Smoking-related prospective memory deficits in a real-world task

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ABSTRACT

Background: Smokers, previous smokers and a never smoked group were compared on self-reported and real world prospective memory (PM – the cognitive ability of remembering to carry out particular actions at some future point in time).

Methods: Twenty-seven current smokers, 24 people who had never smoked and 18 previous smokers were compared using an existing groups design. Scores on the long and short term PM subscales of the Prospective and Retrospective Memory Questionnaire (PRMQ) and scores on a Real World Prospective Memory Task (RWPMT) constituted the dependent measures. Smoking and other drug use were assessed by a Recreational Drug Use Questionnaire. The Hospital Anxiety and Depression Scale gauged levels of anxiety and depression. The National Adult Reading Test measured IQ, and retrospective memory was measured using the PRMQ. Gender, age, anxiety and depression, IQ, alcohol use and the retrospective memory scores, were measured as covariates and controlled for in the analysis.

Results: A series of univariate ANCOVAs were applied to the main PM data across the three groups, controlling for variations in age, gender, mood, IQ, alcohol use and retrospective memory scores. These revealed no significant between-group differences on self-reported PM; however smokers recalled significantly fewer action–location combinations than the never smoked and previous smoker groups on the objective RWPMT.

Conclusions: Existing smokers showed reduced performance on RWPMT when compared to the never smoked group and previous smokers. Real-world PM impairments should be added to a growing list of neuropsychological sequelae associated with persistent smoking.

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1. Introduction

The health consequences of smoking currently cost the UK National Health Service an estimated £5.2 billion each year (Allender et al., 2009). Only relatively recently has research focused upon the behavioural and cognitive consequences of smoking (Parrott et al., 2004). The range of cognitive deficits associated with prolonged smoking include deficits in psychomotor speed (Whalley et al., 2005), verbal and visual memory (Fried et al., 2006; Richards et al., 2003), working memory (Ernst et al., 2001; Fried et al., 2006; Greenstein and Kassel, 2009; Jacobson et al., 2005, 2007; Spilich et al., 1992) and executive function (Glass et al., 2009; Hill et al., 2003; Jacobson et al., 2005; Kalmijn et al., 2002; Tait and Siru, 2009). Recent evidence also suggests that smoking cessation leads to improvements in memory, e.g., in executive function (Brega et al., 2008). This research has focused on laboratory and/or field tests of *retrospective memory* – that is the learning, retention and retrieval of previously presented target material. Though informative, it is also important to establish how smoking affects memory function in an everyday context, of which *prospective memory* plays an important role.

Prospective memory (PM) is the cognitive ability of remembering to carry out particular actions at some future point in time (Brandimonte et al., 1996; McDaniel and Einstein, 2007) and its importance becomes most apparent when failures in everyday remembering occur, e.g., forgetting to take a critical medication on time can have grave consequences (see Kliegel et al., 2008). PM and executive function share prefrontal and frontal lobe resources in the brain (Burgess et al., 2001; Kliegel et al., 2008; Simons et al., 2006) and given that executive deficits are associated with continued smoking (Brega et al., 2008) one might also predict reduced PM functioning as a result of smoking. Only two published studies and one unpublished Ph.D. thesis to date have focused on smoking-related PM deficits. In the first, Heffernan et al. (2005) used the Prospective Memory Questionnaire (PMQ: Hannon et al., 1995) to examine self-reported PM lapses in smokers and a never-smoked comparison group. After statistically controlling for other drug use, smokers reported more lapses in their long term everyday PM (e.g., forgetting to meet with friends) compared with the never-smoked group. Rash (2007) found that deprived smokers reported more lapses on the PMQ compared with a never-smoked group. In the third study, Heffernan et al. (2010) compared smokers

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and a never-smoked group on the Cambridge Prospective Memory Test (CAMPROMPT) which is a laboratory-based measure of time and event based PM tasks. After controlling for other drug use, mood and IQ, smokers recalled significantly fewer time and event based items on the CAMPROMPT than the never-smoked group, with no between-group differences on self-reported PM lapses using a recent measure in the form of the Prospective and Retrospective Memory Questionnaire (PRMQ: Crawford et al., 2003). Taken together, this research reveals mixed findings with regards self-reported PM, with some research observing more lapses being reported by smokers (Heffernan et al., 2005; Rash, 2007) whereas other research shows no such difference (Heffernan et al., 2010). The only study to date utilising a laboratory-based objective measure of PM revealed smoking-related reductions on the CAMPROMPT (Heffernan et al., 2010); supporting the notion that persistent smoking reduces objective PM functioning.

