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Drug and Alcohol Dependence 78 (2005) 235–241

DRUG and ALCOHOL DEPENDENCE

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Self-rated everyday and prospective memory abilities of cigarette smokers and non-smokers: a web-based study

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Received 2 October 2004; received in revised form 8 November 2004; accepted 12 November 2004

Abstract

The present study examined self-ratings of two aspects of everyday memory performance: long-term prospective memory—measured by the prospective memory questionnaire (PMQ), and everyday memory—measured by the everyday memory questionnaire (EMQ). Use of other substances was also measured and used as covariates in the study. To ensure confidentiality and to expand the numbers used in previous studies, an Internet study was carried out and data from 763 participants was gathered. After controlling for other drug use and strategy use, the data from the PMQ revealed that smokers reported a greater number of long-term prospective memory errors than non-smokers. There were also differences between light and heavier smokers in long-term prospective memory, suggesting that nicotine may have a dose-dependent impact upon long-term prospective memory performance. There was also a significant ANOVA group effect on the EMQ, although the trend for more memory errors amongst the heavier smokers was statistically only borderline ($p = .057$). These findings suggest there are selective memory deficits associated with smoking and that long-term prospective memory deficits should be added to the growing list of problems associated with cigarette use.

Keywords: Nicotine; Prospective memory; PMQ; Everyday memory; EMQ

1. Introduction

The acute effects of cigarette smoking on memory task performance have been investigated in a number of studies, using a variety of measures. However, reviews of the effects of nicotine on human cognitive performance have concluded that the findings are very mixed (Heishman et al., 1994; Roth et al., 1992; Sherwood, 1993; Wesnes and Parrott, 1992). For instance, Roth et al. (1992, p. 253.) noted: 'Smoking and nicotine effects on memory are contradictory. Improvement, no change, and impairment have all been observed'. There are numerous factors that need to be taken into account, with one of the most crucial being nicotine abstinence. When smokers are deprived of nicotine, they typically demonstrate mood and cognitive deficits, so that the apparently positive psychobiological effects of nicotine may often reflect the reversal of abstinence symptoms (Parrott et al., 1996; Parrott and Garnham, 1998; Parrott et al., 2004; Williams, 1980). Sakurai and Kanazawa (2002) investigated the effects of smoking either no, one or two cigarettes, on Buschke's selective reminding (memory) task, in non-deprived smokers. Performance on both the memory task and two other cognitive tests remained unchanged at the 'normal' level of non-smoker controls. It can also be difficult to separate memory from other cognitive functions, so that fluctuations in concentration ability may influence memory skills indirectly (Wesnes and Parrott, 1992, p. 148–9). Furthermore, plasma nicotine levels fluctuate in parallel with smoke inhalation patterns. This means that memory storage, consolidation and retrieval, are all

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doi:10.1016/j.drugalcdep.2004.11.008

occurring under constantly changing background levels of nicotine. These factors are extremely difficult to control in acute dose studies, which is why the effects of tobacco smoking on human memory functions remain unclear (Heishman et al., 1994; Roth et al., 1992; Sherwood, 1993; Waters and Sutton, 2000).

