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Review Article

A Critical Review of Techniques Aiming at Enhancing and Sustaining Worker's Alertness during the Night Shift

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Abstract: Two types of methods based on a particular principle allow enhancing and sustaining workers' alertness all along their night work. The first one rather consists in arousing workers by exposing them to stimulant environment conditions (light or noise…) or by giving them natural or pharmacological reactivating substances (caffeine or amphetamines…) for example. The second principle consists in increasing workers' possibilities for resting and allowing them to have short sleep periods or Short Rest Periods (SRP) in an adapted area at the workplace. In order to use these techniques in real work situations, after a critical review taking into account both efficiency, advantages and disadvantages but also applicability and acceptability, the SRP technique stands out as the most efficient method as it has a certain number of advantages with regard to our initial objective.

Key words: Review, Alertness, Sleepiness, Night work, Countermeasures

Introduction

The number of studies dealing with night work and/or shift work has increased since the fifties. This growth goes hand in hand with the expansion of this particular kind of work, which involves today between 15 and 20% of workers in most industrialized countries. Night work, of whatever kind, is not without consequences on workers and their close circle and the problems it creates have been carefully studied both in socio-family and physiological viewpoints.

During night work indeed, "social habits" of work hours on the one hand and family and city hours on the other hand are opposed. The resynchronization of these two elements leads to disruptions of workers' social and family life. Moreover, night workers, who have to sleep and work at unusual hours, face physiological disturbances that affect their work in terms of efficiency and safety. This undeniable fact is due to two main causes. The first one has to do with the quality of recovery sleep. This diurnal sleep is indeed globally shorter and more split[1, 2] because it is disturbed by endogenous and/or exogenous factors[3]. The second cause is directly linked to the circadian rhythm of alertness, which reaches a lower point in the middle of the night (between 1 and 4 in the morning). This time slot, which is favorable to sleepiness[4] and in a roundabout way to human error, is a critical period of the night.

Consequently, it is absolutely imperative to do everything possible to enhance and sustain workers' alertness all along their night-time work. In order to attain this objective, several techniques have already been tested in laboratory and some have even been applied in real work situations. Overall, these techniques can be put into two groups of methods that are based on a particular principle. The first principle consists in arousing workers. Numerous techniques associated with it involve exposure to stimulant environment conditions, the intake of arousing natural or pharmacological substances,

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cognitive or behavioral techniques, rest breaks or secondary work activities and will be dealt with in the first part of this paper. The second principle consists in increasing possibilities for resting and allowing workers to benefit from short sleep periods in adapted areas at the workplace. It will be described in the second part of this paper.

So as to attain the initial objective in the best way, that is to say to find a technique to enhance and sustain workers' alertness all along their night time work and applicable in real work situations, all these techniques will be studied in terms of efficiency on the one hand; the advantages and disadvantages of each one will be emphasized. On the other hand, in order to be able to apply them in real work situations, the feasibility and acceptability of these techniques will be discussed.

1st Part: Arousing Workers

I. Exposure to stimulant environment conditions

This first series of techniques consists in using sensory stimulation, such as light, sound, music or ambient temperature, which will act by stimulating individuals' senses and thus will be able to counter the impairment of their performance and/or alertness in the short term. The use of such environmental stimulation involves increasing sensory stimulation and thus potentiating the activity of the reticular activating system. Some stimuli, such as light, also have phase shifting effects.

A. Light:

Researches carried out by Czeisler and his team since the end of the seventies have shown that circadian cycle is greatly sensitive to varying light exposures during the 24 h of the day[5, 6]. Exposure to bright light (5,000 lux or more, for 3 to 5 h) either advances or delays human circadian rhythms according to what time it takes place during the day and consequently affects most physiological functions[7]. Other studies have since shown that this effect of light exposure already appears with much lower light intensity (from 150 lux onwards)[8, 9].

