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Everyday memory deficits in ecstasy-polydrug users

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Abstract

Recent research suggests that not only does the use of recreational drugs impact on working memory functioning, but more 'everyday' aspects of memory (e.g. remembering to do something in the future) are also affected. Forty-three ecstasy-polydrug users and 51 non-ecstasy users were recruited from a university population. Each participant completed the Cognitive Failures Questionnaire (CFQ) and Everyday Memory Questionnaire (EMQ). Of these, 28 ecstasy-polydrug users and 35 non-ecstasy users completed the Prospective Memory Questionnaire (PMQ). In addition, an objective measure of cognitive failures (the CFQ-for-others) was completed by friends of participants. With the exception of the CFQ-for-others, in each regression equation, cannabis emerged as the only significant predictor of everyday and prospective memory deficits. Significant correlations were found between the different indicators of everyday memory and various measures of illicit drug use. Cannabis featured prominently in this respect. The present study provides further support for cannabis related deficits in aspects of everyday memory functioning. Ecstasy may also be associated with cognitive slips, but not to the same extent as cannabis.

Keywords
ecstasy, MDMA, cannabis, everyday memory, prospective memory, failure

Introduction

With millions of individuals using the recreational drug ecstasy worldwide, the increasing amount of evidence reporting adverse effects of the drug is of major concern. Research suggests that ecstasy (MDMA) has adverse effects on human memory, but while there is substantial evidence of working memory impairments in users of ecstasy (e.g. Morgan, 1999, 2000; Parrot and Lasky, 1998; Wareing *et al.*, 2000, 2004), the investigation of the effects of ecstasy on more everyday aspects of memory is relatively neglected. Crucial aspects of everyday memory include prospective remembering (i.e. remembering to do a certain thing at a certain time in the future) and the occurrence of 'cognitive slips' (e.g. slips of memory, language and attention).

A number of laboratory studies have assessed self-reports of cognitive failures and prospective memory in ecstasy users. Heffernan *et al.* (2001a) assessed Prospective memory in recreational drug users using the prospective memory questionnaire (Hannon *et al.*, 1995). Ecstasy users reported more prospective memory errors on the subscales of short-term habitual prospective memory, long-term episodic prospective memory and internally cued memory than non-users in study one, although there were no group differences in strategies used to aid remembering. This was replicated for short-term habitual and long-term episodic prospective memory in study two of the same paper (Heffernan *et al.*, 2001a), where ecstasy users also performed worse on an executive function task. It was concluded that prospective memory and executive function are linked, although the possible link was not directly investigated. The findings of study one were replicated by Heffernan *et al.* (2001b), where ecstasy users reported more errors in short-term habitual, long-term episodic, and internally cued prospective memory (although the mean occasions of ecstasy use for this study was at least 10 times per month, which is atypically high). There were no group differences in strategies used to remember. In a study on the World Wide Web, Rodgers *et al.* (2001) assessed everyday memory and prospective memory in drug users. It was found that while cannabis use was associated with 'here and now' memory deficits in short-term habitual and internally-cued prospective memory, ecstasy use was associated with long-term memory problems, that were more related to storage and retrieval problems. In a second World Wide Web study, Rodgers *et al.* (2003) found that long-term prospective memory deficits were associated with ecstasy use, while deficits in everyday memory were associated with frequency of cannabis use. Thus it is possible that different recreational drugs affect human memory in distinct ways. Ecstasy users also reported a higher incidence of cognitive slips than non-users (Fox *et al.*, 2001), although this was not replicated by Rodgers (2000), and no differences between ecstasy users,

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cannabis users and non-users were reported on the cognitive failures questionnaire by Heffernan *et al.* (2001a).

Although the World Wide Web is an effective way of collecting large amounts of data, and Rodgers *et al.* (2001, 2003) have managed to attribute specific deficits in everyday memory to specific drugs, it is possible that individuals visiting drug websites may already believe that they have a memory problem, and thus are not representative of the drug-using population as a whole. Therefore one aim of the present study was to assess prospective memory, everyday memory and cognitive failures in recreational ecstasy users in a controlled laboratory setting.

