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Explaining the stress-inducing effects of nicotine to cigarette smokers

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Aims To explain how nicotine dependency causes mood fluctuation and increases daily stress.
Methods Prospective studies show that taking-up smoking leads to higher stress and depression. Cross-sectional studies show that adult smokers report more irritability, stress and depression than non-smokers. Prospective studies show that smoking cessation leads to enduring mood gains. The adverse mood effects of nicotine dependency are explained by the deprivation reversal model. In between cigarettes, most smokers experience subtle abstinence symptoms, and cumulatively these can increase everyday stress. Hence, adolescents who take up smoking become more stressed, and quitting reduces stress. An explanatory leaflet to explain this model was empirically assessed with tobacco smokers.
Results In a cohort study of 82 cigarette smokers, knowledge levels were significantly enhanced by the explanatory leaflet, and this understanding was maintained 1 week later. Hence, normal cigarette smokers can understand the adverse mood consequences of nicotine addiction. The information leaflet could prove useful for tobacco-education packages in schools, and smoking-cessation packages with adults.
Conclusions The deprivation reversal model can be easily described using a simple leaflet. It explains how nicotine dependency can cause mood fluctuation, and outlines the psychological benefits of quitting.

KEY WORDS—nicotine; tobacco; smoking; abstinence; stress; depression

INTRODUCTION

The traditional model for tobacco smoking is that nicotine comprises a psychological aid. In particular, that cigarettes lead to feelings of relaxation and contentment, and help the individual to attend and concentrate. This has led to the nicotine recourse model, which states nicotine provides a useful resource for smokers, and helps them to cope with the vagaries of life (Wesnes and Warburton, 1987; Warburton, 1992). However, these psychological benefits of smoke inhalation are countermanded by the deleterious states that develop during nicotine withdrawal. In-between cigarettes, smokers typically report feelings of stress, anxiety and depression (Hughes *et al*., 1990). This has led to the nicotine deprivation model, which suggests that the supposedly positive effects of smoke inhalation only represent the reversal of these negative abstinence effects (Schachter, 1978; Parrott, 1999). Furthermore, the cumulative experience of negative moods in between cigarettes explains why smokers typically experience worse daily moods than non-smokers (Parrott, 2003, 2006). To briefly summarise, the nicotine resource model proposes that tobacco smokers benefit from their nicotine use, whereas the abstinence reversal model proposes that smokers suffer from their nicotine dependency.

In order to empirically investigate these two contrasting models, an extensive research programme was undertaken. The initial studies from the late 1980s were based within the nicotine resource tradition. They investigated the acute benefits of cigarette smoke and replacement nicotine devices for smoking cessation, such as 2 mg and 4 mg nicotine chewing gum. These early studies confirmed the apparent psychobiological 'gains' in overnight deprived smokers (Parrott and Winder, 1989; Parrott and Roberts, 1991; Parrott and Craig, 1992). They showed that nicotine reinstatement led to better cognitive performance in overnight deprived smokers, findings consistent with the classic research programme of Wesnes and Warburton (1987). One major limitation with these studies, however, was the general absence of non-smoker controls. Hence, the apparent benefits were only apparent against the placebo condition (i.e. nicotine-free gum, or sham smoking)—which in reality comprised a condition of *continued nicotine*

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abstinence (Wesnes and Warburton, 1987; Parrott and Winder, 1989; Parrott and Roberts, 1991; Parrott and Craig, 1992). Hence, the apparent benefits of nicotine did not indicate absolute gains, but only relative gains over continued abstinence.

The next stage comprised a series of real world studies. The core aim was to investigate the mood and cognitive changes of regular smokers over a day of normal cigarette use (O'Neill and Parrott, 1992; Parrott and Joyce, 1993; Parrott, 1994a, 1994b). This design allowed some clarification into the balance between nicotine abstinence (the periods in-between cigarettes), and nicotine reinstatement (the immediate effect of each new cigarette). The design required smokers to self-rate their moods immediately before they lit-up a cigarette, then immediately after they had stubbed the cigarette out. *The emergent findings showed that tobacco smoking was associated with a repetitive vacillation of mood states* (Figure 1). There was a constantly changing balance between abstinence symptoms in between cigarettes, and the mood gains of nicotine reinstatement. Hence, regular nicotine usage directly *caused* mood fluctuation. This pattern was found in around 85% of our sample of 103 cigarette smokers, with the strongest mood changes occurring in the heaviest smokers (Parrott, 1994a). As the empirical findings emerged on the computer screen, they generated a moment of insight; namely that this repetitive mood fluctuation provided the essential key for understanding nicotine dependency (Figure 1).