Given that PM is critical to everyday functioning (McDaniel and Einstein, 2007) it is important to observe whether smoking related PM reductions extend to a real-world paradigm. Since there is a paucity of research that has focused on smoking cessation and putative improvements in memory function (e.g., Brega et al., 2008) it would also be of interest to observe previous smokers and their PM performance. The aims of the present study were threefold; firstly, to determine whether self-reported PM lapses are associated with persistent smoking; secondly, to observe whether smoking-related PM reductions extend to a real-world PM paradigm – if persistent smoking does impede PM function then one would expect such problems to extend to a real-world PM; thirdly, to observe a group of previous smokers to elucidate the relationship between smoking cessation and PM. Given that age, gender and other drug use can impede PM performance (Brandimonte et al., 1996; Heffernan, 2008; Rodgers et al., 2011) and that variations in mood can negatively affect cognition (Parrott et al., 2004) these were controlled for in the main analysis. Since (from the literature presented here) retrospective memory is impaired by smoking, this will also be measured and controlled for in the present study. Finally, it would be prudent to control for variations in IQ and this was therefore also controlled for in the analysis.

2. Materials and method

2.1. Participants

Sixty-nine participants aged 18–35 years old were tested. All the participants were educated to A' level standard and were studying at University in the North East of England. Twenty-seven were existing smokers (16 females) with a mean age of 22.4 years, who were smoking on average 60.7 cigarettes/week and had been smoking for an average of 6.24 years. The smokers only reported using cigarettes and no other tobacco product (e.g., cigars, a pipe). Nine were occasional cannabis users, 5 were occasional ecstasy users and the majority drank some alcohol. Twenty-four participants (21 females) had never smoked any tobacco product, with a mean age of 19.0 years. Eight of the never-smoked group were occasional cannabis users; they reported not using ecstasy and the majority drank some alcohol. The final 18 were previous smokers (15 females) with a mean age of 23.7 years, who had previously smoked on average 70 cigarettes/week and had been smoking for an average of 5.92 years, but had not smoked for an average of 2.5 years. Six of the previous smokers were occasional cannabis users, 5 were occasional ecstasy users and the majority drank some alcohol. See Table 2 for all descriptive data. All of the smokers were asked to smoke immediately prior to their participation in order to avoid them being in a potential state of 'smoking withdrawal' just prior to carrying out the objective PM measure, which some authors have suggested can lead to decrements in cognitive performance independent of the person's smoking pattern (Sakurai and Kanazawa, 2002). Any participant who reported using alcohol within the past 48 h or had reported previously suffering from/or currently suffering from a psychiatric condition (e.g., clinical depression, substance dependence, amnesia) were omitted from the study.

2.2. Design

An existing-groups design was employed utilising pre-existing groups of current smokers, a never-smoked group and a group of previous smokers. The dependent variables were the number of location–action combinations correctly recalled from the Real World Prospective Memory Task (RWPMT), as well as the number of short-term and long-terms self-reported prospective memory failures measured using the Prospective and Retrospective Memory Questionnaire (PRMQ). Gender, age, scores on the anxiety and depression subscales from the Hospital Anxiety and Depression Scale (HADS), pre-morbid IQ (measured using the National Adult Reading Test: NART), other drug use (cannabis, ecstasy, and alcohol measured by the Recreational Drug Use Questionnaire: RDUQ) and the retrospective memory scores from the short and long term subscales of the PRMQ, were measured as covariates. The order of presentation of the tasks (RWPMT, NART, RDUQ, HADS, PRMQ) remained constant across each participant. Testing time was approximately 40 min and ethical approval was gained from the School of Life Sciences at Northumbria University.

2.3. Measures

2.3.1. Demographic details.
Demographic variables included age, gender and education.

2.3.2. Substance use.
Smoking and other drug use was assessed using the University of East London Recreational Drug Use Questionnaire (RDUQ) used in previous research (e.g., Heffernan and Bartholomew, 2006; Parrott et al., 2002). The RDUQ required each participant to answer questions about their smoking status and history (e.g., how many cigarettes smoked per week, how long they had been smoking) and their use of other drugs (their weekly units of alcohol, cannabis, ecstasy, and other drugs used). They were also asked whether they had drunk alcohol within the last 48-h and asked to identify on the questionnaire whether they had previously suffered from/or were currently suffering from a substance dependence disorder, clinical amnesia, or some other psychiatric condition.