The lack of evidence on self-reported cognitive failures and the inconsistent results with reference to the three subscales of the prospective memory questionnaire could reflect a metacognitive deficit in ecstasy users, whereby they do not realise their cognitive slips. Heffernan *et al.* (2005) attempted to control for this by using a self-report and objective measure (video-based) prospective memory task. Ecstasy users reported significantly more forgetting on the long-term prospective memory scale, and also recalled significantly fewer items on the video-based prospective memory task. However, Cohen (1996) argues that self-report questionnaires are assessed better by gaining an independent measure of everyday performance such as that provided by ratings by a third party. In the present study, this concern is addressed by the Cognitive Failures Questionnaire-for-others (CFQ-others), a questionnaire to be completed by individuals who have a significant relationship with the Cognitive Failure Questionnaire (CFQ) respondent. The CFQ-others provides a means of determining whether the self-reports of CFQ respondents lack objectivity, or whether their beliefs about their own cognitive failures are generally accurate. Broadbent *et al.* (1982) found that there was a good correlation between the judgements of CFQ respondents and CFQ-others respondents. The correlation suggests that individuals who report more cognitive slips do in fact produce more such errors. Thus the possibility of a metacognitive deficit in ecstasy users is investigated in the present study.

The suggested relationship between central executive and prospective memory functioning would be in line with the finding that performance of a concurrent central executive task impaired performance in a laboratory-based prospective memory task in non drug using participants (Marsh and Hicks, 1998). This would suggest that the two tasks may share a modality, or that one may be moderated by the other. As noted above, ecstasy users exhibit deficits on a number of executive tasks, and consequently the deficits in prospective memory noted above could be due to reduced executive resources, rather than a specific prospective memory deficit.

To summarize, the present study aims to assess everyday memory via self-reports of cognitive failures, prospective memory and everyday memory in a laboratory setting. In addition, an objective measure of cognitive failures will be included (the CFQ-others). The differential effects of recreational drugs on aspects of everyday memory will also be investigated. As it has been suggested that there is a link between prospective remembering and executive function, the possible mediating effects of executive function on PM will also be investigated.

Method

Design

Linear regression analysis was used to assess the effects of ecstasy on measures of Prospective and everyday memory. As it is also possible that cannabis and working memory capacity are contributory factors these were also submitted to the analysis with any background variables that showed differences between the groups. Thus each of the seven regression analyses had an everyday/prospective memory measure as the dependent variable, and five independent variables (having ever used ecstasy, having ever used cannabis, working memory capacity, gender and alcohol consumption). Non-parametric (Spearman's) correlations were used to assess the relationship between drug use variables and dependent variables.

Participants

Forty-three ecstasy-polydrug users (mean age 21.56; 24 male) and 51 non-ecstasy users (mean age 21.51; 17 male) completed the CFQ and EMQ. As the PMQ only became available to use after the start of data collection, only 28 ecstasy-polydrug users and 35 non-users completed the PMQ. Data collected on the CFQ-others relied on the partners/families of participants returning the questionnaire; the partners/families of 26 ecstasy-polydrug users and 31 non-users returned the questionnaires. Of the 43 ecstasy users, 26 were smokers and 11 non-smokers, while of the 51 non-users, 17 were smokers and 40 non-smokers. The mean number of cigarettes smoked per day was not significantly different between the groups ($n = 10.77$ for users and 11.41 for non-users, $p > 0.05$). Participants were recruited via direct approach to university students and the snowball technique (Solowij *et al.*, 1992). Participants were requested to refrain from ecstasy use for at least 7 days and ideally 10 days prior to testing (mean abstinence period 8.82 weeks, median abstinence period 2 weeks). Participants were also requested not to use any other illicit drugs for at least 24 h and ideally for 7 days prior to testing.

Materials

Patterns of drug use and other relevant lifestyle variables were investigated via means of a background questionnaire. The questionnaire gauged the use of ecstasy and other drugs, as well as age, years of education, general health and other relevant lifestyle variables. In relation to other drugs, participants were asked a range of questions including frequency and duration of use, and the last time that they had used each drug. Participants were also questioned concerning their history of drug use, and using a technique employed by Montgomery *et al.* (2005), these data were used to estimate total lifetime use for each drug. Average weekly dose and the amount of each drug consumed within the previous 30 days were also assessed. Fluid intelligence was measured via Raven's Progressive Matrices (Raven *et al.*, 1998), and premorbid intelligence was assessed via the National Adult Reading Test (NART) (Nelson, 1982).