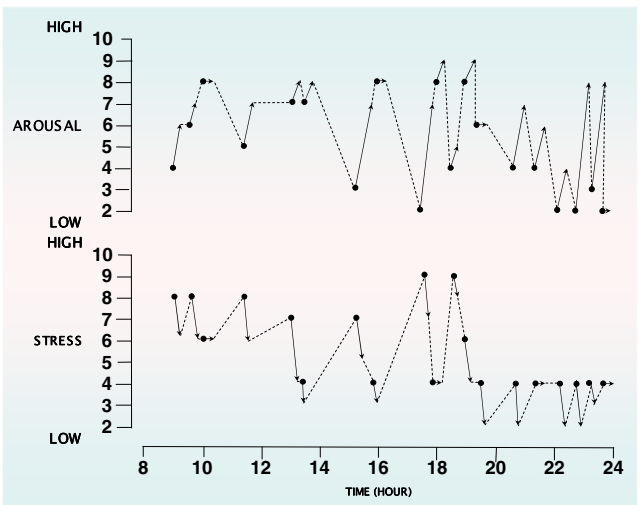

Figure 1. Self-rated feelings of stress and arousal over a day of normal smoking. Arrows indicate the mood effects of each cigarette. Dotted lines indicate the mood changes in-between the cigarettes. Data represent an individual participant from Parrott (1994a)

Next, a series of comparative group studies was undertaken, which compared nicotine-replete smokers, with nicotine-deprived smokers, and non-smoker controls. They showed that nicotine abstinence was associated with significant mood deficits, whereas nicotine-replete smokers had similar moods to non-smoker controls (Parrott *et al*., 1996; Parrott and Garnham, 1998; Parrott and Kaye, 1999). The absence of mood gains in nicotine replete-smokers over non-smokers suggested that there were no genuine mood gains from tobacco smoking. Furthermore, the significantly worse moods of abstinent smokers than non-smoker controls supported the deprivation reversal model. Subsequently, we found more severe abstinence symptoms under a high environmental stress situation, in comparison with a relaxed environmental situation. This same study further showed that nicotine restoration led to mood normalisation under both conditions, so that the relative mood 'gains' (in reality mood 'normalisation') were significantly greater under the high environmental stressor condition (Parrott and Slater, 2000). We have also investigated the effects of nicotine and nicotine abstinence in recreational drug users (Parrott *et al*., 2005). We also showed that these mood changes were not affected by acute pharmacodynamic tolerance—because these mood changes occurred 'over the whole day of smoking' (Parrott, 1994b).

One other group has conducted similar real world studies into cigarette smokers, and they have generated very similar findings. Adan and Sanchez-Turet (2000) assessed mood states every hour over the day and found greater mood fluctuation in cigarette smokers than non-smokers. Furthermore, smokers' moods were sometimes worse than non-smoker controls: 'Smokers have suboptimal activation and mood states at certain times even under the influence of multiple doses of nicotine'. In a subsequent study, they noted that nicotine dependency was associated with 'homeostatic dysregulation of mood control' and concluded that their findings supported the deprivation reversal model (Adan *et al*., 2004). It should perhaps be noted that the deprivation reversal model for nicotine is similar to the reformulation of the negative reinforcement model of Baker *et al*.'s (2004) for all forms of drug dependency. Their review concluded that with all addictive substances, the 'escape and avoidance of negative affect is the prepotent motive' for drug use.