2.3.3. Pre-morbid IQ.
The National Adult Reading Test (NART: Nelson and Willison, 1991) is a standardised test widely used in research and clinical practice as an estimate of pre-morbid IQ and was used here as a measure of general intellectual function here. Each participant was required to read aloud a list of 50 words (for example, "Chord", "Gaoled", "Zealot"). For each word incorrectly pronounced, an error score of one point was recorded (ranging from 0 to 50) and the total number of errors was then converted on the WAIS full scale verbal and performance IQ table to provide a predicted full-scale IQ score per participant.

2.3.4. Anxiety and depression.
The Hospital Anxiety and Depression Scale (HADS: Zigmond and Snaith, 1983) was used to measure anxiety and depression. The HADS comprises a 14 item standardised self-report questionnaire that can be used in non-psychiatric samples. Seven items pertain to generalised anxiety symptoms (for example, "I feel tense or wound up") and the remaining 7 pertain to generalised depressive symptoms (for example, "I have lost interest in my appearance"). A separate overall score was obtained for the anxiety and depression constructs, ranging from between 0 and 21 with the higher score indicating increases in feelings of anxiety and depression.

2.3.5. Real world PM.
The Real World PM Task (RWPMT) measured objective everyday PM. The RWPMT involved presenting a list of 15 specific locations around a university campus (e.g., "when you reach the Students Union"), accompanied by a list of associated actions (e.g., "Ask if there is a job available"). The full list location–action combinations are contained in Table 1. The participant was allowed 1.5 min to memorise the list before accompanying the researcher on a short tour of the university campus where the participant verbally recalled both the location and the associated action, but only when they reached a location that was on the original list. The order of the location–action combinations on the actual tour was different to that presented in the original list in order to reduce any strategy being used before the tour began. In addition to the target locations, several other locations were included which were not contained in the original list, acting as non-target distracter locations (e.g., passing a coffee shop on campus). Interruptions were inserted between locations and comprised of the researcher engaging the participant in general conversation about everyday university life. The inclusion of such distracters and interruptions was to ensure that the PM task was as similar to a more realistic PM scenario as possible (see Ellis and Kvavilashvili, 2000). One point was given for each location–action combination correctly recalled, ranging from 0 to 15 for each participant, with the higher score indicating more proficient PM.

2.3.6. Self-reported PM.
Self-reported PM was measured using the Prospective and Retrospective Memory Questionnaire (PRMQ) which provides a valid and reliable measure of the number of self-reported short-term and long-term PM lapses and similar retrospective memory (RM) lapses experienced by the person (Crawford et al., 2003). The scale contains 16 questions which the participant is asked to complete by circling one of the five possible answers shown immediately below the question e.g., (question) "Do you forget appointments if you are not prompted by someone else or by a reminder such as a calendar or diary?", (answer) very often (score awarded = 5), quite often (score = 4), sometimes (score = 3), rarely (score = 2), never (score = 1). A total score was calculated for each sub-scale of the PRMQ that measured short and long term PM and short and long term RM, with the higher score indicating more lapses in everyday PM and RM.

Table 1
The 15 location–action/memory combinations used on the RWPMT.

Location	Action/item
When you reach the 'University Shop'.	Ask 'Do You Sell Sandwiches?'
At the Business School Entrance.	Ask 'Is Coach Lane Near Hear?'
In the Career Services department.	Ask what the opening hours are.
When you are in the Students Union.	Ask 'When Is The Next Gig?'
Upon reaching the 'Lipman Café'.	Enquire about a part-time job.
In the Art Gallery.	Enquire as to whether they have a 'Lowry'.
When you reach the City Hall.	Ask when is the next graduation?
Upon reaching the Library.	Check for any messages on your mobile phone.
At the Rutherford Hall.	Ask where the nearest telephone is located.
Upon reaching the Sports Centre.	Check the cost of a membership.
At the 'Well Read' Bookshop.	Ask for directions to the Metro.
When you reach the Trinity Building.	Ask where the nearest refectory is located.
When you reach the shop 'Londis'.	Purchase a £10 'top up' for mobile phone.
When you reach the Car Park.	Check what time it is.
When you reach the Book Statue.	Ask the researcher where you can hire a car?'