Sleep quality

A screening questionnaire and the Epworth Sleepiness Scale (ESS) (Johns, 1991) were used to investigate any group differences in sleep quality. The ESS is a measure of subjective daytime sleepiness and contains eight items, which a participant has to score on a scale of 0 (would never doze off in this situation) to 3 (high chance of dozing off in this situation). A total score of all eight items was used in the analysis, and a high score was indicative of increased subjective daytime sleepiness. The screening questionnaire contained a number of questions on sleep quality, e.g. hours per night.

Cognitive failures

The Cognitive Failures Questionnaire and the Cognitive Failures Questionnaire-for-others (Broadbent *et al.*, 1982) were administered. The 25-item CFQ is argued to measure the relationship between attentional performance and general cognitive functioning. The questions relate to different aspects of cognitive functioning and failure, such as perceptual failures (e.g. do you fail to notice signposts on the road?), misdirected actions (e.g. do you bump into people?) and memory failures (e.g. do you forget what you came to the shops to buy?) within the last 6 months. The term 'cognitive failure' is an umbrella term to cover all three types of slip. Each questionnaire item required a number (0–4 inclusive) to be circled. Four corresponded to 'very often' and 0 to 'never' (25 items in total). The direction of scoring for the CFQ was unidirectional, since pilot studies by Broadbent *et al.* (1982) found that reversed wording on some items only confused the participants and there were no differences in a small sample using reversed wording. In the case of the CFQ-for-others half of the items began with 'very often' and half with 'never' (eight items in total). In the original study, Broadbent *et al.* used family or partners of the participant, but due to the nature of student populations, 'housemate' has been added to the list of significant others in the present study. Total scores and percentage of slips reported were calculated to enable comparison between the two measures.

Everyday memory

The Everyday Memory Questionnaire (EMQ) (Sunderland *et al.*, 1983) is a valid and reliable self-report measure of memory lapses in everyday activities. It consists of 27 statements, and in each case, participants respond on a nine-point scale ranging from 'not at all in the last 6 months' to 'more than once a day'. Statements include: 'forgetting where you put something'; 'finding a television story difficult to follow'; a total score for everyday memory is calculated by summing the responses to all items.

Prospective memory

This was assessed using the Prospective Memory Questionnaire (PMQ), which is a reliable and valid self-report measure (Hannon *et al.*, 1995). The PMQ provides measures of three aspects of PM on a scale of 1–9 for each scale. Fourteen questions measure 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 PM, e.g. 'I forgot what I wanted to say in the middle of a sentence'. In addition, 14 questions make up the 'techniques to remember' scale, which provides a measure of the number of strategies used to aid remembering. Responses on the three PM scales range from 1 (little forgetting) to 9 (great deal of forgetting), and for the strategies scale from 1 (few strategies) to 9 (many strategies). For each of the four scales, a total score is calculated by summing the responses in each section, and dividing by the number of items in that section (14 for ST-habitual, LT-episodic and strategies, 10 for internally cued). Thus scores on all four scales ranged from 1–9 with high scores being indicative of much forgetting, and many strategies used to aid remembering.

Computation span

Computation span has been used extensively as an indicator of working memory functioning in the cognitive ageing literature (Fisk and Warr, 1996; Salthouse and Babcock, 1991) and it is similar to the operation span measure used by Miyake *et al.* (2000) in their investigation of executive processes. Participants were required to solve a number of arithmetic problems (e.g. $4 + 7 = ?$) by circling one of three multiple-choice answers as each problem was presented. They were also required to simultaneously remember the second digit of each presented problem. At the end of each set of problems the second digits had to be recalled in the order in which they were presented. The number of arithmetic problems that the participant had to solve, while at the same time remembering each second digit, gradually increased as the test proceeded. For each of the first three trials only a single problem was presented. For the next three trials, two problems were presented. Subsequently, the number of problems presented per trial increased by one every third trial. In order to proceed, the participant was required to be correct in at least two of the three trials at the current level. Computation span was defined as the maximum number of end digits recalled in serial order, with the added requirement that the corresponding arithmetic problems had been solved correctly.