Less is known about the chronic effects of cigarette smoking on everyday cognitive function; indeed the paucity of empirical studies in this area is surprising. However given the well-documented effects of tobacco on measures such as cardiovascular health indices and oxygen-bound haemoglobin (Glantz and Parmley, 1995), it could be predicted that smokers might exhibit compromised cognitive abilities. Our aim here was therefore to assess self-reported aspects of memory in regular users of tobacco/nicotine. The two aspects of memory we focused upon were prospective and everyday memory. Prospective memory (PM) refers to the process of remembering to do things at some future point in time (Brandimonte et al., 1996). Examples of prospective memory include remembering to attend a particular function—such as a party, or to carry out a particular task at some future point in time—such as remembering to pay a bill on time, lock your door after leaving the house, and so on. Prospective memory has only recently been subjected to systematic empirical research, but this has ranged from laboratory studies to self-rated assessments (Brandimonte et al., 1996; Ellis et al., 1999). The prospective memory questionnaire (PMQ), developed by Hannon et al. (1995) is a self-rating scale that requires participants to record the number of times their prospective memory has failed them within a given period of time. The PMQ contains a number of subscales that measure various aspects of memory, as well as gauging the number of strategies used to aid memory. The PMQ has proved to be a useful tool in estimating the effectiveness of PM in a number of settings. These include its use as a neuropsychological instrument in the study of brain damaged patients (Hannon et al., 1995) and it has recently been used to explore self-rated prospective memory deficits in regular users of ecstasy, marijuana and alcohol abuse (Heffernan et al., 2001a,b,2002; Rodgers et al., 2001; Rodgers et al., 2003). In addition, the PMQ correlates well with objective measures of prospective memory (Hannon et al., 1995). The everyday memory questionnaire (EMQ) was developed by Sunderland et al. (1983). The EMQ focuses on common memory lapses in everyday activities such as telling someone a story or joke that you have already told them, or having to go back and check whether you have done something that you meant to do. The EMQ has proved useful in measuring everyday cognitive lapses associated with a range of psychoactive substances, such as ecstasy/MDMA and cannabis (Heffernan et al., 2001b).

The present study investigated the everyday memory skills of smokers in comparison with non-smokers using the Internet as a medium for data collection. We asked participants to describe their current use of legal psychoactive drugs (e.g. alcohol, cigarettes), and their lifetime use of illicit recreational drugs (e.g. amphetamine, cocaine, ecstasy/MDMA, others). We also asked them to complete the two self-rating memory questionnaires: the EMQ and the PMQ. Our questionnaire also covered the extent of current use of cigarettes, and thus we were also able to compare non-smokers, with light, moderate and heavier tobacco smokers. We conducted the study via the Internet for a number of reasons. One is the large sample sizes accessible through such methods, and hence high statistical power available for multivariate analyses. Another is that many recreational drugs are illegal. A web-based design allowed a measure of anonymity not usually feasible in laboratory studies, and thus increased the likelihood that they will disclose such "sensitive" information (Rodgers et al., 2003; Buchanan et al., 2002). While use of the Internet for research is relatively new, there is a growing body of evidence that indicates that, given that appropriate methodology is used, web-based research is both viable and valid and indeed offers many advantages over traditional techniques for some research questions (see, e.g. Birnbaum, 2000).

2. Method and subjects

Data from 763 participants remained after screening for multiple submissions from the same computer and submissions that appeared to be fraudulent or mischievous (such as where very young participants claimed to have doctoral degrees) was conducted. Of these remaining participants, 465 (60.9%) were female. The modal age group was 21–25 years (32%). The majority of these respondents came from Europe (71%) and many were well educated, having some university or college education (31%). The majority of participants ($N = 465$; 61.3%) stated that they were non-smokers. Eighty-two participants smoked 1–4 cigarettes (or equivalent) per day (10.8%), 125 smoked between 5 and 14 cigarettes a day (16.4%), and 87 smoked 15 cigarettes a day or more (11.5%).

A web site was created for the purposes of data acquisition which could be accessed via a number of different addresses (e.g. http://www.drugresearch.org.uk/). Memory was assessed using two self-report questionnaires. The first was the everyday memory questionnaire. This is a valid and reliable self-report measure of common memory lapses in everyday activities comprising of 27 statements. Examples included "telling someone a story or joke that you have told them once already" and "forgetting where things are normally kept or looking in the wrong place for them" (Sunderland et al., 1983). Responses were on a nine-point scale ranging from 'Not at all in the last six months' to 'More than once a day', with high scores indicating more forgetting. Prospective memory was assessed using the prospective memory questionnaire, a valid and reliable self-report measure (Hannon et al., 1995). Three aspects of PM are assessed. Fourteen questions cover short-term habitual PM (e.g. "I forgot to turn my alarm clock off when I got up this morning"). Fourteen items measure long-term episodic PM (e.g. "I forgot to pass on a message to someone"). Ten questions measure internally-cued (IC) PM (e.g. "I forgot what I wanted to say in the middle of a sentence"). The PMQ provides a measure of self-reported errors in the previous week, or month or year, depending upon the specific questionnaire item. These scales range from 1 to 9, with greater scores indicating more faulty prospective memory. In addition, 14 further questions make up the 'techniques to remember' scale which measures the number of strategies used to aid memory (e.g. "I rehearse things in my mind so I will not forget to do them"). Scores on this latter scale range from 1 to 9; higher scores indicate greater use of memory strategy aids (Hannon et al., 1995).