3. Results

3.1. Descriptive analysis

Table 2 contains the means and standard deviations (in brackets) comparing current smokers, the never-smoked group and previous smokers on age, cigarette consumption per week, length of smoking in years, the units of alcohol consumed per week, cannabis use (joints per week), ecstasy use (tablets per week), pre-morbid IQ (NART), HADS anxiety and depression scores, long-term retrospective memory (PRMQ–RMLT) and short-term retrospective memory scores (PRMQ–RMST) taken from the PRMQ, long-term PM (PRMQ–PMLT) and short-term PM (PRMQ–PMST) scores taken from the PRMQ, and scores from the Real-World PM Task (RWPMT). Chi-square analysis revealed no significant difference in the distribution of males and females across the three groups (χ^2 (2) = 4.35, p = 0.11). There was no significant difference between the current smokers and previous smokers in terms of the number of cigarettes smoked per week (t (43) = 0.88, p = 0.38), nor in terms of the duration of smoking across their lifetime (t (43) = 0.25, p = 0.79) – see Table 2 for means and standard deviations.

3.2. Analysis of co-variance

In order to control for variations in age, gender, other drug use, mood, IQ scores (NART), and RM scores taken from the PRMQ for long-term RM (PRMQ–LTRM) and short-term RM (PRMQ–STRM) RM, this data was incorporated into a series of univariate analysis of covariance tests (ANCOVAs) applied to the PM data. A univariate ANCOVA applied to the long-term PM data (PRMQ–PMLT) revealed no relationship between PRMQ–PMLT and gender (F (1, 56) = 0.03 p = 0.84), alcohol use (F (1, 56) = 0.31, p = 0.57), cannabis use (F (1, 56) = 0.03, p = 0.85), ecstasy use (F (1, 56) = 0.01, p = 0.89), IQ scores (F (1, 56) = 0.06, p = 0.79), HADS anxiety scores (F (1, 56) = 0.35, p = 0.55), HADS depression scores (F (1, 56) = 1.87, p = 0.17), nor retrospective long-term memory scores from the PRMQ (F (1, 56) = 3.42, p = 0.07). However, age (F (1, 56) = 6.38, p < .05) and retrospective short-term memory scores taken from the PRMQ (F (1, 56) = 12.5, p < 01) did impact upon PRMQ–PMLT. After controlling for these covariates the ANCOVA revealed no significant difference between smokers, previous smokers and the never-

smoked group in terms of their PRMQ–PMLT data (F (2, 56) = 0.06, p = 0.93).

A univariate ANCOVA applied to the short-term PM data (PRMQ–PMST) revealed that there was no relationship between PRMQ–PMST and gender (F (1, 56) = 2.50, p = 0.11), age (F (1, 56) = 1.79, p = 0.18), alcohol use (F (1, 56) = 0.63, p = 0.43), cannabis use (F (1, 56) = 0.07, p = 0.78), ecstasy use (F (1, 56) = 0.08, p = 0.76), IQ scores (F (1, 56) = 1.65, p = 0.24), HADS anxiety scores (F (1, 56) = 0.08, p = 0.77), HADS depression scores (F (1, 56) = 1.93, p = 0.17), nor retrospective long-term memory scores from the PRMQ (F (1, 56) = 0.00, p = 0.98). However, retrospective short-term memory scores from the PRMQ did impact upon PRMQ-PMST (F (1, 56) = 38.4, p < 001). After controlling for these covariates the ANCOVA revealed no significant difference between smokers, previous smokers and the never-smoked group in terms of their PRMQ–PMST data (F (2, 56) = 1.06, p = 0.35).

A univariate ANCOVA applied to the Real-World PM Task (RWPMT) revealed that there was no relationship between RWPMT and gender (F (1, 56) = 3.32, p = 0.07), age (F (1, 56) = 0.14, p = 0.71), alcohol use (F (1, 56) = 1.02, p = 0.31), cannabis use (F (1, 56) = 0.85, p = 0.36), ecstasy use (F (1, 56) = 1.00, p = 0.32), IQ scores (F (1, 56) = 0.92, p = 0.34), HADS anxiety scores (F (1, 56) = 0.41, p = 0.52), HADS depression scores (F (1, 56) = 0.07, p = 0.79), retrospective long-term memory scores from the PRMQ (F (1, 56) = 1.51, p = 0.22), nor short-term memory scores from the PRMQ (F (1, 56) = 0.001, p = 0.98). After controlling for variations in these covariates the ANCOVA revealed a significant difference between smokers, previous smokers and the never-smoked group in terms of their RWPMT data (F (2, 56) = 19.0, p < 0.001). Pairwise Bonferroni comparisons revealed that the never-smoked group (mean = 12.1) performed significantly better than smokers (mean = 8.88) (p < .001) and that the previous smokers (mean = 11.0) performed significantly better than smokers (p < .001), with no significant difference between the never-smoked group and previous smokers (p = .12).