Random letter generation (Baddeley, 1996)

A computer display and concurrent auditory signal was used to pace responses. Participants were asked to speak aloud a letter every time the signal was presented. They were told to avoid repeating the same sequence of letters, to avoid producing alphabetical sequences, and to try to speak each letter with the same overall frequency. Individuals attempted to produce three sets of 100 letters; one set at a rate of one letter every 4 sec, a second set at one letter every 2 sec, and a third at one letter every 1 sec. The order in which the sets were generated was randomized. The experimenter recorded the responses on an answer sheet. The test yields four scores. First, the number of alphabetically ordered pairs; second, a repeat sequences score corresponding to the number of times that the same letter pair is repeated; third, a 'redundancy' score, which measures the extent to which all 26 letters of the alphabet are produced equally often (0% being truly random); and fourth, the number of letters produced. In the first three cases, higher scores indicate poor performance; in the fourth the opposite is the case. The scores for each separate variable, at each of the three generation rates, were standardized. A single score for each random generation measure was produced by averaging the standardised scores for the three production rates. These in turn were averaged to produce an overall composite score.

Procedure

Participants were informed of the general purpose of the experiment, and written informed consent was obtained. The tasks were administered under laboratory conditions, and a computer running MS-DOS was used for the computer based tasks. The tests were administered in the following order: background questionnaire, sleep quality questionnaires, NART, CFQ, EMQ, PMQ, random letter generation, computation span, and Raven's progressive matrices. Participants were given the CFQ-for-others and asked to get someone that had a day-to-day experience with them to fill it in. The CFQ respondents were requested not to discuss the responses that they had made prior to completion of the CFQ-for-others. The CFQ-for-others was returned via post in a pre-paid envelope. Participants were fully debriefed, paid £15 in store vouchers, and given drugs education leaflets. The study was approved by the Ethics Committee of Liverpool John Moores University, and was administered in accordance with the ethical guidelines of the British Psychological Society.

Results

Background measures

The scores for background measures are set out in Table 1. A series of t-tests revealed that there were no significant differences between the groups in age, self-rated health, random letter generation, fluid intelligence, premorbid intelligence, years of education, subjective daytime sleepiness, or average hours of sleep per night. Ecstasy-polydrug users did however report consuming significantly more units of alcohol per week, $t(76.99) = 3.60$, $p < 0.001$ (as Levene's test was significant, degrees of freedom have been adjusted accordingly). Ecstasy-polydrug users also attained a lower level on the computation span task, indicating reduced working memory capacity, $t(92) = -3.45$, $p < 0.001$.

Everyday memory performance

The scores for everyday memory measures are set out in Table 2. Inspection of the table reveals that ecstasy-polydrug users scored higher than non-users on the CFQ and EMQ, indicating a higher incidence of self-reported everyday memory and cognitive failure slips. With regard to the CFQ-for-others, the relatives/significant others reported more cognitive slips among ecstasy-polydrug users than non-users (means of 14.65 and 10.71 respectively). Table 2 also reveals that ecstasy-polydrug users scored slightly higher than non-users on the four subscales of the PMQ.

To assess whether users' own perceptions of cognitive failures were similar in magnitude to the equivalent judgements produced by others, the CFQ and CFQ-for-others responses were compared for users and non-users. The percentage of slips reported for each scale was calculated and analysed using a mixed design, with one within participants factor for 'cognitive failures', (with two levels, self-report versus others), and ecstasy-polydrug user group between participants. Mean percentages of self-reported slips and other-reported slips were similar for each group (indicating that ecstasy users were self-aware of their cognitive failures). This was supported by a main effect of ecstasy use, $F(1,55) = 9.20$, $p < 0.01$. The interaction between cognitive failures and having used ecstasy was however non-significant indicating that ecstasy users were aware of their cognitive slips $F(1,55) = 1.36$, $p > 0.05$.