REAL WORLD PROSPECTIVE STUDIES

Cross-sectional studies generally find that smokers report higher levels of stress, depression, suicidal behaviour, low self-esteem and poor self-efficacy (Lloyd and Lucas

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1997; Malone *et al*., 2003; Parrott *et al*., 2004). However, this cross-sectional data is inherently limited, because smokers and non-smokers may differ in personality, socio-economic class, genotype or other crucial factors. Prospective studies can control this problem, because the same individuals are monitored repeatedly over time. The two explanatory models have very different predictions. The nicotine resource model predicts that taking-up smoking will lead to reduced stress, and that those who stop smoking will lose the benefits of nicotine and become more stressed. In contrast, the deprivation reversal model predicts that adolescents who take up smoking will suffer from increased moodiness and more daily stress, whereas cessation will lead to more stable moods and reduced stress.

Several large prospective studies have been undertaken, where children and young adolescents were monitored regularly for several years. These studies have repeatedly demonstrated that the uptake of smoking is psychologically damaging. Wu and Anthony (1999) prospectively investigated the effects of tobacco initiation in 8–14-year-old schoolchildren, and found that tobacco uptake led to a modest increase in subsequent feelings of depression. Johnson *et al*. (2000) found that regular cigarette smoking when 16 years old was associated with more generalised anxiety and panic disorder, at subsequent assessments 5 years later. Steuber and Danner (2005) prospectively monitored over 14 000 adolescents and found that cigarette smoking led to higher rates of depression. They also noted a gender difference, in that female adolescents in particular showed 'increases in depression around the onset of smoking and decreases around the time of quitting'. McGee *et al*. (2000) undertook a large prospective study in New Zealand, monitoring a range of behavioural and mental health measures. Many factors were related to the initial uptake of smoking, including early socio-economic disadvantage. However, those adolescents who took up regular smoking reported an increased risk of psychological problems 3 years later, including more anxiety-depressive disorders. Oquendo *et al*. (2004) investigated the factors associated with suicides and attempted suicides in major depression. Cigarette smoking was found to be a strong predictor of suicidal acts, along with the clinical severity of depression. Other prospective studies, which found that smoking could exacerbate stress and/or depression, are outlined in an earlier review (Parrott, 2006). However, it should be emphasised that these relationships are complex and multi-factorial. Hence, numerous co-factors can modulate the adverse effects of smoking on mood, including psychosocial, genetic and biological influences; for an example of these complex interactions, see Goodman and Capitman (2000).

Turning to the effects of smoking cessation, several prospective studies have found that quitting leads to reduced stress. The first study to report this was by Cohen and Lichtenstein (1990), who assessed over 200 smokers intending to quit. Those who failed to quit reported high stress levels at baseline, and this continued at the same high stress level over the subsequent 1, 3 and 6 month test periods. In contrast, the small group of successful quitters reported steadily reducing levels of stress over time, so that after 6 months they had become significantly less stressed. Crucially, their stress levels at pre-quit baseline were identical to those of non-quitters; hence, it was not just the less stressed individuals who managed to quit. A similar pattern was reported by Parrott (1995) in a smoking cessation study undertaken at two London health centres. Significantly, reduced levels of stress were found after 3 and 6 months of confirmed smoking cessation, despite stress levels at baseline being almost identical for successful and non-successful quitters. Hence, a significant reduction in stress after quitting was not an artefact of lower stress at baseline, while stressful life events were also unchanged for both groups over the study period (Carey *et al*., 1993).

Chassin *et al*. (2002) found that the significant mood gains of cessation were maintained over time, with decreased levels of stress 6 *years* after quitting. Furthermore, when they had been active smokers, their stress levels were significantly higher than non-smokers, but after enduring cessation, their stress levels were at the same levels as non-smokers. Berlin *et al*. (2010) assessed a cohort of 133 adults with a history of clinical depression who were attempting to quit smoking. Three groups emerged: the successful or 'continuous' abstainers, the intermittent or 'point prevalence' abstainers and unsuccessful quitters. These three groups did not differ in baseline stress values, but following attempted cessation, the continuous and point prevalent abstainer groups reported significantly less anxiety-psychic than non-abstainers. More specifically, during the 8-week period following target cessation, stress levels increased in the unsuccessful quitters and decreased in the successful quitters (see Figure 2 in Berlin *et al*., 2010). The increased daily stress of their failed quitters may be due to partially cutting down—because this would increase daily stress (Parrott, 2006).