All these results have been useful as a starting point to carry out field researches[10]. First, dealing with the treatment of affective disorders, investigations, like those led by Lindsley and Buchan (1988) on people with seasonal affective disorders, have pointed out that bright light exposure has immediate arousing effects on these patients[11]. Bright light therapy increases alertness and wakefulness by activating the reticular formation[12, 13]. Then, in the case of sleep disturbances, it has been thought relevant to apply this technique to shift workers (and/or night workers), notably. Experiments have been conducted in order to attempt to reduce negative effects due to the bad adjustment of night workers' circadian system on their performances and alertness during the shift, but also on the quality of their subsequent main sleep[14]. For a review, see[15].

In this prospect, Czeisler and his team[16] show that by exposing night workers to bright light (from 7,000 to 12,000 lux) all along their night shifts and to darkness during daytime, their physiological adjustment to these work hours may be accelerated (a complete adaptation to this schedule may be obtained after 4 night shifts in such conditions of light exposure): bright light has circadian phase shifting effects. In more concrete terms, this means that the states of alertness and cognitive performance are significantly improved during night time. These results were later confirmed by other investigations. Exposure to bright light during a simulated night shift leads to enhanced performance, reduced sleepiness at work and improved main sleep patterns following this shift[17–19].

Finally, a field study led by Baker in 1995 with nuclear industry shift workers has demonstrated the benefits of light exposure and its feasibility at the workplace[20]. The system in use sets automatically light intensity and duration of exposure as the shift goes by. The use of this system has not only allowed improving these workers' alertness and performance during night shift, but it has also allowed increasing subsequent main sleep length and quality. Other subjective benefits, notably linked to mood, have also been observed.

Nevertheless, despite the positive effects and aroused interest presented by this first technique, it has been too rarely tested in the long term and in situations that differ from the artificial frame of the laboratory. A major complaint about the use of bright light in the field was that it made the readjustment to a daytime schedule after night work more difficult[21]. This presumably interferes with workers's social and family commitments during their time off. If workers have to return to a daytime schedule, they may take a few days to reentrain[22] and so will therefore be "out of sync" during their time off. Moreover, this technique, which is hard to implement (and even impossible) in certain kinds of work environment, has got numerous disadvantages that cannot be ignored, mainly such as fatigue and unpleasantness that may be induced by such an exposure. It is also to be noted that this technique is restricting and relatively expensive.

B. Noise:

Many studies have been directed toward the effects of

noise on performance. Variables such as the nature of noise, the nature of task, the period of daytime or individual differences have been studied (see[23] for a review of the effects produced by moderate noise intensity on performance). In his first experience for example, Wilkinson has concluded that white noise has positive effects on performance, by generating a continuous white noise at 100 dB to subjects who were deprived from sleep for 32 h[24]. According to him, noise and sleep deprivation induce two types of different "fatigues" whose actions might be opposed. To a certain extent, noise has the advantage of making up for the impairment of performance due to circadian changes, by increasing the person's level of general arousal.

The resort to such intensity levels has fortunately since been abandoned because of the risks of auditory disorders. Besides, some other studies have since then got the opportunity to confirm that the same beneficial effects of noise on performance could be obtained with more moderate noise intensities (75–85 dB). Studies led by Tassi and associates in 1992 should be mentioned. They have shown that the continuous generating of a pink noise at 75 dB not only allows counteracting sleep inertia following a night nap taken at the first part of night (from 1 to 2 o'clock), but also has a positive effect on subsequent cognitive performance[25]. Tassi's next studies clearly show that positive effects of noise on performance (and more precisely on the response time) depend upon factors such as the time of day and the deprivation of prior sleep[26]. Studies that were led on this point in real work situations are much rarer. Studies led with motorists are the closest in type and have shown that exposure to noise, or to a combination of noises, may be a good means of countering sleepiness and fatigue, for it allows enhancing these drivers' alertness[27]. Moreover, noise may have a positive effect on the subjects' moods[28].