Use of other drugs

Inspection of Table 3 reveals that while the use of other drugs among the ecstasy-polydrug users was commonplace, among the non-users it was limited mainly to the use of cannabis. The ecstasy-polydrug users

Table 1 Mean age, intelligence scores and other background variables

	Ecstasy users		Non-users	
	Mean	SD	Mean	SD
Age	21.56	1.68	21.51	1.79
Units of alcohol/week	23.62	15.69	13.11	11.71
Self-rated health	3.60	0.76	3.84	0.92
Sleep (hours/night)	8.02	1.47	7.99	1.32
Epworth sleepiness scale total	6.26	3.25	5.57	2.59
Years of education from age 5	15.95	1.57	15.94	1.76
Raven's progressive matrices total	48.84	5.93	48.22	5.30
NART total	28.95	6.91	30.27	5.74
Computation span	3.60	1.61	4.71	1.49
Random letter generation	0.04	0.39	−0.03	0.45

Table 2 Mean scores on everyday memory measures

	Ecstasy users		Non-users	
	Mean	SD	Mean	SD
Everyday memory questionnaire	97.24	35.34	77.28	28.07
Cognitive failures questionnaire	46.95	15.28	39.68	12.93
Cognitive failures-others	14.65	6.44	10.71	3.63
PM-long-term episodic	3.06	1.52	2.52	0.76
PM-short-term habitual	1.26	0.32	1.19	0.32
PM-internally cued	2.92	1.25	2.30	0.76
PM-strategies	3.29	1.65	2.84	1.41
CFQ-percentage of slips reported	45.42	16.66	38.58	10.29
CFQ-others: percentage of slips reported	45.79	20.14	33.47	11.36

Table 3 Indicators of drug use among ecstasy users and non-ecstasy users

	Ecstasy users			Non-users		
	Mean	SD	*n*	Mean	SD	*n*
Total use						
Ecstasy (tablets)	346.50	379.32	43	—	—	—
Amphetamine (grams)	77.29	172.74	12	4	—	1
Cannabis (joints)	4087.89	5484.74	31	1277.76	1453.19	18
Cocaine (grams)	37.83	61.96	20	—	—	—
Amount used during previous 30 days						
Ecstasy (tablets)	4.67	6.45	42	—	—	—
Amphetamine (grams)	1.20	2.68	5	—	—	—
Cannabis (joints)	48.25	77.02	30	8.26	10.65	17
Cocaine (grams)	2.54	2.38	18	—	—	—
Number ever used						
Amphetamine	21	—	—	2	—	—
Cannabis	40	—	—	26	—	—
Cocaine	34	—	—	5	—	—

had a lifetime dose of cannabis more than three times that of the non-users (4088 joints to 1228 joints), in addition to having smoked more in the last 30 days (48.25 joints compared to 8.26 joints). A *t*-test revealed that all of the group differences were statistically significant, $t(36.75) = 2.74$, $p < 0.01$ for total lifetime dose; $t(30.93) = 2.80$, $p < 0.01$ for amount used in the last 30 days (As Levene's test was significant, degrees of freedom have been adjusted accordingly).

Correlations of everyday memory measures with indices of drug use

Due to the small number of illicit drug users among the non-ecstasy-polydrug user group it was not possible to control statistically for the effects of drugs through the use of analysis of covariance. Therefore it is possible that some or all of the apparent ecstasy-related effects might have been attributable to the effects of other drugs. To address this possibility, correlations were performed with different measures of ecstasy, amphetamine, cannabis and cocaine use. Measures of lifetime use of each drug and the amount of each drug consumed within the last 30 days were included[1]. For each of these a value of zero was entered for non-users of the drug in question. In addition, for each illicit drug, a categorical variable in which users and non-users of each drug were coded as 0 or 1 respectively was included.

[1]Those in the non-user group who reported that they had ever used amphetamine or cocaine ($n = 2$ and 5, respectively) felt that they were unable to estimate their pattern of use accurately.

A full Bonferroni correction is not appropriate in this case, as the performance measures are intercorrelated (Sankoh *et al.*, 1997). However multiple comparisons remain potentially problematic, therefore an intermediate level of correction has been used, with correlations being evaluated at $p < 0.01$. The results, set out in Table 4, show that ecstasy use was significantly correlated with a number of the performance measures. Having ever used ecstasy was significantly correlated with EMQ, CFQ and CFQ-for-others scores, while total lifetime dose of ecstasy was significantly correlated with CFQ-for-others scores.

