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STRESS AND AROUSAL CIRCADIAN RHYTHMS IN SMOKERS AND NON-SMOKERS WORKING DAY AND NIGHT SHIFTS

M. E. E. JONES[1]*, Bsc AND A.C. PARROTT[1], BSc, PhD, CPsychol, FBPs S
[1]*Department of Psychology, University of East London, London, U.K.*

ABSTRACT

Twenty smokers and twenty non-smokers completed a brief Mood State Questionnaire every 2 hours, over one day shift and one night shift. The subjects comprised male police officers and factory workers, aged 23–57 years. Cigarette smokers reported significantly higher stress levels than non-smokers on both day and night shifts ($p < 0.05$). This confirms previous findings that smokers are often more stressed than non-smokers. Stress levels varied over time within each shift ($p < 0.001$), but the circadian patterns did not differ between smokers and non-smokers. Thus smoking did not alter circadian mood rhythms, nor did it facilitate stress control. Self-rated levels of arousal showed the archetypal inverted-U pattern over time in both smokers and non-smokers. There was no difference in mean arousal levels between subgroups, indicating that cigarettes did not lead to greater alertness. The shift × time interaction was significant for both stress ($p < 0.001$) and arousal ($p < 0.003$), indicating different circadian rhythms during the day shift and the night shift. Finally, while smokers consumed slightly more cigarettes during the night shift than day shift (22.3, 19.4 respectively, $p < 0.05$), mean stress and arousal levels did not differ between shifts. The implications of these findings for smoking behaviour are discussed.

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KEY WORDS — cigarette; nicotine; smoking; mood; stress; arousal; circadian rhythm; shift work

Cigarette smoking has been found to produce a number of diverse psychophysiological changes. These include increased physiological arousal, feelings of alertness, faster information processing and improved vigilance.[1–3] The act of smoking also reduces feelings of stress and aids relaxation.[4–7]

Typically, an inverted-U function has been found for self-rated feelings of arousal, with levels peaking around midday and decreasing over the late afternoon and evening. Arousal levels fall to their lowest during the night, which can make it difficult for nightshift workers to maintain optimal alertness.[8] Parrott and Joyce[9] found that self-rated feelings of anxiety/stress decreased over the day in both smokers and non-smokers. While average stress levels did not differ between smokers and non-smokers, smokers started the day with higher stress than nonsmokers, but ended with slightly lower stress levels. Complex circadian patterns were obtained for self-rated feelings of arousal.

The physiological functions served by cigarette smoking have so far only been studied for day workers, not night workers. It is for this reason that the present study was undertaken. The basic aim was to investigate whether smoking subserves similar psychological functions during the day and night. Self-rated feelings of stress and arousal were monitored in shift workers over one working day shift and one working night shift, while the number of cigarettes smoked was also monitored. It was predicted that smoking would be more frequent during night shifts and that this would be accompanied by greater mood modulation.

METHODS

Subjects

Subjects were all males from a variety of ethnic backgrounds; they comprised manual workers from a local factory and police officers. All subjects

*Correspondence to: M. E. E. Jones, Department of Psychology, University of East London, London E15 4LZ, UK. Tel: (44) 0181 5907722 Fax: (44) 0181 8493697

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routinely worked rotating shifts with scheduled rotation. None were paid for participation. Of the 45 returned questionnaires, five were omitted due to incomplete data. The remaining 40 subjects comprised two subgroups: non-smokers ($N = 20$: age range 23–53 years) who had never smoked, or not smoked for over 1 year, and smokers ($N = 20$: age range 27–46 years) who currently smoked between 15 and 40 cigarettes a day (mean = 20.0 cigarettes per day).

Assessment measures

The Mood State Questionnaire was derived from the Short Adjective Checklist (SACL[10]).

Two questions were taken from the SACL stress factor (questions 1 and 2), while two were taken from the SACL arousal factor (questions 3 and 4). The resulting mood questionnaire[11] is summarized below:

Tense	strongly slightly neither slightly strongly	*Relaxed*
Nervous	strongly slightly neither slightly strongly	*Calm*
Energetic	strongly slightly neither slightly strongly	*Tired*
Alert	strongly slightly neither slightly strongly	*Drowsy*

Each question was scored from 1 to 5. The first two questions were combined to produce the overall stress score (2 = low, 10 = high), while the two latter questions generated the arousal score (2 = low, 10 = high). In addition, the Smoking Motivation Questionnaire[5,6] was also completed.