Be that as it may, it seems that when all is said and done, noise effects on performance at work are quite complex. Noise is not always found to be beneficial indeed. It produces decrements in performance if task demands are heavy or if noise is loud enough to mask feedback from the machine, instruments or inner speech[29]. In any case, it is important to emphasize the fact that the generating of noise during an extended period of time produces, in addition to its unpleasantness, an extra tiredness for the night workers exposed to it. This may cause some ethical problems.

C. Music:

Most studies showing beneficial effects of music on vigilance performance were led after the seventies. For example, in their reference study Davies and associates (1973) showed that performance in a visual alertness task are better in terms of right detection and latency in the condition music (75 dBA) versus no music[30]. More recently, Beh and his team[31] came to the same conclusions by showing beneficial effects of moderate intensity music (55–57 dBA) on vigilance performance. According to Fontaine and associates (1979), the generating of music, even of low intensity, seems to prevent performance decrements over time[32] and may be helpful to the maintenance of alertness in situations that require sustained attention, without impairing performance to the task[33].

These results were quickly followed by more practical applications. First, in the field of motoring, where listening to the car radio may be a good way of reducing sleepiness while driving, in the short term only[34]. Then in professional situations, where music is the method most frequently used. Industrial studies actually have shown that a musical background in general improves workers' performance[35, 36].

We should nevertheless emphasize the fact that, as with noise, the stimulant value of music is relative to its own characteristics: the more varied the music, the more stimulant it is[37]. However, these results vary from one individual to another and are different according to the task[31]. Be that as it may, the use of music has a double advantage as compared to noise:

— first on performance, which are better with music than with noise, even at the same intensity;
— then on morale as the attitude of most workers toward background music is favorable[38, 39].

D. Temperature and ventilation:

Results of researches dealing with the effects of ambient temperature on performance are relatively contradictory, unless they are carefully brought together according to the type of tasks, as Grether did, and a bit later as Hancock did[40, 41]. Ambient temperature seems to have a significant impact on performance and alertness via induced changes of internal temperature. Alertness is reduced upon exposure to high temperature (> to 28°C) in cognitive tasks as well as in vigilance tasks.

However, very few studies were led on the use of ambient temperature as a means of arousing individuals. The study of Dewasmes and his team should be mentioned. In 1995 they used thermal environment in order to counter performance and/or alertness impairment. They conclude that this experimental factor has a contrasted effect. At the beginning of night indeed, temperature enhances performance whether it is felt as slightly cold or hot, but at the end of night its influence is inverted. Its impact also varies according

to the task[42]. However that may be, these thermal operations are likely to be unpleasant and the source of stress caused by them cannot be ignored[41].

To some extent, ventilation may also be used as a means of getting aroused, although it is often studied in the same way as temperature. Opening a window of the car while driving, like listening to the car radio, is one of the most frequent methods used by motorists in order to counter sleepiness[43]. However, few studies have confirmed the efficiency of this technique[44], apart from in the short term, that is to say as a temporary solution until having a break notably[34].

II. Intake of natural or pharmacological substances

This second group of techniques includes the intake of natural or pharmacological substances (see[45] for a review).

A. Natural substances:

The simple fact of eating or drinking has an arousing function on the system, whatever the substance. Some substances are more especially known for their arousing qualities, and caffeine is the most studied. It has been known for centuries and stimulates the central nervous system through up-regulating the receptors of adenosine, a molecule whose effects are opposed to those of caffeine.

Convergent studies have shown the positive effects of caffeine on alertness and performance during daytime as well as during night time[46–49]. These effects can be felt as soon as a moderate amount of caffeine (between 2 and 4 mg/kg) is taken, whatever its shape (coffee, tea or energy drink)[50].

However, studies on the use of caffeine as a means of improving night workers' alertness are rarer. All studies that have been registered have only been led during simulated night shifts. Thus, in 1990 Walsh and associates showed that the intake of 4 mg/kg of caffeine at the beginning of a work period significantly reduces sleepiness (measured with the iterative MSLT sleepiness test) and increases the ability of remaining awake (measured with the RTSW test)[51]. These results were later completed and confirmed by other studies. For example, Muehlbach and Walsh (1995) gave their subjects 4 mg/kg of caffeine in 2 equal doses at 2 different periods (22.30 and 1.20) during 3 consecutive simulated night shifts and have shown that caffeine taken in precise doses and at precise periods reduces sleepiness and performance impairment during night-time work hours[52]. However, no known field study has been led on this theme for the time being. We have only been informed thanks to investigations that show that caffeine is frequently and spontaneously used by workers in order to get aroused[45].