In relation to other drugs, cannabis appears to be an especially important predictor of everyday memory deficits. Indeed, being a cannabis user and total lifetime dose of cannabis were significantly correlated with *all* measures of everyday memory (at $p < 0.01$). Amount used in the last 30 days was significantly correlated with PM-internally cued. Aside from cannabis, ever having used cocaine was significantly correlated with CFQ-for others and PM-internally cued scores. Indices of amphetamine use were also significantly correlated with memory scores; Ever having used amphetamine with CFQ, CFQ-for-others and PM-internally cued and total lifetime dose with CFQ and CFQ-for-others scores.

In order to better identify the factors associated with everyday memory deficits among ecstasy-polydrug users, a series of regression analyses were performed with the measures of everyday memory functioning as dependent variables. As both ecstasy and cannabis use have been implicated in deficits in prospective and everyday memory in previous research, having ever used ecstasy and having ever used cannabis were both included as independent variables in each of the analyses. In addition, computation span was also included to assess any possible mediating effects that working memory may have on everyday memory functioning. As there was a significant difference between ecstasy users and non-users on some of the background variables (namely gender and alcohol consumption) these were also included in the regression analyses. In summary, seven regression analyses were performed with five independent variables in each case.

For the everyday memory questionnaire, the regression model was significant, $R^2 = 0.140$, $F(5,84) = 2.73$, $p < 0.05$. Both having ever used ecstasy and having ever used cannabis approached significance: $t = -1,\ 74$, $p = 0.085$ for ecstasy use and $t = -1.89$, $p = 0.062$ for cannabis. All other independent variables in the model were non-significant.

For the LT episodic scale of the PMQ, the regression model was non-significant, $R^2 = 0.144$, $F(5,56) = 1.89$, $p > 0.05$. However, having ever used cannabis was a significant predictor of PMQ-LT performance, $t = -2.08$, $p < 0.05$. All other independent variables in the equation were non-significant.

For the ST habitual scale of the PMQ, the regression model was non-significant, $R^2 = 0.152$, $F(5,56) = 2.01$, $p > 0.05$. Once again,

Table 4 Correlations with indices of drug use

	Ecstasy	Cannabis	Cocaine	Amphetamine
Ever used				
EMQ	−0.283*	−0.328*	−0.165	−0.159
CFQ	−0.272*	−0.380*	−0.170	−0.225*
CFQ-others	−0.333*	−0.329*	−0.441*	−0.515*
PM-LT episodic	−0.159	−0.368*	−0.142	−0.158
PM-ST habitual	−0.111	−0.394*	−0.190	−0.186
PM-internally cued	−0.276	−0.465*	−0.307*	−0.323*
PM-strategies	−0.130	−0.479*	−0.013	−0.076
Total lifetime use				
EMQ	0.242	0.305*	0.202	0.214
CFQ	0.215	0.361*	0.158	0.267*
CFQ-others	0.312*	0.440*	0.329	0.389*
PM-LT episodic	0.116	0.416*	0.122	0.201
PM-ST habitual	0.065	0.366*	0.304	0.097
PM-internally cued	0.224	0.515*	0.258	0.330
PM-strategies	0.053	0.452*	−0.017	0.072
Use in last 30 days				
EMQ	0.139	0.197	0.061	0.120
CFQ	0.034	0.165	0.015	0.064
CFQ-others	0.105	0.301	0.044	—
PM-LT episodic	0.045	0.213	−0.051	0.161
PM-ST habitual	0.004	0.068	0.034	−0.116
PM-internally cued	0.153	0.380*	0.095	0.077
PM-strategies	−0.008	0.208	−0.169	−0.154

*Correlation significant at $p < 0.01$, one-tailed.

having ever used cannabis was a significant predictor of ST habitual prospective memory, $t = -2.60$, $p < 0.05$. All other independent variables in this analysis were non-significant.

For the internally cued subscale of the PMQ, the regression model was significant, $R^2 = 0.209$, $F(5,56) = 2.95$, $p < 0.05$. Again, cannabis use was the only significant predictor of internally cued PM, $t = -2.70$, $p < 0.01$, and all other independent variables were non-significant.