Tobacco and other drug use was assessed by the web-based version of the UEL Recreational Drug Use Questionnaire (Parrott, 2000; Rodgers et al., 2003). Respondents estimated their level of use of tobacco as well as other drugs (alcohol, ecstasy, amphetamines, cocaine, LSD, barbiturates, opiates, magic mushrooms, anabolic steroids, solvents and cannabis). Participants were required to select a typical frequency from a drop-down menu. For all questions regarding drugs, a 'prefer not to answer' option was also included. The smoking question read "Tobacco: roughly how many cigarettes (or equivalent) do you usually smoke per day?" In response, participants could select 'non-smoker', '1–4 cigarettes or equivalent per day', '5–14 cigarettes or equivalent per day', 'More than 15 cigarettes or equivalent per day', or 'Prefer not to answer'.

Instructions provided to participants at the start of each of these questionnaires replicated the written instructions for the traditional versions of each instrument as closely as possible. The amendments were mainly for technical reasons e.g. 'select' rather than 'circle' the appropriate option.

Participants completed a number of demographic questions (age, sex, location, occupation and education), also questions relating to their participation (how they found out about the study, whether they were currently under the influence of any substance, and whether there was any reason their data should not be used in analyses). These instruments were all presented as interactive forms on a single web page. The final dependent variable was 'mistakes made when completing the questionnaire'. If participants submitted an incomplete form they were informed of this and requested to supply the missing data then resubmit the form. The number of times each participant made such a mistake was recorded.

Ethical approval came via University of Westminster (Buchanan et al., in press). There was a brief introduction to the study that also explained that participants' responses were both voluntary and confidential. Each participant clicked an informed consent button on the web site reading "I understand the nature of the study and wish to continue". Participants were recruited using several methods including messages posted to relevant Internet discussion groups, links from online experiments, notices on web-pages and announcements in our home institutions. Participants first saw an informed consent page. This page informed participants that the study was designed to investigate everyday behaviour and recreational drug use. There was also a link to a statement on anonymity and confidentiality. Participants then saw a page bearing brief instructions, demographic items, the EMQ, PMQ and drug use questionnaires, and questions about their participation. After completing all the items, participants clicked on a button labelled "Finished" at the bottom of the page.

Participants who had not answered all the questions saw a page indicating this, which asked them to return to the form and fill it out completely prior to resubmission. Those who had answered all the items saw a debriefing page. This thanked them, outlined the purpose of the study, provided links to web sites with information about drugs, and also a link to a page where a summary of results would be posted on conclusion of the study. An e-mail contact address was also provided for respondents who wished to submit feedback or ask questions.

3. Findings

Prior to the main analysis, the psychometric properties of the EMQ and PMQ subscales were critically examined. This was because these instruments had originally been developed and validated for pencil-and-paper administration. There are theoretical arguments (Buchanan and Smith, 1999) and empirical reasons (Fouladi et al., 2002) why the psychometric properties of psychological tests may change subtly when implemented on the web. Thus, it is advisable to re-evaluate all tests when used on the web, in the same way as establishing the validity of other web-based research techniques (Krantz and Dalal, 2000).

According to Hannon et al. (1995), the model underlying the PMQ has four factors, corresponding to the subscales described above. However, exploratory factor analysis with extraction of four principal components followed by Varimax rotation, did not support this model. Full details of the analysis are presented elsewhere (Buchanan et al., in press), but the basic findings were as follows. The items comprising the long-term (LT) and techniques to remember (TR) scales clearly loaded together on discrete factors in the expected way. However, the items comprising the short-term (ST) and internally-cued subscales each had their highest loadings scattered across three different factors, and did not cluster together in the expected (two discrete constructs) way. This indicates that the groups of items nominally falling within the ST and IC subscales did not actually form unidimensional constructs. Thus, the latent structure of the current dataset did not replicate the (theoretically distinct) constructs delineated by Hannon et al. (Buchanan et al., in press), rendering the ST and IC scores uninterpretable and essentially meaningless. In addition, the short-term subscale had somewhat low reliability (Cronbach's alpha = .68). The reliability on the internally-cued subscale did exceed the .7 threshold (.86) but the pattern of factor loadings suggests that this is due to the fact that almost all of the (nominally) internally-cued items had substantive loadings on the long-term factor.