Nevertheless, despite all the positive effects described here, one should keep in mind that there are also some disadvantages. Indeed, the intake of repetitive and important caffeine doses may lead to the appearance of side effects like trembling, tachycardia, anxiety, nervousness, stress and digestive disorders. Caffeine intake may also affect subsequent sleep negatively[53, 54]. Finally, people get quickly used to its stimulant effects[55] and thus have to repeat their caffeine intake, which puts another limit to its interest.

B. Nicotine:

Nicotine, administered via cigarette smoking, skin patches, or subcutaneous injection, has shown to improve attention/information processing and working memory measures in smoking-deprived healthy human smoking population[56–58] as well as in nonsmoking populations[59–61]. It was generally conceded that smoking enhanced "arousal" which then enhanced performance on the various tests administered[62, 63]. Perhaps one of the most significant cognitive findings that was attributed to the act of smoking was the enhancement of vigilance and concentration[63–68]. Several lab studies confirmed and extended the increasing effects of nicotine on vigilance: after the intake of nicotine (orally or trandermally) overall levels of performance (accuracy and speed) are improved. It has been shown that the decrement in performance with time has been shown to be prevented with nicotine. See[69] for a review.

However, the conflict between health and performances' enhancement cannot be overlooked. The negative impact of caffeine on health and the nicotine addiction, are well known and well documented. This may cause some ethical problems.

C. Pharmacological substances:

Two main groups of molecules may be used as pharmacological countermeasures: amphetamines and eugregorics.

First, amphetamines were quickly noticed for their arousing effect. Like caffeine, amphetamines are stimulants of the central nervous system. Combatants from the whole world used this molecule during the Second World War in large numbers and it has been subject to many laboratory studies, notably in sleep deprivation situations. For example, the intake of 20 mg in the morning after 2 consecutive sleepless nights is enough to enhance the subjects' alertness and performance[70]. Various studies thus showed its beneficial effects on alertness, mood and performance on subjects who were sleep deprived for 48 to 60 h[71, 72].

According to Roussel (1995), amphetamines are part of the best pharmacological agents that counter the effects of sleep deprivation[73]. However, their effects may considerably differ from a substance to another, and for a same substance, from a dose to another. Important side effects (state of anxiety, confusion, rise of blood pressure, heart rate and temperature) as well as the possible risk of abuse should nevertheless lead us to reject the idea of regularly having recourse to this type of substance in work situations.

Then, eugregorics were discovered more recently and they also have this arousing effect[74–76]. Modafinil is the most known and the most powerful and even if most researches were made with patients suffering from sleep disorders, some rare studies showed its positive effects on healthy subjects[77]. Its benefits may be obtained with the intake of a 200 mg dose and are only followed by very limited side effects (moderate rise of blood pressure and of heart rate). They are notably opposed to troubles induced by sustained wakefulness on performance and subjective sleepiness. Molecules of the eugregorics family consequently seem to present some interest in comparison with caffeine and amphetamines. Still, it should be kept in mind that its use is not natural and may cause ethical attention whenever it is regularly used in work situations, for its long-term effects after several months or years are still today completely unknown.

III. Behavioral and cognitive techniques

Numerous techniques are used for increasing self-efficacy in athletes and could be investigated with shift workers. We will study two techniques that we find the most representative, namely hypnosis and expectancy.

