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Everyday Memory deficits in Ecstasy-Polydrug Users

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Abstract

Rationale/Objectives: Recent research suggests that not only does the use of recreational drugs impact working memory functioning, but more "everyday" aspects of memory (e.g. remembering to do something in the future) are also affected. *Methods:* 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. *Results:* There was a main effect of ecstasy-polydrug use on CFQ, EMQ, CFQ-for-others, Long-Term (LT) PM and internally cued PM scores. These were slightly attenuated following control for working memory capacity. Correlations were found between the different indicators of everyday memory and various measures of illicit drug use. Cannabis featured prominently in this respect. In addition, all ecstasy-related deficits were reduced to below statistical significance following control for cannabis use. *Conclusions:* 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, cognitive 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 nonusers (Fox et al, 2001), although this was not replicated by Rodgers (2000), and no differences between ecstasy users, cannabis users and nonusers 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 are subjective, 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 & Hicks, 1998). 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 summarise, 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: A multivariate design was used for the Everyday Memory Questionnaire (EMQ) and CFQ, with scores as the dependent variables. A univariate design was used for the CFQ-for-others and for the PM-strategies. A multivariate design was used for the PMQ, with the three subscales as the dependent measures (long-term episodic, short-term habitual, internally cued). In all analyses, ecstasy user/nonuser was the between participants variable. ANCOVA was used to assess the possible mediating effects of executive function (computation span, random letter generation), gender, strategies used to aid remembering and cannabis on everyday memory. 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 nonusers (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 nonusers 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 nonusers returned the questionnaires. 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 hours 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" (8 items in total). In the original study, Broadbent et al. use 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 9-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 4 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 4 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 & Warr, 1996; Salthouse & 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 s, a second set at one letter every 2 s, and a third at one letter every 1 s. The order in which the sets were generated was randomised. 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 standardised. A single score for each random generation measure was produced by averaging the standardised scores for the three production rates.

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

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, pre-morbid 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, $t(76.99) = 3.60$, $p<.001$ (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, $t(92) = -3.45$, $p<.001$.

<Insert Table 1 Here>

The scores for everyday memory measures are set out in Table 2.

CFQ and EMQ: Table 2 shows that ecstasy-polydrug users scored higher than nonusers on the CFQ and EMQ, indicating a higher incidence of self-reported everyday memory and cognitive failure slips. There was a main effect of ecstasy-polydrug use on these measures, $F(2,88) = 4.61$, $p<.05$ for Pillai's Trace. Separate univariate analyses revealed that ecstasy-polydrug users scored significantly higher on both the EMQ and CFQ, $F(1,89) = 9.02$; 6.05, $p<.01$ and $p<.05$ respectively.

CFQ-for-others: The relatives/significant others reported more cognitive slips among ecstasy-polydrug users than nonusers (means of 14.65 and 10.71 respectively). Univariate ANOVA revealed that this difference was significant, $F(1,55) = 8.44$, $p<.01$.

PMQ: Table 2 shows that ecstasy-polydrug users scored slightly higher than nonusers on the four subscales of the PMQ. The three memory measures (long-term episodic, short-term habitual and internally cued prospective memory) were incorporated into MANOVA. The main effect of ecstasy-polydrug use was non-significant, $F(3,59) = 2.00$, $p>.05$, as was the univariate ecstasy-related difference in short-term habitual PM, $F(1,61) = 0.61$, $p>.05$. Ecstasy-polydrug related deficits in long-term and internally cued PM were significant, $F(1,61) = 3.32$, $p<.05$ one-tailed, and $F(1,61) = 5.82$, $p<.05$ respectively. Univariate ANOVA revealed that ecstasy users did not use significantly more strategies to remember than nonusers, $F(1,61) = 1.35$, $p>.05$.

Interaction between CFQ and CFQ-for-others: 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 nonusers. 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, $F(1,55) = 9.20$, $p<.01$. The interaction between cognitive failures and having used ecstasy was however non-significant indicating that ecstasy users were aware of their cognitive slips $F(1,55) = 1.36$, $p>.05$.

<Insert Table 2 Here>

Inspection of Table 3 reveals that while the use of other drugs among the ecstasy-polydrug users was commonplace, among the nonusers it was limited mainly to the use of cannabis. The ecstasy-polydrug users had a lifetime dose of cannabis more than three times that of the non-users (4088 joints to 1228 joints), in addition to using it more frequently (2.90 times a week, compared to 0.84 times a week), having smoked more in the last 30 days (48.25 joints compared to 8.26 joints), and having a larger average weekly dose (13.91 joints compared to 5.84 joints). In relation to the cannabis measures, t-test revealed that all of the group difference were statistically significant $t(36.75) = 2.74$, $p<.01$ for total lifetime dose; $t(39.21) = 3.93$, $p<.01$ for frequency of use; $t(30.93) = 2.80$, $p<.01$ for amount used in the last 30 days; and $t(45.89) = 2.14$, $p<.05$ for average dose (As Levene's test was significant, degrees of freedom have been adjusted accordingly).

<Insert Table 3 Here>

Correlations 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 other than cannabis through the use of ANCOVA (see below). Therefore it is possible that some

or all of the 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, the number of times each drug was consumed each week, the amount of each drug consumed within the last 30 days, and the average weekly dose (i.e. total amount consumed divided by the length of use in weeks) were all included[1]. For each of these a value of zero was entered for nonusers of the drug in question. In addition, for each illicit drug, a categorical variable in which users and nonusers of each drug were coded as 0 or 1 respectively was included.

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 calculated using the procedure outlined by Sankoh et al. (1997). 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. Average weekly ecstasy dose was also significantly correlated with EMQ, CFQ and PM-internally cued scores.