3.3. Correlational analysis

A set of Pearson correlations were applied to the data from the *current smokers* to explore any relationship between the number of cigarettes smoked per week and length of smoking in years with scores on the self-reported prospective memory scores for PRMQ–RMLT, PRMQ–RMST, PRMQ–PMLT and PRMQ–PMST, as well as scores on the RWPMT. These revealed no significant relationship between the number of cigarettes smoked per week and PRMQ–RMLT (r(27) = −.05, p = 0.79), PRMQ–RMST (r(27) = −.01, p = 0.94), PRMQ–PMLT (r(27) = .21, p = 0.27), PRMQ–PMST (r(27) = .11, p = 0.56), nor for RWPMT (r(27) = .02, p = 0.91). There was also no significant relationship between the number of years spent smoking cigarettes and PRMQ–RMLT (r(27) = −.26, p = 0.17), PRMQ–RMST (r(27) = .13, p = 0.50), PRMQ–PMLT (r(27) = .22, p = 0.26), PRMQ–PMST (r(27) = .21, p = 0.29), nor for RWPMT (r(27) = .09, p = 0.65). A set of Pearson correlations were also applied to the data from the *previous smokers* to explore whether there was any relationship between the number of cigarettes they had smoked previously per week and length of previous smoking in years with scores on the same measures. This revealed no significant relationship between cigarettes smoked per week and PRMQ–RMLT (r(18) = −.22, p = 0.37), PRMQ–RMST (r(18) = .14, p = 0.55), PRMQ–PMLT (r(18) = −.11, p = 0.65), PRMQ–PMST (r(18) = −.10, p = 0.68), nor for RWPMT (r(18) = .26, p = 0.29). There was also no significant relationship between the number of years spent smoking cigarettes previously and PRMQ–RMLT (r(18) = −.09, p = 0.71), PRMQ–RMST (r(18) = −.33, p = 0.17), PRMQ–PMLT (r(18) = .13, p = 0.60), PRMQ–PMST (r(18) = .23, p = 0.35), nor for RWPMT (r(18) = −.12, p = 0.61).

Table 2
Means and standard deviations (in brackets) comparing smokers, the never-smoked group and previous smokers on age, cigarettes smoked per week for current smokers and prior history of this for previous smokers, the duration of smoking across their lifetime for current smokers and prior history of this for previous smokers, alcohol, cannabis, and ecstasy tablets per week, NART (IQ) scores, HADS Anxiety and Depression (Depn.) scores, PRMQ retrospective memory long-term (PRMQ–RMLT) and short-term (PRMQ–RMST) scores, PRMQ prospective memory long-term (PRMQ–PMLT) and short-term (PRMQ–PMST) PM scores and RWPMT scores.

	Smokers (N = 27)	Never-smoked (N = 24)	Previous smokers (N = 18)
Age	22.4 (5.13)	19.0 (2.22)	23.7 (5.99)
Cigarettes (p/week)	60.7 (32.0)	N/A	70.0 (36.6)
Duration of Smoking (across lifetime)	6.24 (4.72)	N/A	5.92 (2.95)
Alcohol (p/week)	31 (25.1)	20.5 (17.5)	18.2 (18.3)
Cannabis (p/week)	1.04 (1.31)	0.04 (0.20)	1.00 (1.81)
Ecstasy (p/week)	0.67 (1.14)	Zero	0.72 (1.56)
NART scores	106 (3.17)	106 (3.12)	106 (2.40)
HADS anxiety	6.80 (3.51)	6.10 (3.43)	6.05 (2.99)
HADS Depn.	2.50 (1.86)	2.10 (1.62)	2.88 (3.46)
PRMQ–RMLT	9.70 (2.59)	9.04 (2.34)	9.72 (3.10)
PRMQ–RMST	10.3 (2.36)	9.25 (2.41)	9.77 (2.46)
PRMQ–PMLT	11.2 (2.67)	9.83 (2.92)	10.8 (2.08)
PRMQ–PMST	12.4 (3.04)	10.9 (2.94)	11.9 (2.53)
RWPMT	8.88 (2.20)	12.1 (0.81)	11.0 (1.32)

4. Discussion

The results revealed a number of things. Firstly, there were no significant differences between smokers, the never-smoked group and previous smokers on either the short-term or long-term PM subscales of the self-report PRMQ measure. Secondly, previous smokers and the never-smoked group recalled significantly more location–action combinations on the RWPMT task than smokers, with no significant difference between the previous smokers and the never-smoked group. These findings were observed after screening out participants who reported using alcohol within the past 48 h or had reported suffering from a psychiatric condition and after statistically controlling for age gender, other drug use, mood, IQ, and retrospective memory scores using the ANCOVA model.