A. Hypnosis:

Hypnosis appears to facilitate physical performance for some people in some circumstances[78, 79]. For example, some studies have shown that hypnosis could help workers to keep a sufficient alertness level in order to correctly fulfill their supervision tasks. The results of an experiment conducted by Davies and Tune (1969) should be mentioned[80]. The subjects had to fulfill a vigilance task in a cold thermal environment. Thanks to hypnosis, subjects who had been hypnotized had less shiver responses and better performance than subjects who had not been hypnotized. A bit later, Barabasz (1980) showed the positive effects of hypnosis on alertness in a detection task. Indeed, the group of subjects who had been asked to improve their performance after being hypnotized significantly made fewer mistakes than the group who had been told opposed instructions[81].

According to Penn and associates (1990), this technique might be useful to shift workers in promoting alertness and relaxation at work as well as at home[82]. Nevertheless, its efficiency is still discussed. Putting this method into practice may be problematic as far as practicability is concerned, for workers would have to be trained and to put a sustained effort in order to do it. Moreover the application of hypnosis may cause ethical problems.

B. Expectancy:

Other techniques that have already been used to enhance athletes' performance could be used with shift workers. For example, expectancy seems to be a good means of increasing performance in numerous situations. We will mention an experiment conducted by Ware and Baker (1977) to briefly illustrate this technique. They observed that suggestions to workers that the task would be 'short and challenging' produced fewer vigilance decrements than 'monotonous and boring' task expectancies[83].

Even if its efficiency has been broadly shown in sports, its application in work situations still remains very marginal. However that may be, workers have to put many efforts to apply the expectancy method as well as all other cognitive techniques for these methods to be efficient, but these efforts might be a too hard requirement from workers.

IV. Breaks and secondary activities

The objective of this fourth and last group of techniques is to counter monotony at work, either by introducing short rest breaks, or by varying activities. Breaks are here associated with arousing techniques and will be mainly considered as periods when activities can be manifold.

A. Breaks:

Field researches have shown that task distribution among teams changes according to work schedule[84]. During night shifts, these collective organizations of activities notably aim at arranging frequent free time periods in order to get aroused or to rest[85]. According to Lille and Andlauer (1981), activities should be renewed every 90 to 120 min in order to keep a sufficient alertness level[86]. Indeed, variety in work tasks is almost as favorable as breaks[87], as well as interspersed breaks where one can have different individual or group activities (walking, talking, eating or drinking…).

In vigilance research, it has been demonstrated that rest pauses aid the maintenance of efficiency. If short breaks are judiciously used, they allow to alleviate fatigue and increase productivity and efficiency by breaking work monotony[88–91]. In an experimental situation of a simulated

supervision of a continuous process, in 1989, Lancry showed that having a break at night has a beneficial effect on the fulfillment of tasks, if it lasts long enough (at least 20') and if it is accompanied with a real physical and mental break with the main activity, thus allowing to have individual or collective recreational leisure breaks (playing video games, doing intellectual or motor activities…), to have communal meals or even naps[92]. A bit later, he suggested to comedians to introduce a break while dubbing a movie in order to counter deteriorations appearing after 2 h. This half-hour break should be spatial and linked with the professional activity. The results lead him to conclude it has beneficial effects upon the quality of the task that is carried out and upon the comedians' self-assessed alertness[93]. Recently, Dinges's group has found the potential usefulness of brief (7-min) hourly breaks as an in-flight fatigue countermeasure. The physiological and subjective data indicate that the breaks reduced nighttime sleepiness for at least 15-min post-break and may have masked sleepiness for up to 25 min[94].

Nevertheless, little research has been conducted on the most beneficial timing and length during breaks. However this may be, these parameters should take into account human (biological rhythms, aging…) and organization (kind of work, schedule) factors[95]. According to Cail and Floru (1993), breaks are more efficient if they are taken before one gets tired, during work on a visual display unit for example[96].