For current purposes we may conclude that the PMQ short-term and internally-cued subscales were not psychometrically satisfactory, as far as this web-based sample is concerned. These scales were therefore not included in this analysis, since any conclusions based on them are likely to be unsound. All the other measures were psychometrically satisfactory. Cronbach's alpha values (reliability indices) were high for the PMQ long-term scale (alpha = .85), the PMQ techniques to remember scale (alpha = .89), and the overall EMQ (alpha = .94).

The effect of reported cigarette consumption on each of the remaining memory scores (EMQ, PMQ long-term scale) and the number of mistakes made completing the questionnaire were examined by means of multivariate analyses of covariance (MANCOVA). In this project, participants were asked to report their level of use of a number of different legal and illegal recreational drugs. This permits the effect of each of these to be assessed, and also permits the use of other substances to be controlled, when evaluating the impact of a single substance such as tobacco. Accordingly, the extent to which other substances that we have shown to impact upon cognitive function (ecstasy, cannabis, alcohol and LSD; see Ling et al., 2003; Rodgers et al., 2003) covaried with tobacco use was assessed using Spearman's correlations. As shown in Table 1, level of tobacco use was positively associated with use of ecstasy, cannabis and LSD. Table 2 shows the breakdown of these other substances across the different smoking groups. The non-smokers, 1–4 cigarettes per day group, 5–14 cigarettes per day group, and 15 cigarettes or more per day group differed significantly in their use of ecstasy, cannabis and LSD, but not in their alcohol use. In terms of ecstasy, cannabis and LSD, the majority of the smokers and non-smokers were in the non-user category for these other drugs.

Table 1
Spearman's correlations between tobacco use and other substances

Substance	Spearman's rho	*N*	*p*
Ecstasy	.218	762	.000
Cannabis	.274	759	.000
Alcohol	.050	762	.171
LSD	.232	762	.000

Note: Sample size for cannabis is lower as some participants chose not to report their level of use.

Accordingly, use of each of these drugs was employed as a separate covariate in the analyses. In addition, the 'techniques to remember scale' of the PMQ was also included as a covariate because use of memory strategies may affect memory performance.

There was no effect of level of reported smoking on the number of errors made when completing the study $F(3, 759) = 1.41$, $p > .05$. Analysis indicated that level of reported smoking had a significant effect on the long-term scale of

Table 2
Self-reported frequency of other psychoactive drug use for non-smokers ($N = 465$), 1–4 cigarettes per day group ($N = 82$), 5–14 cigarettes per day group ($N = 125$), and 15 cigarettes or more per day group ($N = 87$) (based on % counts per group)

	Ecstasy (MDMA) lifetime use (times used)				
	Never (%)	1–9 Times (%)	10–99 Times (%)	>100 (%)	Chi-square
Non-smokers	72	11.2	14	2.8	62.4, d.f. = 9; $p < .001$
1–4 Cigarettes per day	50	21.9	19.5	8.6	
5–14 Cigarettes per day	38.8	23.8	30.1	7.3	
More than 15 cigarettes per day	62.1	9.2	19.5	9.2	
	Cannabis use per month				
	Non-user (%)	1–4 Times (%)	5–20 Times (%)	>20 (%)	Chi-square
Non-smokers	70.6	18	4.9	6.5	93.7, d.f. = 9; $p < .001$
1–4 Cigarettes per day	41.5	28	18.3	12.2	
5–14 Cigarettes per day	30.3	29.6	16.8	23.3	
More than 15 cigarettes per day	58.8	16	10.3	14.9	
	Alcohol use per week				
	0 Units (%)	1–9 Units (%)	10–24 Units (%)	>25 Units (%)	Chi-square
Non-smokers	21.6	43.6	27.6	7.2	14.8, d.f. = 9; non-significant
1–4 Cigarettes per day	10.9	42.6	34.2	12.3	
5–14 Cigarettes per day	19	38.8	36.6	5.6	
More than 15 cigarettes per day	26.4	34.5	27.6	11.5	
	LSD lifetime use				
	Never (%)	1–9 Times (%)	10–99 Times (%)	>100 Times (%)	Chi-square
Non-smokers	81.5	13.4	5.1	0	55.0, d.f. = 9; $p < .001$
1–4 Cigarettes per day	59.9	21.8	18.3	0	
5–14 Cigarettes per day	54.9	25.4	18.2	1.5	
More than 15 cigarettes per day	63.4	20.6	12.6	3.4	