Procedure

All subjects were given an instruction booklet, a set of Mood State Questionnaires (×4) and the Smoking Motivation Questionnaire. The Mood State Questionnaire was to be completed at the following times: 12 midnight, 2.00 am, 4.00 am, 6.00 am, 8.00 am, 10.00 am, 12 noon, 2.00 pm, 4.00 pm, 6.00 pm, 8.00 pm, and 10.00 pm. If asleep at any times, subjects ticked the 'asleep' box. Smokers also indicated how many cigarettes had been smoked within each 2-hour time period. This procedure was carried out over one working day shift and one working night shift, when they would not be consuming alcohol. Subjects were asked to follow this procedure on the same working day for each shift.

Treatment of results

A three-way split-plot ANOVA was performed on these data, with one between-subjects factor, group (smoker, non-smoker) and two within-subjects factors, shift (day, night) and time (eight time periods).

RESULTS

With self-rated feelings of stress, significant ANOVA main effects were found with groups ($p < 0.05$), time ($p < 0.001$) and shift × time interaction ($p < 0.001$). Feelings of stress were significantly higher in smokers than non-smokers and varied over time (Table 1; Fig. 1). The significant shift × time interaction showed that patterns of stress changes over time differed between each shift. Although stress levels were slightly higher when working nights, this difference was not significant ($p = 0.104$), two-tail.

With self-rated feelings of arousal, significant ANOVA effects were found for time ($p < 0.001$), and shift × time interaction ($p < 0.05$). Arousal levels therefore differed over time, while these circadian patterns of change also differed between shifts (Table 1; Fig. 2). Arousal levels peaked higher when working nights compared to days, but also showed a steeper decline later in the shift. Significantly more cigarettes were smoked during night shifts (mean = 22.3) compared with day shifts (mean = 19.4, $p < 0.009$).

Table 1 — ANOVA stress and arousal findings (two-tailed probability values)

	Stress			Arousal		
	F-value	d*f*	*p*-value	*F*-value	d*f*	*p*-value
Groups (smoker/non-smoker)	4.53	1;38	*0.040*	1.61	1;38	0.212
Shift (day/night)	2.78	1;38	0.104	0.39	1;38	0.536
Time (8 time periods)	9.81	7;266	*0.001*	52.58	7;266	*0.001*
Groups × Shift	0.89	1;38	0.352	0.55	1;38	0.465
Groups × Time	0.40	7;266	0.902	1.93	7;266	0.065
Shift × Time	6.51	7;266	*0.001*	3.14	7;266	*0.003*
Groups × Shift × Time	1.01	7;266	0.389	0.88	7;266	0.525