Rest breaks are most usually constituted of social activities, but they may also be more active, with physical exercises or simple movements. Few studies have finally investigated potential arousing effects of exercises and movements at work, however it has been observed at several times that people will move around at work in order to decrease fatigue and increase alertness[88]. The simple fact of activating one's muscles from time to time is a good means of stimulating one's system and thus countering sleepiness and fatigue[97]. These results have been confirmed by Bonnet and Arand (1999) in sleep deprivation conditions, as they demonstrated that various levels of physical activities had a positive impact upon the ability of remaining awake[98]. In the same way, motorists or long-distance truck drivers are deeply advised to regularly stop for a few minutes and walk around their vehicle. This technique seems conceivable in industrial environment, for it requires neither expensive equipment nor complex training. These exercises should be light and relatively short in order not to lead to the opposed effect[99, 100].

B. Variation in work:

This last technique has to do with the tasks required from the subject (the worker), for it consists in varying the activity itself, "enriching" it by introducing a task that has no link with the main task and does not alter it: it is called a secondary task. Introducing one or several secondary tasks within the main task has been inspired from drivers, who do several activities in order to remain awake, and seems to allow sustained alertness and performance[101]. In spite of all, studies on its efficiency are still quite rare and are certainly the most numerous in the field of motoring and train driving.

In 1999 for example, Verwey and associates led an original study by asking their subjects, who were driving a car in monotonous conditions, to do some secondary mental activities with a gamebox. The results are definite and clearly demonstrate that the use of this gamebox decreases the impairment of performance that is usually observed in such conditions. Carrying out a secondary task here means doing a play mental activity and consequently seems to be a good means of countering subjects' alertness impairment[102].

The "dead man" system is a typical kind of secondary task and it is used in some monotonous and more or less automated driving tasks. The principle consists in operating an extra control with a certain temporal frequency, for example every minute. Some studies have shown that this kind of secondary task may easily be carried out automatically with very low alertness levels though[103]. This system does not seem to prevent the tired driver from falling asleep, with eyes closed for 20 to 30 s, between two programmed operations.

Consequently, even if the efficiency of this technique has sometimes been proved in helping to sustain a good alertness level, it is absolutely not infallible. Performing more than one task simultaneously might be hazardous, for the secondary task may be carried out more carefully than the main task. Finally, long-term effects induced by the use of a secondary task cannot be ignored. Indeed, it might on the contrary lead to excessive fatigue in a more or less long term, for the subject is asked to carry out a heavier task.

2nd Part: Increasing Possibilities for Resting

This second method simply consists in taking small portions of sleep, which are more commonly called naps. Napping means having a rest at any time of day that is 50% shorter than night sleep, according to Dinges[104], or 25% shorter according to Naitoh[105]. Its positive effects are well known and its use can be manifold (see[106] for a review). Indeed, this rest break can be used in anticipation, in order to prepare for sleep loss in advance (in this case it is called a "prophylactic nap"), to counteract sleep loss or deprivation or as a means of sustaining alertness during a sleepless period,

notably during a night shift. We will here consider rest break under this sole meaning. In this case we will call it Short Rest Period (SRP).

I. Advantages and practical observations

Taking a SRP during night shift seems to be a good means of countering sleep loss effects that are induced by shift and/or night work[107]. Several studies have been directly led on the effects of taking a SRP during night shift on subjects' alertness. Although they have used different methodologies, they all have helped to demonstrate its numerous benefits: first on performance but also on subjective and physiological sleepiness. In 1994 for example, Matsumoto and Harada showed that taking a two-hour SRP at 1 am or 3 am during night shift counters the increase of subjective sleepiness that is usually to be observed all along night shift[108]. In the same way, Saito and Sasaki notice that early-morning subjective sleepiness can be lowered by taking a one- or two-hour SRP at 3 am[109]. Taking a one-hour SRP (at 2 am in Rogers' experiment and at 9 pm or 4.30 am in Gillberg's) equally allows enhancing performance in some tests[110, 111]. Response time seems to be the measure that is the most sensitive to SRP effects[104, 110, 111] and is thus important in supervision tasks or driving notably. Finally, physiological sleepiness can be decreased for a short while thanks to the effect of SRP[110, 112].