Table 3
Mean (and standard deviation) scores on prospective memory questionnaire long-term (PMQ-LT) subscale and everyday memory questionnaire (EMQ) by level of smoking

	Non-smoker	Cigarettes per day			
		1–4	5–14	>15	ANOVA group effect
PMQ-LT	2.27 (.96)	2.46(1.08)	2.36 (1.19)	2.76 (1.38)	$F = 6.86$; $p = .001$
EMQ	74.31 (28.23)	82.03(27)	80.22 (31.83)	81.16 (35.56)	$F = 3.05$; $p = .028$

the PMQ, $F(3, 759) = 6.86$, $p < .001$ (see Table 3). Pairwise comparisons (with Bonferroni adjustment) indicated that participants who reported smoking 15 or more cigarettes per day reported significantly more problems than either non-smokers ($p < .01$) or than those who stated they smoked 5–14 cigarettes per day ($p < .05$). An analysis of the first and second order polynomials across the levels of reported smoking was also conducted; these analyses indicated that the effect of dosage was a linear one ($p < .01$). There was an effect of cigarette consumption on scores on the EMQ, $F(3, 759) = 3.05$, $p < .028$ (see Table 3). Pairwise comparisons showed that participants who smoked 15 or more cigarettes per day had a borderline trend towards more memory failures than non-smokers ($p = .057$; two-tailed).

A further investigation of the influence of smoking on PMQ-LT score helped to understand the contribution made by heavy use of cigarettes to cognitive deficits (Cohen's d effect sizes are given in brackets). A typical heavy smoker is likely to report 21.59% more problems with long-term aspects of prospective memory than someone who does not smoke ($d = .43$) and to report 16.46% more problems than individuals who say they have a moderate level of smoking (5–15 cigarettes per day, $d = .40$).

4. Discussion

Acute dose studies of cigarette smokers have often concluded that smoking enhances memory performance (Waters and Sutton, 2000). However since they have involved briefly deprived smokers, the apparent cognitive gains may reflect the temporary reversal of abstinence effects (Hale et al., 1999; Krebs et al., 1994). Williams (1980) found no effects of mild, moderate and strong cigarettes on an immediate memory task in overnight nicotine-deprived smokers. However it was also noted that: 'Absolute gain scores were misleading therefore more account had to be taken of pre-smoking performance' (Williams, 1980, p. 87). Williams found that when the gain scores were regressed on the pre-smoking values, performance remained impaired under sham smoking, but improved significantly in the two high dose cigarette conditions. The effects of cigarette smoking have been investigated in numerous acute dose studies, and improvements, deteriorations, and unchanged memory performance levels have all been reported (Roth et al., 1992; Wesnes and Parrott, 1992). The cognitive functioning of cigarette smokers is affected by numerous potentially confounding factors, with the effects of nicotine deprivation and reinstatement difficult to disentangle, which is why the mood and cognitive effects of nicotine can be so variable (Heishman et al., 1994; Sherwood, 1993). In an explanatory model, Parrott (1998) suggested that cognitive performance was often slightly enhanced when plasma nicotine levels peaked, but that this period was brief and transitory. In-between cigarettes, cognitive performance deteriorated to a level 'below' that of non-smokers. Thus, the main effects of nicotine dependency were to cause mood lability and variable cognitive performance over the day (Parrott, 1998; Parrott et al., 2004; also Adan and Sanchez-Turet, 2000).