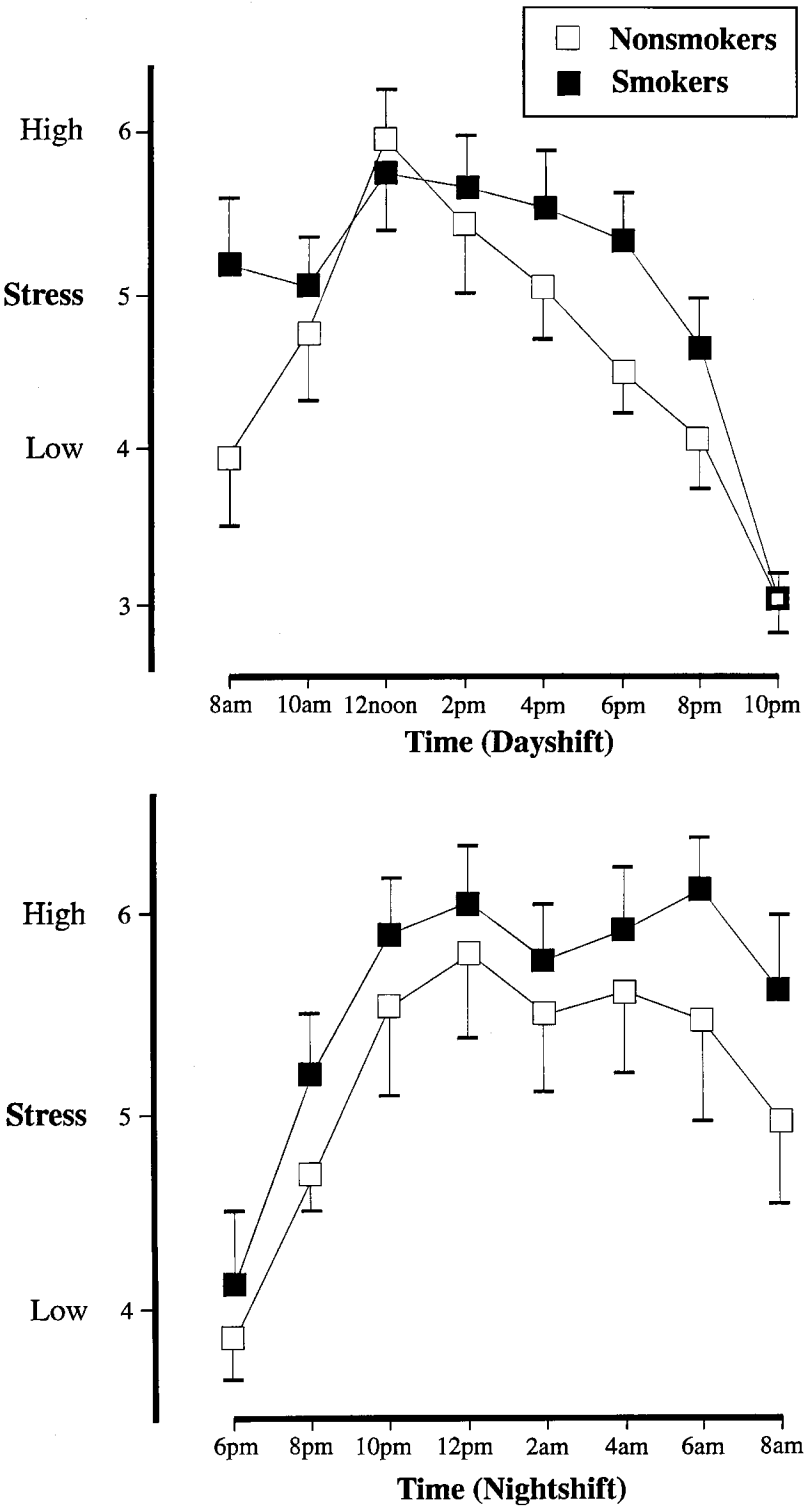

Fig. 1

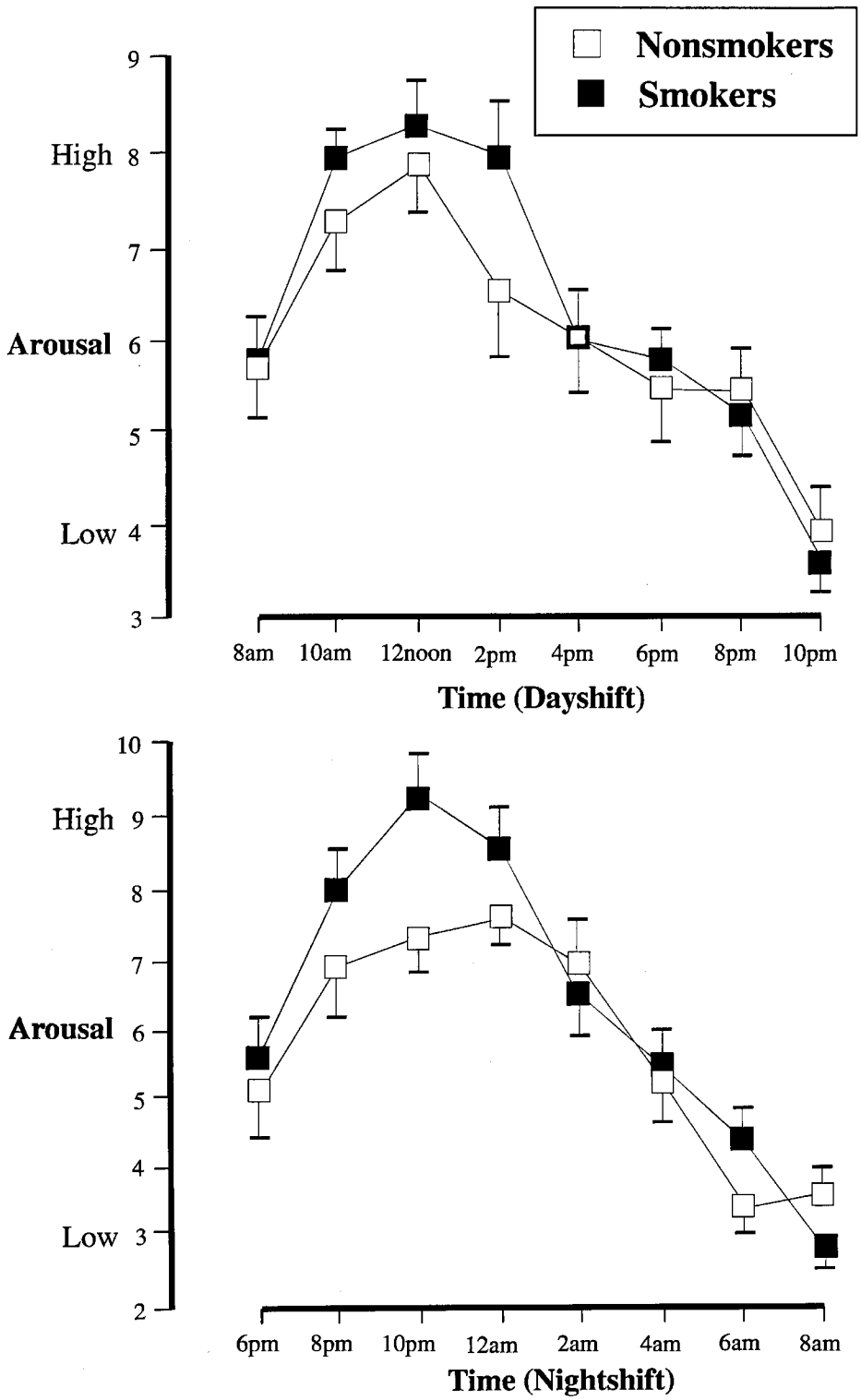

Fig. 2

DISCUSSION

Smokers reported significantly higher stress levels than non-smokers on both day and night shifts ($p < 0.05$; Fig. 1). This agrees with a number of previous studies where smokers have been found to experience higher levels of daily stress than non-smokers. In the UK Health and Lifestyle Survey involving over 9000 subjects, current smokers were significantly more stressed than either non-smokers or former smokers.[12,13] Robertson[14] similarly found that heavy smokers experienced higher levels of anxiety, neuroticism and depression than non-smokers. Cohen and Williamson[15] also reported higher levels of self-rated stress in current smokers than non-smokers. Furthermore in a longitudinal study of smokers attempting to quit, those who managed to stop smoking reported decreasing levels of stress over time, whereas those who failed in their cessation attempt reported consistently high stress levels throughout the study.[16] In a brief overview, West[17] concluded: 'Smokers do not present as less anxious than nonsmokers. Indeed, in surveys they emerge as significantly more anxious overall'.

The relationship between smoking and stress has been a subject of controversy for many years.[18,19] The two main explanations proposed for this relationship are the nicotine resource model and the deprivation reversal model. The nicotine resource model suggests that nicotine is a useful resource, used by smokers to control their daily moods.[20] The deprivation reversal model suggests that smoking has no real beneficial functions and that the positive feelings which accompany the act of smoking reflect the reversal of the deleterious mood effects of nicotine deprivation.[21] In a development of the latter model, Parrott[9,22] suggests that smoking is a direct pharmacological cause of stress. According to this explanation, smokers routinely experience a source of stress not experienced by non-smokers: acute nicotine depletion. They suffer from nicotine withdrawal when they have not smoked recently, and smoking then restores their normal moods. This model explains not only why smokers are more stressed than non-smokers, but also why former smokers become less stressed when they quit.[9,22]