There may also be similar benefits of cessation to the cardiac system, because regular smoking also causes fluctuations in cardiac activity over the day. Adan and Sanchez-Turet (1995) found that the adverse

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effects of nicotine on the cardiac system of young smokers were 'More apparent in the diurnal variations than in the mean level of heart rate and blood pressure' (also Adan and Sanchez-Turet, 2001). Hajek *et al*. (2010) investigated stress levels in cigarette smokers being medically treated for myocardial infarct or coronary artery bypass surgery. All 469 smokers were advised to stop smoking, and while 41% maintained cessation for a year, 59% remained as continuing smokers. The abstainer group reported significantly lower stress after the year ($p < 0.001$), whereas stress levels for the continuing smoker subgroup remained unchanged from baseline values. Furthermore, there were no differences between the two groups neither in baseline stress, nor in their reported usage of cigarettes to control stress; indeed, baseline scores for these variables were almost identical.

Reduced stress following smoking cessation is, therefore, a robust empirical phenomenon. During the immediate days and weeks following cessation, feelings irritability and stress generally increase, and tobacco cravings can be pronounced. However, this withdrawal period is only temporary, and if abstinence can be maintained over the initial weeks of cessation, these tobacco cravings become less frequent and less intense. Daily moods also gradually improve as the smoker loses their nicotine dependency. This deprivation reversal explanation of how smoking causes stress was published in the American Psychologist (Parrott, 1999). The article was the placed on a number of American smoking-cessation websites, and over the next few years I received a number of positive emails from former smokers. In personal testimonies, they stated that the article had helped them understand the rationale for their nicotine dependency. The model had also helped them to maintain cessation and withstand their tobacco cravings. In a subsequent article, I expanded the model to include other moods states such as depression (Parrott, 2003). Later, I debated the methodological and theoretical issues around these contrasting models and their implications for nicotine researchers (Parrott, 2006).

INFORMATION LEAFLET FOR SMOKERS: THE DEPRIVATION REVERSAL MODEL EXPLAINED

The deprivation reversal model was then summarised in a brief information leaflet written by RM while an undergraduate research student. The explanatory leaflet was written using simple terminology, to inform normal smokers about the deprivation reversal model (Murphy and Parrott, 2005). More recently, AP shortened the leaflet to make it more focused, although it remains basically similar to the original (Table 1).

Table. 1. Smoking and stress: Information leaflet for cigarette smokers

It is still widely believed that smoking cigarettes relieves feelings of stress. However the evidence now shows that nicotine dependency can cause stress.

Does nicotine have true calming effects? When feeling tense and anxious most smokers light up a cigarette. They find that this relieves their feelings of tension, and help them to feel relaxed. Hence most smokers believe that cigarettes help them to cope with the stresses and strains of everyday life. However this apparent calming effect is not genuine. It is largely due to the temporary reversal of abstinence symptoms.

Why does smoking make you moody? When smokers have not had a cigarette for a period, they often feel tense and irritable. This is when they really want a cigarette – 'nicotine craving'. Their next cigarette immediately reverses these unpleasant feelings. This shows that nicotine dependency makes you moody. You feel stressed and irritable in between cigarettes, and smoking allows you to feel normal again. This pattern describes the mood changes of most cigarette smokers.

What happens when young people take up smoking? Scientific studies have monitored youngsters throughout their adolescence. They have found that those who take–up smoking report more stress one year later. Other studies have found that taking up cigarettes leads to more depression and greater anxiety, in later years.

What happens when adults quit smoking? For a few weeks most smokers experience tobacco cravings and feelings of irritation. But over time these cravings will disappear. After several months, former smokers report feeling less stressed than when they were smokers! They feel better in many different ways, as their physical health and psychological well-being both improve.

Summary.

•There are no real mood benefits to nicotine.
•Instead the nicotine habit makes cigarette smokers feel more stressed and depressed.
•So if you are a smoker – then quit now.
•It will be tough for a few weeks.
•But after a few months you will feel better – both physically and mentally.