The present study revealed that cigarette smokers reported significantly worse everyday long-term prospective memory function than non-smokers, this was evident after controlling for the use of other substances and the number of strategies used to aid remembering. These findings are consistent with nicotine dependency as a source of psychobiological distress. Thus, smokers experience peak nicotine levels for only a brief period after each cigarette, but then in-between cigarettes their plasma nicotine levels gradually fall (Sakurai and Kanazawa, 2002). Thus, for each piece of information that needs to be memorised, its initial sensory reception, then its consolidation and storage, and finally its subsequent retrieval, will each be conducted against a background of changing and uncertain plasma nicotine levels. This may help explain why cigarette smokers reported memory problems and impairments. The current findings also revealed some interesting differences between light and heavier smokers, suggesting that nicotine may have a dose-dependent impact upon everyday prospective memory.

The everyday memory questionnaire also generated a significant between-group ANOVA effect, with a general trend for more memory errors in each of the three subgroups of smokers (Table 3). However the between-group comparisons (involving Bonferonni corrections for multiple comparisons) were statistically only borderline. Currently the nature of the relationship between cigarette smoking and everyday memory is thus unclear, with the significant overall effect being accompanied by the non-significant between-group comparisons. Further studies are therefore needed to clarify the integrity of everyday memory functioning in tobacco smokers. Future research might also investigate the different aspects of everyday memory functions covered by the EMQ (e.g. spatial memory, conversational monitoring, monitoring short-term everyday activities, Sunderland et al., 1983), since it may be that only some of them are affected by nicotine/smoking.

Although the large sample size obtained from the current web-based approach is advantageous, in certain aspects our sample may have been rather skewed. For example, there was a slight preponderance of women, and approximately one-third were young people with a college education. Thus, the web-based approach may be less likely to gain access to particular subgroups within society, such as older people. This difficulty in ensuring balanced participant samples, should be noted when interpreting the findings from this web-based study. Future researchers might also include ratings of depression, given the correlation between smoking and clinical depression (Breslau et al., 1992; Hall et al., 1993), also the link between depression and self-belief in one's own memory capabilities (Hendricks et al., 2002).

Despite these limitations, the current web-based findings agree with the extensive literature on the adverse psychobiological effects of nicotine dependency. These results suggest that prospective memory—which is an important aspect of everyday cognitive functioning—should be included in the list of neuropsychological deficits associated with smoking (Table 3). Adolescent smokers who take up smoking prospectively report increased levels of stress and depression in later years, whereas adult smokers who quit smoking report subsequent improvements in their feelings of stress and depression (Cohen and Lichtenstein, 1990; Goodman and Capitman, 2000; McGee et al., 2000). There is now an extensive body of prospective studies showing that the uptake of smoking leads to a range of psychobiological problems (summarised in Parrott, 2003). The supposed mood 'benefits' of smoke inhalation only reflect the temporary reversal of abstinence effects, and the repetitive experience of irritability and poor moods in-between cigarettes, directly causes smokers to suffer from heightened levels of stress and depression; this explanatory model is described more fully elsewhere (Parrott, 1999, 2000, 2003).

5. Conclusions

In conclusion, the present findings show that cigarette smokers report more memory problems than non-smokers. This is apparent in the higher rates of long-term prospective memory impairments reported by smokers. However no firm conclusions can be offered in relation to everyday memory, and further studies assessing the self-rated EMQ abilities of regular smokers are warranted. Future studies should also prospectively investigate the memory abilities of adolescents who take up smoking, and the effects of smoking cessation on memory skills. Laboratory studies typically assess the immediate effects of nicotine reinstatement in deprived smokers and as a consequence are likely to show nicotine in an optimal light. Yet even then, cigarette smokers often only show memory levels equivalent to non-smoker controls (see Fig. 1a in Sakurai and Kanazawa, 2002). What is needed are real life memory tasks, performed under realistic conditions of intermittent smoking, where plasma nicotine levels are constantly changing. It is predicted that these are the conditions when the storage and retrieval of information in memory will be most problematic. One such approach might include video simulations wherein the participant needs to remember to carry out certain activities when particular locations are reached—a recent development in the prospective memory literature with high ecological validity (Titov and Knight, 2001).