The comparative profiles of mood change over the day for smokers and non-smokers have been assessed in only one previous study. Parrott and Joyce[9] reported a significant group by time interaction, with smokers starting the day with higher stress than non-smokers but ending the day with slightly lower stress. It was hypothesized that the high initial stress reflected overnight nicotine depletion, while the steeper stress decrease over the day reflected the gradual accumulation of nicotine.[9] One central aim of the current investigation was therefore to replicate this earlier study. However, the current findings are ambivalent in this regard. The subgroup by time interaction was non-significant here ($F = 0.044$; Table 1), whereas it was significant earlier. Thus in the current study, smokers started the day with higher stress levels than non-smokers (5.2 compared with 3.9), while by the end of the day stress levels were similar for both groups (each 3.0; Fig. 1). This general pattern of higher stress during the first part of the day, then lower stress levels later in the day,also agrees with Thayer,[23] who has noted: 'Tense energy mood is usually present during the first third of the day, while later tense energy is replaced by tense-tiredness' (p. 53).

During the night shift a different circadian mood pattern was evident, with high stress levels throughout the whole period from 10.00 pm to 6.00 am (Fig. 1). This is the time of day when circadian arousal levels are normally at their lowest.[8] It may be that since night shift working is unnatural, it is therefore also stressful. However, it should be noted that stress levels during the night shift were not significantly different from those during the day shift, although they were slightly higher (5.4 at night, compared to 4.8 during the day; $p = 0.104$, two-tail). As with the day shift, cigarette smokers during the night shift reported higher stress levels than non-smokers. However, unlike the day shift, this subgroup difference remained consistent throughout the whole time period. Thus smokers commenced the night shift more stressed than non-smokers, reported higher peak stress levels during the middle of the night and remained more stressed in the early morning (Fig. 1). This consistent mood difference between groups shows that increasing plasma nicotine levels (found with repeated cigarette smoking[24]) were not having any beneficial effects (contrasting with our earlier findings,[9] also see above paragraph). Thus cigarette smoking was not providing a means for mood modulation at night.

Arousal rhythms demonstrated an inverted-U pattern over time, in both smokers and non-smokers (ANOVA time effect: $p < 0.001$). This inverted-U arousal pattern is typical of studies where subjects rate their feelings of alertness over

the day.[8,11]. This inverted-U pattern was found on both shifts (Fig. 2), although, somewhat surprisingly, peak arousal was higher at night than day, but then declined more steeply as the morning approached (shift by time interaction: $p < 0.003$; Fig. 2). There were no differences between subject groups in mean arousal levels, nor were any of the subgroup interaction terms significant. Thus there were no differences between smokers and non-smokers in their profiles of self-rated feelings of arousal. Again, this agrees with the many studies where current smokers and non-smokers report similar average levels of arousal/alertness (see review by Wesnes and Parrott[2]).

There was a slight, but statistically significant increase in the number of cigarettes smoked at night (22.3 compared to 19.4 during the day, $p < 0.023$). This confirmed our prediction that more cigarettes would be smoked during the night shift, since it was expected to be more tiring and stressful than the day shift. However, it was also expected that any increase in cigarette consumption would be accompanied by a greater degree of arousal modulation and stress modulation. But as noted earlier, there was no difference in the amount of stress or arousal change between shifts. However, it may be that the numbers of cigarettes consumed during the day and night were too similar for any differential psychological effects to be evident. Overall, therefore, the reason for the greater cigarette consumption at night needs to be further investigated. It might be related to a greater opportunity for smoking breaks at night, or the less demanding work profiles typically found.[25]

The present study has raised a number of issues for further investigation. The degree of adaptation to the shift period was not recorded in this study. Therefore, the shift groups may have included a range of subjects, some of whom were well adapted (ie already working more than 1 week on that shift pattern) and others who were poorly adjusted (ie new to that shift schedule). Further studies might investigate this factor and compare well adjusted and poorly adjusted workers. Another topic for study could be the use of cigarettes by smokers during the process of shift adaptation. Finally, the effects of nicotine deprivation and smoking cessation during shifts need to be studied. Does the night shift constitute a particularly difficult period to go without cigarettes, or is smoking cessation equally difficult during the night and day?