For the techniques scale of the PMQ, the regression model was significant, $R^2 = 0.316$, $F(5,56) = 5.17$, $p < 0.01$. This was due to having ever used cannabis and units of alcohol consumed in a week being significant predictors, $t = -3.40$, $p < 0.001$ for cannabis and $t = -3.10$, $p < 0.01$ for alcohol.

For the CFQ, the regression model was significant, $R^2 = 0.194$, $F(5,85) = 4.08$, $p < 0.01$. Again this was due to having ever used cannabis being a significant predictor, $t = -2.70$, $p < 0.01$. The regression model for the CFQ-for-others was also significant, $R^2 = 0.221$, $F(5,49) = 2.78$, $p < 0.05$. Having ever used ecstasy approached significance, $t = -1.76$, $p = 0.085$, although all other independent variables were non-significant.

To summarize, having ever used cannabis seems to be the most important predictor of everyday and prospective memory deficits in ecstasy users.

Discussion

Ecstasy-polydrug users scored higher than non-users on a number of everyday memory measures, and lower on a working memory measure: the CFQ, EMQ, two subscales of the PMQ (long-term episodic and internally cued PM), and computation span. Ecstasy-polydrug users were also rated higher by friends on the CFQ-for-others. The interaction between CFQ and CFQ-for-others scores and ecstasy-polydrug use was non-significant, indicating that ecstasy users do realise their cognitive slips. However, in the regression analyses, cannabis use emerged as the most important predictor of prospective and everyday memory deficits in ecstasy users. This was also reflected by the magnitude of the correlations between cannabis use variables and everyday memory measures.

The findings of the present study provide tentative support for previous research. First, we found that ecstasy-polydrug users rated themselves higher on the CFQ, indicating increased incidence of cognitive slips. Our results are consistent with those of Fox *et al.* (2001) who reported a higher incidence of cognitive slips in ecstasy users than in non-users. However, Rodgers (2000) and Heffernan *et al.* (2001a) did not find any ecstasy-related differences on this version of the questionnaire. This may be due to differences in lifetime drug consumption. While both studies report that the ecstasy user group had used ecstasy 20 times over a 5-year period, Heffernan *et al.* (2001a) also report that the average dose was one tablet per session. As the average dose in the present study was 346.5 tablets, this raises the possibility that the types of slip assessed by the cognitive failures questionnaire are relatively preserved until a certain threshold of ecstasy use is reached. However, it is noteworthy that in previous research (e.g. Rodgers *et al.*, 2001) there was a clear dissociation between cannabis-related and ecstasy-related everyday memory deficits. In the present study deficits appear to be more attributable to cannabis use than ecstasy use.

Ecstasy users were also rated higher by friends on the CFQ-for-others. The percentages of reported slips for the CFQ and CFQ-for-others were relatively similar (45.42 and 45.79 for ecstasy users; 38.58 and 33.47 for non-users). The interaction between ecstasy use and self- and other-reported slips was non-significant. It has been suggested that the absence of a deficit on this task in previous research may reflect a metacognitive deficit in ecstasy users, which renders them unable to monitor their cognitive state accurately. However, the results of the present study suggest that this group of ecstasy-polydrug users do realise their cognitive slips, which provides further support for Heffernan *et al.* (2005) who found self-reported PM and objective PM slips in ecstasy users were similar.

Although ecstasy-polydrug users scored significantly higher on the EMQ indicating increased incidences of slips in everyday memory, cannabis use again emerged as a more important predictor than ecstasy use. Similarly, Rodgers *et al.* (2003) found that frequency of cannabis use was the most important predictor of everyday memory scores.

Working memory capacity did not emerge as a significant predictor of memory deficits in the regression equation. Heffernan *et al.* (2001a) suggested a link between executive functioning and prospective memory deficits in ecstasy users (as ecstasy users performed worse on both a word fluency task and PM task in their study), although they did not directly investigate such an interaction. The present study highlights the limited importance of working memory capacity as a mediator of differences in everyday memory in drug users. This may be compared with the situation among older adults, who perform worse on PM tasks partly due to decreased working memory capacity (e.g. Martin and Schuman-Hengsteler, 2001). In view of the differences noted there is little to suggest that the mechanisms underlying drug related deficits in everyday memory are the same as those underlying age-related deficits.