In the same way and in order to attain an improvement objective, other studies have been conducted on the most beneficial timing and length of SRPs. First as regards its length, opinions are unanimous and it is obvious that two- or more hour SRPs are clearly beneficial in countering performance impairment[113]. However, short rest breaks (5 to 20 min) are enough in order to show their benefits[114]. In the field of motoring, benefits of 10 to 15 min SRPs in countering sleepiness while driving have equally been observed[115, 116]. This result is very important with respect to work situations, where choosing SRP length should equally be determined by demands linked to the situations themselves. In industrial environment among others, allowing SRPs lasting more than one hour indeed seems hardly conceivable.

From this viewpoint and in order to answer the question of SRP timing, Sallinen and associates (1998) have tested the efficiency of a 50 min and 30 min SRP taken either in the first part of night (1 am) or in the second part of night (4 am)[112]. They conclude that a 50 min or 30 min SRP is beneficial whatever its timing, which consequently has no influence whatever on its efficiency. However, other researchers have come to other findings. Gillberg (1984) certifies that taking a SRP at 4.30 am is more efficient than taking one at 9 pm[110]. Matsumoto (1981) studied the effect of a two-hour SRP taken at different periods at night and concluded that nadir is the most favorable period for napping in order to counter deleterious effects of night work[117]. The lack of unanimous answers to this question may be due to the use of different methodologies. However this may be, SRP efficiency eventually seems to be a consequence of sleep itself rather than of its length or timing[118, 119]. Napping seems beneficial if material and environmental conditions are there and according to Dinges, it is the most efficient if taken as soon as possible, before sleep loss is felt[104]. At a lower level of involvement, some studies have revealed that simply lying down and relaxing already allows some psycho-physiological recovery while improving morale[120] and performance[119, 121].

In any case, napping is already very common in some occupations, whenever the amount of work allows it. For example, it is allowed at hospital or for airline pilots during transcontinental flights[122]. In other countries such an organization of night work has already been well-established, such as in Japanese industries[123]. An investigation on sleep habits of Japanese shift workers was conducted by Kogi in 1981–1982 and showed that 40% take a short rest break during their night shift (after a collective or informal agreement with managers' tacit permission)[124]. Ninety-six % of night workers who were interviewed think these naps are very positive[125]. In France, two field studies were conducted over two period of one year each with volunteer shiftworkers operating in an industrial plant[126]. They were authorized, under certain conditions, to use individual sleeping areas, for a maximum of one hour, between 23h30 and 3h30, in individual bedrooms next to the control room. Subjective (questionnaires, interviews) and objective (actimeter) measures were collected. Results showed that, even if introducing SRP is a complex issue, napping at the work place is feasible and acceptable. This new organization was very well accepted by the participants. For them, the most obvious effect was the increase on the quality of their night work, this new organization introduced a general satisfaction about the quality and the easiness of the work at night. In addition, the new organization was left to the subjects themselves and this proved to be fully satisfactory.

Moreover, it is to be emphasized that in addition to being beneficial in the short term, taking a SRP has also long-term positive effects especially on the circadian cycle, as the implementation of napping during night shift counters sleep loss due to shift work[123]. According to Minors and Waterhouse, this SRP "resets" the biorhythm[127]. It may have

very positive effects on numerous biological functions such as cardiovascular or digestive functions, known to get disturbed by shift and/or night hours. In any case, this technique may be a good way of allowing an additional time for rest to workers, who mostly already lack sleep chronically. However it is important to specify that no subsequent research to re-assess this function has been conducted so far.

II. Disadvantages and practical restrictions

Nevertheless, despite beneficial effects of this technique and the practice in use, one should keep in mind that its introduction at the workplace has side effects and can cause practical problems. Its implementation in industrial environment clearly constitutes a complex problem and all factors that regulate it should imperatively be taken into consideration[128].