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REFERENCES

1. Golding, J. and Mangan, G. L. Arousing and dearousing effects of cigarette smoking under conditions of stress and mild sensory isolation. *Psychophysiology*, 1982; **19**(4): 449–452.
2. Wesnes, K. and Parrott, A. C. Smoking, nicotine and human performance. In: *Factors Affecting Human Performance*, Vol. II. Smith, A. and Jones, D. (Eds) Academic Press, New York, 1992.
3. Wesnes, K. and Warburton, D. M. Smoking, nicotine and human performance. *Pharmacol. Therapeut*. 1983; **21**: 189–208.
4. Dunn, W. L. Experimental methods and conceptual models as applied to the study of motivation in cigarette smoking. In *Smoking Behaviour Motives and Incentives*. Dunn, W. L. (Ed.) Winston, Washington DC, 1973.
5. Parrott, A. C. Individual differences in stress and arousal during cigarette smoking. *Psychopharmacology*, (1994); **115**: 389–396.
6. Russell, M. A. H., Peto, J. and Patel, V. A. The classification of smoking by a factorial structure of motives. *J. Roy. Statist. Soc*. 1974; **137**: 313–346.
7. Silverstein. Cigarette smoking, nicotine addiction and relaxation. *J. Personal. and Soc. Psychol*. 1982; **42**: 946–950.
8. Folkard, S. Diurnal variation. In: *Stress and Fatigue in Human Performance*. Hockey, R. (Ed.) Wiley, Chichester, 1983, pp. 245–272.
9. Parrott, A. C. and Joyce, C. Stress and arousal rhythms in cigarette smokers, deprived smokers and nonsmokers. *Hum. Psychopharmacol*. 1993; **8**: 21–28.
10. Mackay, C. J., Cox, T., Burrows, G. and Lazzenni, T. An inventory for the measurement of self-reported stress and arousal. *Brit. J. Soc. Clin. Psychol*., 1978; **17**: 283–284.
11. Parrott, A. C. Cigarette smoking: Effects upon self-rated stress and arousal over the day. *Addict. Behav*. 1993; **18**: 389–395.
12. Cox, D. B., Blaxter, M. *et al*. *The Health and Lifestyle Survey*. The Health Promotion Trust, London, 1987.
13. West, R. J. Beneficial effects of nicotine: Fact or fiction? *Addiction* 1993; **88**: 589–590.
14. Robertson, J. A. Coping, social support and drinking among young married couples. In: *Addiction Controversies*. Warburton, D. (Ed.) Harwood, London, 1990, pp. 296–313.

15. Cohen, S. and Williamson, G. Perceived stress in a probability sample of the United States. In: *The Social Psychology of Health*. Spacapan, S. and Oskamp, S. (Eds) Sage, California, 1988, pp. 31–68.
16. Cohen, S. and Lichtenstein, E. Perceived stress, quitting smoking and smoking relapse. *Health Psychol*. 1990; **9**: 466–478.
17. West, R. J. The nicotine replacement paradox in smoking cessation: How does nicotine gum really work? *Brit. J. Addict*. 1992; **87**: 165–167.
18. Gilbert, D. G. and Wesler, R. Emotion, anxiety and smoking. In: *Smoking and Human Behaviour*. Ney, T. and Gale, A. (Eds) Wiley, Chichester, 1989.
19. Pomerleau, O. F. and Pomerleau, C. S. Research on stress and smoking: Progress and problems. *Brit. J. Addict*. 1991; **86**: 599–604.
20. Warburton, D. M. The puzzle of nicotine use. In: *The Pharmacology of Addiction*. Lader, M. (Ed.) Oxford University Press, Oxford, 1988.
21. Schachter, S. Pharmacological and psychological determinants of smoking. In: *Smoking, Behaviour, Physiological and Psychological Influences*. Thornton, R. E. (Ed.) Churchill-Livingstone, Edinburgh, 1978.
22. Parrott, A. C. Does cigarette smoking increase stress? *Addiction* 1994; **89**: 142–144.
23. Thayer, R. E. *The Biopsychology of Mood and Arousal*. Oxford University Press, Oxford, 1989.
24. Benowitz, N. L. Pharmacokinetic considerations in understanding nicotine dependence. In: *The Biology of Nicotine Dependence*. Ciba Foundation Report 152, Wiley, Chichester, 1990, pp. 186–209.
25. Grandjean, E. P., Baschera, P., Martin, E. and Weber, A. The effects of various conditions on subjective states and critical flicker fusion frequency. In: *Vigilance*. Mackie, R. R. (Ed.) Plenum, New York, 1977, pp. 331–339.