Acknowledgements

This study was undertaken as part of a collaborative research group comprised of those researchers named as authors on the paper. There was no internal or external funding provided for this project.

References

Adan, A., Sanchez-Turet, M., 2000. Effects of smoking on diurnal variations of subjective activation and mood. Hum. Psychopharmacol. 15, 287–294.

Birnbaum, M.H., 2000. Psychological Experiments on the Internet. Academic Press, San Diego.

Brandimonte, M., Einstein, G.O., McDaniel, M.A., 1996. Prospective Memory: Theory and Applications. Lawrence Erlbaum Associates, New York.

Breslau, N., Kilbey, M., Andreski, P., 1992. Nicotine withdrawal symptoms and psychiatric disorders: findings from an epidemiological study of young adults. Am. J. Psychiatry 149, 464–469.

Buchanan, T., Smith, J.L., 1999. Using the Internet for psychological research: personality testing on the World-Wide Web. Br. J. Psychol. 90, 125–144.

Buchanan, T., Ali, T., Heffernan, T.M., Ling, J., Parrott, A.C., Rodgers, J., Scholey, A.B., 2002. Psychometric properties of online self-report memory questionnaires: the EMQ and PMQ. In: Proceedings of the 5th German Online Research Conference (GOR), Stuttgart, Germany, October 10–11, 2002.

Buchanan, T., Ali, T., Heffernan, T.M., Ling, J., Parrott, A.C., Rodgers, J., Scholey, AB. Non-equivalence of online and paper-and-pencil psychological tests: the case of the prospective memory questionnaire, behavior research methods, instruments, and computers, in press.

Cohen, S., Lichtenstein, E., 1990. Perceived stress, quitting smoking, and smoking relapse. Health Psychol. 9, 466–478.

Ellis, J., Kvavilashvili, L., Milne, A., 1999. Experimental tests of prospective remembering: the influence of cue-event frequency on performance. Br. J. Psychol. 90, 9–23.

Fouladi, R.T., McCarthy, C.J., Moller, N.P., 2002. Paper-and-pencil or online? Evaluating mode effects on measures of emotional functioning and attachment. Assessment 9, 204–215.

Glantz, S.A., Parmley, W.W., 1995. Passive smoking and heart disease: mechanisms and risk. JAMA 273, 1047–1054.

Goodman, E., Capitman, J., 2000. Depressive symptoms and cigarette smoking among teens. Pediatrics 196, 748–755.

Hale, C.R., Gentry, M.V., Meliska, C.V., 1999. Effects of cigarette smoking on lexical decision-making. Psychol. Rep. 84, 117–120.

Hall, S., Munoz, R., Reus, V., Sees, K., 1993. Nicotine, negative affect and depression. J. Consult. Clin. Psychol. 61, 761–767.

Hannon, R., Adams, P., Harrington, S., Fries-Dias, C., Gibson, M.T., 1995. Effects of brain injury and age on prospective memory self-rating and performance. Rehab. Psychol. 40, 289–297.

Heffernan, T.M., Ling, J., Scholey, A., 2001a. Subjective ratings of prospective memory in ecstasy users. Hum. Psychopharmacol. 16, 339–344.

Heffernan, T.M., Jarvis, H., Rodgers, J., Scholey, A.B., Ling, J., 2001b. Prospective memory, everyday cognitive failures and central executive functions in recreational users of 'ecstasy'. Hum. Psychopharmacol. 16, 1–6.

Heffernan, T.M., Moss, M., Ling, J., 2002. Subjective ratings of prospective memory in chronic heavy alcohol users. Alcohol Alcohol. 37, 269–271.

Heishman, S.J., Taylor, R.C., Henningfield, J.E., 1994. Nicotine and smoking: a review of the effects on human performance. Exp. Clin. Psychopharmacol. 2, 345–395.