The first disadvantage is of course the phenomenon of sleep inertia, which in literature is presented as the main obstacle to the introduction of this technique[129]. Indeed, if the alarm sounds, the operator must be able to react the most quickly and rightly possible, even if he/she is having a short rest break then. In concrete terms, sleep inertia has to do with the refractory period (from 10 to 20 min hypovigilance) which takes place just after waking up and results in performance impairment. Though, performance following the SRP are not lower than those observed without SRP[112, 26]. Studies that were led in this field demonstrate that on the one hand, sleep inertia affects speed and not answer accuracy; on the other hand, its intensity depends on several factors:

— sleep length[130, 131]
— sleep quality[130, 131]
— stage of prior sleep[132, 133]
— sleep timing[117]
— prior time awake[134].

However, Tassi and associates (1992) demonstrate that applying an arousing technique immediately after awakening is enough so as to counteract sleep inertia, by taking a one-hour SRP either at 1 am or at 3 am[25]. Indeed, they manage to completely remove this sleep inertia by exposing their subjects to a continuous moderate intensity noise (75 dB) immediately after awakening. Other environmental factors such as cold and light are all the more so likely to have exactly the same effect.

The second side effect has to do with subsequent diurnal sleep. Is taking a SRP during night shift going to disturb the next day sleep and correlatively impair alertness during the following night shift? Several studies have already been conducted in order to answer this question and their findings are reassuring. On the one hand, Matsumoto and Harada (1994) report that having a two-hour SRP during night shift reduces the length of the following daytime main sleep but not the whole amount of sleep (SRP + daytime main sleep) and they do not notice any effect on alertness during the subsequent night shift either[108]. On the other hand, Sallinen (1998) only notices marginal effects of SRP on the following daytime sleep: reduction of SWS in the 50-minutes SRP condition, but no difference if the no-SRP condition is compared to the (SRP + main sleep) condition[112]. Finally, our first long field study led in a nuclear plant shows that taking a SRP during night shift has a limited effect on the average subsequent diurnal sleep length. Indeed, main sleep following night shift with SRP tends to be shorter than main sleep following night shift without SRP and this difference can reach about 13.8 min[126].

Finally, so as to be successful, the introduction of SRP in industrial environment should also take into account the level of workers' and managers' acceptability of the technique. Indeed, this new way of organizing work nights disrupts years of habits and bias, on which very few studies have been led by now. The implementation of napping in industry is a complex issue which must be regarded as a multifactorial one, in particular, the managers' support is essential for the succes of this implentation (Bonnefond, in the process of writing). One should not only face preconceived ideas, such as being unable to fall asleep at will, and thus one may resort to some methods other than drugs in order to make the sleeping process easier, such as in the case of behavioral[135], cognitive[136] or environmental[137] strategies. It may be possible indeed to train anybody to sleep for short periods of time if he/she is highly motivated to do so. But one should also face ideas such as napping meaning lack of ambition or motivation, which can counter this practice.

Conclusion

Finally, numerous techniques associated with the "arousing principle" are efficient fatigue countermeasures to a certain extent and allow sustaining subjects' performance. However, most of them have only been tested in laboratory and have more or less important disadvantages (some have limited efficiency in time or a potential restricting and unpleasant nature, some are likely to lead to additional tiredness, there may be cost and practicability problems in the case of introduction in industrial environment or ethical obstacles…). Consequently, these techniques can be rationally considered only if they are exceptionally used, for a short while and not for regular work.

However, the second principle, which suggests increasing

workers' possibilities for resting by allowing in a strict regulation to have short sleep periods in a converted area at the workplace, stands out as having a certain number of advantages as regards our initial objective. This method, which has been validated in laboratory, not only allows enhancing workers' alertness during their night work, but also, and that is why it differs from other methods, increasing their global amount of daily sleep. In order to entirely attain our original objective, in terms of efficacy and applicability in real work situations, the next stage now consists in applying this technique in the field so as to answer both questions of applicability and acceptability of this SRP technique in real work situation.

To conclude and as an opening point, it is worthy to note that a lot of studies, requiring in themselves a review, had combined between then some of these countermeasures. More particularly, the combination of a SRP technique with a technique associated with an "arousing principle" like modafinil[138] or caffeine[139] demonstrated their important benefits. These combinations could also be some efficient methods to enhance and sustain worker's alertness during the night shift.

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