and its industrial consequences. *International Journal of Production Research*, *11*, 39–55.

MURRELL, K. F. H. (1979). *Ergonomics: Man in his Working Environment*. London: Chapman & Hall.

MUZET, A., NICOLAS, P., TASSI, G., DEWASMES, G., & BONNEAU, A. (1995). Implementation of napping in industry and the problem of sleep inertia. *Journal of Sleep Research*, *4*(Suppl. 2), 67–69.

NERI, D. F., OYUNG, R. L., COLLETTI, L. M., MALLIS, M. M., TAM, P. Y., & DINGES, D. F. (2002). Controlled breaks as a fatigue countermeasure on the flight deck. *Aviation, Space and Environmental Medicine*, *73*, 654–664.

POKORNY, M. L. I., BLOM, D. H. J., VAN LEEUWEN, P., & VAN NOOTEN, W. N. (1987). Shift sequences, duration of rest periods, and accident risk of bus drivers. *Human Factors*, *29*, 73–81.

REID, N., ROBINSON, G., & TODD, C. (1993). The quantity of nursing care on wards working 8- and 12-hour shifts: a follow up study. *International Journal of Nursing Studies*, *30*, 403–413.

REYNER, L. A. & HORNE, J. A. (1997). Suppression of sleepiness in drivers: Combination of caffeine with a short nap. *Psychophysiology*, *34*, 721–725.

ROGERS, A. S., SPENCER, M. B., STONE, B. M., & NICHOLSON, A. N. (1989). The influence of a 1-h nap on performance overnight. *Ergonomics*, *32*, 1193–1205.

ROSA, R. (1995). Extended work shifts and excessive fatigue. *Journal of Sleep Research*, *4*(Suppl.), 51–56.

ROSEKIND, M. R., SMITH, R. M., MILLER, D. L., CO, E. L, GREGORY, K. B., WEBBON, L. L., GANDER, P. H., & LEBACQZ, J. V. (1995). Alertness management: Strategic naps in operational settings. *Journal of Sleep Research*, *4*(Suppl. 2), 62–66.

SAITO, K. & SASAKI, T. (1995). Sleepiness and fatigue during early morning hours after a 30 minute nocturnal nap. *Shiftwork International Newsletter*, *12*, 53.

SAITO, K. & SASAKI, T. (1996). The effect of length of a nocturnal nap on fatigue feelings during subsequent early morning hours. *Journal of Science of Labour*, *30*, 305–317.

SALLINEN, M., HARMA, M., AKERSTEDT, T., ROSA, R., & LILLQVIST, O. (1998). Promoting alertness with a short nap during a night shift. *Journal of Sleep Research*, 7, 240–247.

SALVENDY, G. (Ed.) (1981). *Proceedings of the International Conference on Machine-Pacing and Occupational Stress*. Cincinatti, OH: National Institute for Occupational Safety and Health.

STAVE, A. M. (1977). The effects of cockpit environment on long term pilot performance. *Human Factors*, *19*, 503–514.

TUCKER, P., FOLKARD, S., & MACDONALD, I. (2003). Rest breaks and accident risk. *Lancet*, *361*, 680.

VAN DIEEN, J. H. & VRIELINK, H. H. E. O. (1998). Evaluation of work-rest schedules with respect to the effects of postural workload in standing work. *Ergonomics*, *41*, 1832–1844.

WAGNER, J. A. (1988). Time-of-day variations in the severity of injuries suffered by mine shiftworkers. *Proceedings of the Human Factors Society, 32nd Annual Meeting*, Anahiem, CA, 24–28 October, pp. 608–611.

WOOD, D. D., FISHER, D. L., & ANDRES, R. O. (1997). Minimizing fatigue during repetitive jobs: Optimal work-rest schedules. *Human Factors*, *39*, 83–101.

WYATT, S. & FRASER, J. A. (1925). *Studies in Repetitive Work with Special Reference to Rest Pauses*, I.F.R.B. Report No. 32. London: HMSO.