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Table 2. Beliefs about cigarette smoking and stress: effects of an information leaflet and a control leaflet in two matched groups of cigarette smokers (Murphy and Parrott, 2005)

Question	Group	Baseline	After the information	1 week. later	ANOVA time effect
'Cigarettes are a real aid for relaxation'.	Control group	3.5 + − 1.2	3.4 + − 1.3	3.5 + − 1.3	non-significant
'Cigarettes are a real aid for relaxation'.	Intervention group	3.3 + − 1.2	2.5 + − 1.2	2.4 + − 1.3	signif decrease $p < 0.001$
'Adolescents who start smoking will show greater stress one year later'.	Control group	2.1 + − 1.0	2.1 + − 1.2	2.0 + − 1.0	non-significant
'Adolescents who start smoking will show greater stress one year later.'	Intervention group	2.1 + − 1.0	3.2 + − 1.4	3.3 + − 1.3	signif increase $p < 0.001$

Higher scores indicate greater agreement with the question.
ANOVA, analysis of variance.

RM undertook an empirical study with 82 cigarette smokers, in the age range 19–64 years, whose mean cigarette consumption was 15.9 cigarettes/day. Two leaflets were prepared, the stress information leaflet (Table 1) and the matched control leaflet that described the adverse effects of tobacco smoking on oral health—using similar phrases and sentences. The unpaid volunteers were randomly split into two equivalent groups for each leaflet, with similar gender distribution, age range and daily cigarette consumption. Beliefs about smoking were measured on a series of self-rating questions. Several questions were unrelated to the study aims, viz 'Cigarette smoking is a useful activity at a party', whereas others covered beliefs about stress and smoking, viz 'Adolescents who start smoking will show greater levels of stress one year later'. The questionnaire was completed on three occasions: pre-intervention baseline, immediately after reading the information leaflet, and 1 week later.

The findings from two of the stress questions are summarised in Table 2. They showed that beliefs about stress and smoking were similar between groups at baseline and remained unchanged in the control group who had read the leaflet about smoking and oral health. In the positive intervention group, beliefs about smoking and stress were significantly changed after reading the explanatory leaflet and remained at these new values 1 week later (Table 2). The other stress questions showed a similar pattern of changes. Hence, the leaflet helped explain how smoking can cause stress, and this level of understanding remained afterwards. This shows that normal smokers could understand the leaflet, and that this attitudinal change remained for at least 1 week. Further studies could be undertaken. The leaflet might be employed with adults intending to quit, to investigate if the leaflet helped them initiate cessation or maintain it over time. The leaflet could also be used with health education packages for school children and adolescents.

OVERVIEW

There is extensive empirical evidence that cigarette smoking is psychologically damaging. In particular, nicotine dependency causes repetitive mood fluctuations over the day, and this means that smokers can experience slightly higher levels of daily stress than non-smokers (Parrott, 1995, 1999, 2003, 2006; Adan and Sanchez-Turet, 2000; Adan *et al*., 2004). It should be noted that these increases can be subtle, and that regular smoking will often prevent these unpleasant abstinence effects from developing. Hence, many light smokers will be close to non-smokers in their daily moods (Parrott, 1994a). However, in heavy smokers, the adverse mood effects of tobacco smoking are far more pronounced and can, therefore, comprise an important source of increased stress, irritability and depression (Parrott, 2003, 2006). Hence, the very real mood benefits of quitting cigarettes—to all regular smokers. The deprivation reversal model was explained using a simple information leaflet (Table 1), and an empirical study showed that it could modify the beliefs of normal cigarette smokers (Table 2). Future studies with this leaflet might be undertaken in real world studies of health education during childhood or adolescence, and in smoking cessation clinics or web-pages. Similar leaflets might also be designed for other recreational drugs. The paradox of recreational drugs is that they are generally taken for pleasure, but typically lead to psychobiological distress; the psychobiological rational for this was outlined in Parrott (2008). Hence, similar information leaflets could be designed for other psychoactive drugs, because the underlying processes are broadly similar (Baker *et al*., 2004).

CONFLICTS OF INTEREST

The authors have declared no conflict of interest.

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