Concerning the data from the self-reported PM, the finding that there were no significant differences between the three groups on the short-term and long-term PM subscales of the PRMQ is consistent with Heffernan et al. (2010) who also failed any smoking-related self-reported deficits using the PRMQ, but is inconsistent with previous research that has used the PMQ (e.g., Heffernan et al., 2005). One reason for this inconsistency could be that smokers may vary in self-awareness of their own memory problems – with some cohorts of smokers being more aware than others. Such an explanation has been applied to other drug-using cohorts previously (e.g., alcohol, cocaine and ecstasy users (Verdejo-Garcia and Perez-Garcia, 2008)) and bolsters the argument for including an objective measure of PM here. There are two outcomes concerning the data from the RWPMT. Firstly, the finding that current smokers recalled significantly fewer location–action combinations on the RWPMT when compared with the never-smoked group is consistent with Heffernan et al. (2010), but more importantly extends this observation to a real-world PM scenario. Secondly, the observation that previous smokers' scored higher on the RWPMT than current smokers is interesting and could be indicative of some improvements in PM function in those who have stopped smoking, but no firm conclusion can be made due to the cross-sectional nature of the design used here. Smoking abstinence should be studied using a longitudinal design following the same cohort of participants moving from a period of current smoking to a period of abstinence before any firm conclusion can be made about smoking cessation and improvements in PM performance. The failure to find any correlations between the numbers of cigarettes smoked per week or years spent smoking and any of the PM measures in the current smokers or previous smokers is inconsistent with previous research that found a relationship between years spent smoking and CAMPROMPT performance in current smokers (Heffernan et al., 2010). Correlational analyses are highly sensitive

to sample size and this might be one possible explanation for the weak correlations between the number of cigarettes smoked per week or years spent smoking and PM problems experienced in the current smokers, in which case a larger sample size of current smokers is needed before reaching any firm conclusions. However, it is equally feasible that the weak correlations stem from the restricted number of cigarettes smoked per week (with an average of 60.7 cigarettes smoked/week) and the relatively limited number years spent smoking (an average of 6.24 years) in what is a young cohort of current smokers. Future studies should therefore consider a wider range of cigarette consumption per week and a greater range of smoking history in years (incorporating a wider age spread of participants) in order to explore potential dose-related/smoking duration related differences between current smokers and the control groups in terms of PM problems.

The finding that smokers' performance on the RWPMT was significantly lower than the never-smoked group is the first to demonstrate that smoking-related reductions in PM extend to a real-world paradigm. Recent thinking in the field of PM research has emphasised the need to utilise real-world PM tasks (McDaniel and Einstein, 2007) and this may be of paramount importance since deficits in real world PM might best reflect the difficulties experienced in the daily lives by those who continue to smoke. Although the findings of the current study and the previous research (Heffernan et al., 2010) suggest smoking-related reductions in PM function, it is at present, unclear as to what putative damage (if any) there might be to those mechanisms that underpin PM. Previous research has shown that chronic smoking behaviour is linked to cerebral degeneration or brain atrophy (Meyer et al., 1999; Nooyens et al., 2008; Sabia et al., 2008). Brain imaging studies have demonstrated links between performance on objective PM tasks and activity in the prefrontal cortex, hippocampus and thalamus of the human brain (Burgess et al., 2001; Kliegel et al., 2008; Simons et al., 2006) and it is feasible that if persistent smoking causes some underlying damage, then it may be located in one or more of these regions. Future research should elucidate these links by using brain-imaging techniques alongside objective PM tasks comparing current smokers with a never-smoked group.