Hendricks, M.P.H., Aldenkamp, A.P., van der Vlugt, H., Alperts, W.C.J., Vremeulen, J., 2002. Memory complaints in medically refractory epilepsy: relationship to epilepsy related factors. Epilepsy Behav. 3, 165–172.

Krantz, J., Dalal, R., 2000. Validity of web-based psychological research. In: Birnbaum, M.H. (Ed.), Psychological Experiments on the Internet. Academic Press, San Diego, CA, pp. 35–60.

Krebs, S.J., Petros, T.V., Beckwith, B.E., 1994. Effects of smoking on memory for prose passages. Physiol. Behav. 56, 723–727.

Ling, J., Heffernan, T.M., Buchanan, T., Rodgers, J., Scholey, A.B., Parrott, A.C., 2003. Effects of alcohol on subjective ratings of prospective memory and everyday memory deficits. Alcohol. Clin. Exp. Res. 6, 970–974.

McGee, R., Williams, S., Poulton, R., Moffitt, T., 2000. A longitudinal study of cannabis use and mental health from adolescence to early adulthood. Addiction 95, 491–504.

Parrott, A.C., 1998. Nesbitt's paradox resolved? Stress and arousal modulation during cigarette smoking. Addiction 93, 27–39.

Parrott, A.C., 1999. Does cigarette smoking cause stress? Am. Psychol. 54, 817–820.

Parrott, A.C., 2000. Cigarette smoking does cause stress. Am. Psychol. 55, 1159–1160.

Parrott, A.C., 2003. Cigarette-derived nicotine is not a medicine. World J. Biol. Psychiatry 4, 49–55.

Parrott, A.C., Garnham, N.J., 1998. Comparative mood states and cognitive skills of cigarette smokers, deprived smokers, and non-smokers. Hum. Psychopharmacol. 13, 367–376.

Parrott, A.C., Garnham, N.J., Wesnes, K., Pincock, C., 1996. Cigarette smoking and abstinence: comparative effects upon cognitive task performance and mood state over 24 hours. Hum. Psychopharmacol. 11, 391–400.

Parrott, A., Morinan, A., Moss, M., Scholey, A., 2004. Understanding Drugs and Behaviour. Wiley, Chichester.

Rodgers, J., Buchanan, T., Scholey, A.B., Heffernan, T.M., Ling, J., Parrott, A., 2001. Self-reports of memory ability in recreational users of 'ecstasy': a web-based study. Hum. Psychopharmacol. 16, 619–625.

Rodgers, J., Buchanan, T., Scholey, A.B., Heffernan, T.M., Ling, J., Parrott, A.C., 2003. Patterns of drug use and the influence of gender on self-reports of memory ability amongst ecstasy users: a web-based study. J. Psychopharmacol. 17, 379–386.

Roth, N., Luitger, B., Hasenfratzm, M., Battig, K., Knye, M., 1992. Smoking deprivation in early and late smokers and memory functions. Psychopharmacology 106, 253–260.

Sakurai, Y., Kanazawa, I., 2002. Acute effects of cigarettes in non-deprived smokers on memory, calculation and executive functions. Hum. Psychopharmacol. 17, 369–373.

Sherwood, N., 1993. Effects of nicotine on human psychomotor performance. Hum. Psychopharmacol. 8, 155–184.

Sunderland, A., Harris, J.E., Baddeley, A.D., 1983. Do laboratory tests predict everyday memory? J. Verb. Learn. Verb. Behav. 22, 341–357.

Titov, N., Knight, R.G., 2001. A video-based procedure for the assessment of prospective memory. Appl. Cogn. Psychol. 15, 61–83.

Waters, A.J., Sutton, S.R., 2000. Direct and indirect effects of nicotine/smoking on cognition in humans. Addict. Behav. 25, 29–43.

Wesnes, K., Parrott, A.C., 1992. Smoking, nicotine, and human performance. In: Smith, A., Jones, D. (Eds.), Factors Affecting Human Performance, vol. 2. Academic Press, London.

Williams, D.G., 1980. Effects of cigarette smoking on immediate memory and performance in different kinds of smoker. Br. J. Psychol. 71, 83–90.