The focus of the present study was intended to be ecstasy use. However, a number of other illicit drugs consumed by the participants tested here appear to have produced effects on the measures that were administered. Cannabis use seems to be a particularly important predictor of everyday memory deficits. Indeed, cannabis was a significant predictor in all regression analyses (with the exception of the CFQ for others), and having ever used cannabis and total lifetime dose were significantly correlated with all everyday memory measures. Given that 40 (maximum 43) of the ecstasy users and 26 (maximum 51) of the non-users had ever tried cannabis, with 30 and 18 respectively being able to estimate lifetime consumption, it is entirely possible that the ecstasy-related group differences in ratings of everyday memory reflect some aspect of ecstasy-cannabis use, or cannabis only use (e.g. Schwartz *et al.*, 1989). In fact, this is rather more likely given the relative magnitudes of the correlations. Studies which have attempted to adequately control for cannabis use via ANCOVA and regression analysis have found a dissociation between the two drugs in terms of their impact on aspects of everyday memory functioning: Rodgers *et al.* (2003) found that while cannabis use predicts self-reports of failures in everyday memory, long-term prospective memory deficits were related to ecstasy use. Rodgers *et al.* (2001) also found that cannabis use was related to self-reports of 'here and now' (ST and internally cued PM) memory deficits, while ecstasy use was associated with long-term PM deficits. Heffernan *et al.* (2001a, 2001b) also found that ecstasy-related deficits in PM remained significant after control for alcohol, cannabis and cocaine, and a cannabis only group did not report more cognitive failures compared to ecstasy users and controls (Heffernan *et al.*, 2001a). The lifetime cannabis use of both the ecstasy-polydrug group, and the group who had ever used cannabis were both higher than for previous studies. It is therefore possible that the apparent cannabis effect on all measures (rather than just the short-term memory deficits as in previous studies) reflects the higher levels of consumption. To summarize, we concede that the ecstasy-polydrug related deficits in the present study actually reflect some aspect of cannabis use, as suggested by Croft *et al.* (2001), although previous research suggests that some everyday memory deficits are related to ecstasy use. Some indices of cocaine (two significant) and amphetamine (six significant) were also correlated with everyday memory measures. However, the participants that these analyses were based were all ecstasy-polydrug users, so this should be treated with some caution.

As with most studies in this area, there are a number of limitations. Due to the quasi-experimental design of the study, it is possible that the groups in each study may have differed on some variable other than ecstasy use. Some possibilities have been excluded such as intelligence (NART and Raven's) and aspects of sleep quality.

Clearly there were differences in the use of other illicit drugs. Group differences in other variables such as general health, nutrition, or some premorbid condition predating drug use (Verheul, 2001) cannot be ruled out. We obviously cannot guarantee the purity of the tablets consumed by the ecstasy users in the present study (Cole *et al.*, 2002); though in a recent review of the literature, Parrot (2004) reports that analysis of the contents of ecstasy tablets from amnesty bins in nightclubs revealed that purity of tablets is approaching 100% MDMA. All participants reported being ecstasy free for at least 7 days (mean abstinence period was 8.82 weeks, median abstinence period 2 weeks), and we have no reason to believe this information to be false (participants were not informed that they would be excluded prior to testing). The present study also relied on self-reports of memory slips. A more objective measure of cognitive failures (the CFQ-for-others) suggests that the self-reports in the present study are accurate; this is likely to be the case for prospective memory deficits also (Heffernan *et al.*, 2005).

To conclude, the present study sought to determine what the impact of ecstasy-polydrug use would be on aspects of everyday memory functioning. Ecstasy-polydrug related deficits were observed on a prospective memory questionnaire, and a number of everyday cognitive slip questionnaires. Objective measures of cognitive failures suggest that ecstasy-polydrug users do realise their memory lapses. Cannabis use did however emerge as a more important predictor of everyday memory lapses than ecstasy use. Everyday memory lapses in drug users were not mediated by reduced working memory capacity as in the cognitive ageing literature.

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