4.1. Limitations and future research

There are a number of limitations and areas for improvement in future research. Self-reported drug use can be problematic due to issues of accuracy/honesty of the participant. Future research should adopt biological drug-screening methods to provide objective measures of drug use, which also offers the opportunity to screen out participants using other drugs. Clearly a cross-sectional

design limits any conclusion with regards the relationship between stopping smoking and putative improvements in PM function. Future research should consider a longitudinal design that maps changes in PM performance from a state of current smoking to a period of abstinence in the same cohort. A further issue with the present study is the relatively small sample size. The present study had a sample size of 69, which may have lacked sufficient power to detect differences characterised by small effect sizes (i.e., differences on the self-report measures). The current study sample was made up of a cohort of relatively young university students (83% were under age 25 years), therefore limiting the generalisation of these findings to wider populations (i.e., different age and social groups). Future research might also wish to utilise a battery of PM tests alongside the RWPMT so that convergent evidence can be sought in relation to smoking-related PM decline. Since CE and PM appear to be linked, future research should test CE function alongside PM in order to establish whether reductions in one set of processes (PM) accompany reductions in the other (CE).

5. Conclusions

The results of this study suggest that persistent smoking reduces performance within a real world PM paradigm and these should be added to a growing list of neuropsychological sequelae associated with persistent smoking. These findings may have implications for public health campaigns. Educating the public, as well as medical and nursing staff responsible for treating those with substance-related disorders, is a move welcomed by Government health watchdogs. For example, the Department of Health has recently commissioned guidelines for best practice in smoking cessation and have highlighted the need for evidence-based practice with regards to helping people stop smoking and maintain abstinence (Chambers, 2009). Although the present study demonstrates a link between persistent smoking and reduced real-world PM function, further work is needed before any firm conclusions can be reached.

References

Allender, S., Balakrishnan, R., Scarborough, P., Webster, P., Rayner, M., 2009. The burden of smoking-related ill health in the UK. Tob. Control 18, 262–267.

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

Brega, A.G., Grigsby, J., Kooken, R., Hamman, R.F., Baxter, J., 2008. The impact of executive cognitive functioning on rates of smoking cessation in the San Luis Valley Health and Aging Study. Age Ageing 37, 521–525.

Burgess, P.W., Quayle, A., Frith, C.D., 2001. Brain regions involved in prospective memory as determined by positron emission tomography. Neuropsychologia 39, 545–555.

Chambers, M., 2009. NHS Stop Smoking Services: Service and Monitoring Guidance for 2010/11. National Health Service Report, Poole, Dorset, UK.

Crawford, J., Smith, G., Maylor, E., Della Sala, S., Logie, R., 2003. The Prospective and Retrospective Memory Questionnaire (PRMQ): normative data and latent structure in a large non-clinical sample. Memory 11, 261–275.

Ellis, J., Kvavilashvili, L., 2000. Prospective memory in 2000: past, present, and future directions. Appl. Cogn. Psychol. 14, S1–S9.

Ernst, M., Heishman, S.J., Spurgeon, L., London, E.S., 2001. Smoking history and nicotine effects on cognitive performance. Neuropsychopharmacology 25, 313–390.

Fried, P.A., Watkinson, B., Gray, R., 2006. Neurocognitive consequences of cigarette smoking in young adults – a comparison with pre-drug performance. Neurotoxicol. Teratol. 28, 517–525.

Glass, J.M., Buu, A., Adams, K.M., Nigg, J.T., Puttler, L.I., Jester, J.M., Zucker, R.A., 2009. Effects of alcoholism severity and smoking on executive neurocognitive function. Addiction 104, 38–48.

Greenstein, J.E., Kassel, J.D., 2009. The effects of smoking and smoking abstinence on verbal and visuospatial working memory capacity. Exp. Clin. Psychopharmacol. 17, 78–90.

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. Rehabil. Psychol. 40, 289–297.

Heffernan, T.M., 2008. The impact of excessive alcohol use on prospective memory: a brief review. Curr. Drug Abuse Rev. 1, 36–41.

Heffernan, T.M., Bartholomew, J., 2006. Does excessive alcohol use in teenagers affect their everyday prospective memory? J. Adolesc. Health 39, 138–140.

Heffernan, T.M., Ling, J., Parrott, A.C., Buchanan, T., Scholey, A.B., Rodgers, J., 2005. Self- rated everyday and prospective memory abilities of cigarette smokers and non-smokers: a web-based study. Drug Alcohol Depend. 78, 235–241.

Heffernan, T., O'Neill, T., Moss, M., 2010. Smoking and everyday prospective memory: a comparison of self-report and objective methodologies. Drug Alcohol Depend. 112, 234–238.

Hill, R.D., Nilsson, L.-G., Nyberg, L., Backman, L., 2003. Cigarette smoking and cognitive performance in healthy Swedish adults. Age Ageing 32, 548–550.

Jacobson, J.L., Krystal, J.H., Mencl, W.E., Westervelt, M., Frost, S.J., Pugh, K.R., 2005. Acute and chronic effects of smoking on adolescent smokers. Biol. Psychiatry 57, 56–66.

Jacobson, L.K., Mencl, W.E., Constable, R.T., Westerveld, M., Pugh, K.R., 2007. Impact of smoking abstinence on working memory neurocircuitry in adolescent daily tobacco smokers. Psychopharmacology 193, 557–566.

Kalmijn, S., van Botel, M.P.J., Verschuren, M.W.M., Jolles, J., Launer, L.J., 2002. Cigarette smoking and alcohol consumption in relation to cognitive performance in middle age. Am. J. Epidemiol. 156, 936–944.

Kliegel, M., Jager, T., Altgassen, M., Shum, D., 2008. Clinical neuropsychology of prospective memory. In: Kliegel, M., McDaniel, M.A., Einstein, G.O. (Eds.), Prospective Memory: Cognitive, Neuroscience, Developmental and Applied Perspectives. Lawrence Erlbaum Associates, New York, pp. 283–302.

McDaniel, M.A., Einstein, G.O., 2007. Prospective Memory: An Overview and Synthesis of an Emerging Field. Sage, London, pp. 219–226.

Meyer, J., Rauch, G.M., Crawford, K., Rauch, R.A., Konno, S., Akiyama, H., Terayama, Y., Haque, A., 1999. Risk factors accelerating cerebral degenerative changes, cognitive decline and dementia. Int. J. Geriatr. Psychiatry 14, 1050–1061.

Nelson, H.E., Willison, J., 1991. National Adult Reading Test (NART) Manual, 2nd ed. NFER-Nelson, Windsor, UK.

Nooyens, A.C.J., van Gelder, B.M., Verschuren, W.M.M., 2008. Smoking and cognitive decline among middle-aged men and women: the Doetinchem Cohort Study. Am. J. Public Health 98, 1–7.

Parrott, A.C., Buchanan, T., Scholey, A.B., Heffernan, T., Ling, J., Rodgers, J., 2002. Ecstasy/MDMA attributed problems reported by novice, moderate and heavy recreational users Human Psychopharmacol. Clin. Exp. 17, 309–312.

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

Rash, C.J., 2007. Effects of smoking and nicotine withdrawal on prospective memory. Unpublished Ph.D. Dissertation. Louisiana State University, USA.

Richards, M., Jarvis, M.J., Thompson, N., Wadsworth, M.E.J., 2003. Cigarette smoking and cognitive decline in midlife: evidence from a prospective birth cohort study. Am. J. Public Health 93, 994–998.

Rodgers, J., Buchanan, T., Scholey, A.B., Heffernan, T.M., Ling, J., Parrott, A.C., 2011. Prospective memory: the influence of ecstasy, cannabis and nicotine use and the W.W.W. Open. Addict. J. 4, 44–45.

Sabia, S., Marmot, M., Dufouil, C., Singh-Manoux, A., 2008. Smoking history and cognitive function in middle age from the Whitehall II Study. Arch. Intern. Med. 168, 1165–1173.

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

Simons, J.S., Scholvinck, M.L., Gilbert, S.J., Frith, C.D., Burgess, P.W., 2006. Differential components of prospective memory? Evidence from fMRI. Neuropsychologia 44, 1388–1397.

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Spilich, G.J., June, L., Renner, J., 1992. Cigarette smoking and cognitive performance. Brit. J. Addict. 87, 1313–1326.

Tait, R.J., Siru, R., 2009. Executive cognitive function and cessation of smoking among older smokers. Aging Health 5, 33–37.

Verdejo-Garcia, A., Perez-Garcia, M., 2008. Substance abusers' self-awareness of the neurobehavioral consequences of addiction. Psychiatry Res. 158, 172–180.

Whalley, L.J., Fox, H.C., Deary, I.J., Starr, J.M., 2005. Childhood IQ, smoking, and cognitive change from age 11 to 64 years. Addict. Behav. 30, 77–88.

Zigmond, A.S., Snaith, R.P., 1983. The hospital anxiety and depression scale. Acta Psychiatr. Scand. 67, 361–370.