In relation to other drugs, cannabis appears to be an especially important predictor of everyday memory deficits. Indeed, being a cannabis user, total lifetime dose of cannabis, and average weekly dose of cannabis were significantly correlated with all measures of everyday memory (at $p<.01$). Frequency of cannabis use was significantly correlated with EMQ, CFQ, CFQ-for-others, PM-internally cued and PM-strategies scores, while amount used in the last 30 days was significantly correlated with PM-internally cued. 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, total lifetime dose with CFQ and CFQ-for-others scores and average dose with CFQ scores.

<Insert Table 4 Here>

So to summarise, cannabis appears to be a more important predictor of everyday memory deficits than ecstasy use, although on one scale (the CFQ-for-others) ecstasy emerged as a more significant predictor.

Covariate Analyses

Units of alcohol consumed in a week and gender composition were significantly different between the groups, thus these were incorporated into ANCOVA to control for the contribution of these factors to memory deficits.

EMQ and CFQ: After controlling for gender, the main effect of ecstasy use remained significant, $F(2,87) = 5.07$, $p<.01$, as did the univariate analyses, $F(1,88) = 9.18; 8.05$, $p<.005$ and $p<.01$ for EMQ and CFQ respectively. Following control for units of alcohol used in a week, the main effect of ecstasy use remained significant, $F(2,85) = 5.00$, $p<.01$. Ecstasy-related differences in EMQ and CFQ scores were intensified after controlling for alcohol use, $F(1,86) = 9.65; 6.95$, $p<.01$ in both cases.

CFQ-for-others: After controlling for gender, the main effect of ecstasy use remained significant, $F(1,54) = 8.23$, $p<.01$, and also after control for units of alcohol consumed in a week, $F(1,52) = 9.02$, $p<.01$.

PMQ: After controlling for gender, the main effect of ecstasy remained non-significant, $F(3,58) = 2.15$, $p>.05$, as did differences in short-term PM ($F<1$). The ecstasy-related differences in long-term PM and Internally cued PM remained

significant after control for gender, $F(1,60) = 3.26$, $p<.05$ one tailed and $F(1,60) = 6.37$, $p<.05$ respectively. After controlling for average units of alcohol consumed in a week, the main effect of ecstasy use remained non-significant, $F(3,37) = 1.12$, $p>.05$, as did differences in short-term PM ($F<1$). Ecstasy-related differences in long-term PM were reduced to below statistical significance after control for alcohol use. Again, although slightly attenuated the ecstasy-related differences in internally cued PM remained significant after control for alcohol use, $F(1,59) = 3.31$, $p<.05$ one-tailed.

As it was also possible that strategies used to remember may have mediated the number of prospective memory slips (more strategies used may decrease the number of slips), this was incorporated into ANCOVA. The main effect of ecstasy use remained non-significant, $F(3,58) = 1.71$, $0>.05$, as did short-term PM ($F<1$). Ecstasy-related differences in long-term PM were reduced to below statistical significance following control for strategies used to remember. After control for strategies used to remember, ecstasy-related differences in internally cued PM remained significant, $F(1,60) = 5.08$, $p<.05$.

Homogeneity of regression was obtained with respect to all covariates in this block, $p>.05$ for the group by covariate interaction.

Everyday Memory and Executive Function

One aim of the study was to assess the possible mediating role of executive resources on deficits in prospective memory. Therefore, computation span and random letter generation were also controlled for.

EMQ and CFQ: After controlling for working memory capacity, the main effect of ecstasy use remained significant, $F(2,83) = 2.99$, $p<.05$ (one-tailed). Although slightly attenuated, the ecstasy-related deficits in EMQ and CFQ scores remained significant, $F(1,84) = 5.91$, $p<.05$ for EMQ; $F(1,84) = 3.74$, $0<.05$ (one-tailed) for CFQ.

Homogeneity of regression was obtained, p>.05 for the group by covariate interaction.

CFQ-for-others: The main effect of ecstasy use also remained significant after control for working memory capacity, $F(1,50) = 6.62$, $p<.05$. Homogeneity of regression was obtained with respect to random letter generation ($p>.05$ for the group by covariate interaction); the group by covariate interaction was however significant for computation span, $F(1,50) = 9.09$, $p<.01$, so this result should be treated with some caution.

Prospective Memory: After controlling for working memory, the main effect of ecstasy remained non-significant, $F(3,54) = 1.34$, $p>.05$, as did differences in short-term PM ($F<1$). The ecstasy-related differences in long-term PM were reduced to below statistical significance after control for working memory capacity. Although slightly attenuated, ecstasy-related differences in internally cued PM remained significant after control for working memory capacity, $F(1,56) = 3.88$, $p<.05$ one-tailed. Homogeneity of regression was obtained with respect to these covariate, $p>.05$ for the group by covariate interaction.

It is therefore apparent that working memory capacity is not an important mediator of everyday memory deficits in ecstasy-polydrug users and cannabis users.

Finally the analyses were re-run with cannabis use variables[1] as covariates.

EMQ and CFQ (28 ecstasy users, 16 nonusers): After controlling for cannabis use, the main effect of ecstasy use was reduced to below statistical significance, $F(2,37) = 0.31$, $p>.05$. Group differences in CFQ and EMQ were also reduced to below statistical significance, $F(1,38) = 0.49$, $p>.05$ for CFQ; $F(1,38) = 0.51$, $p>.05$ for CFQ.

[1] Average dose, amount consumed in the last 30 days, total lifetime dose, frequency of use.

Homogeneity of regression was obtained, $p>.05$ for the group by covariate interaction, with the exception of frequency of cannabis use on the CFQ.

CFQ-for-others: The main effect of ecstasy use was reduced to below statistical significance following control for cannabis use, $F(1,24) = 0.75$, $p>.05$. Homogeneity of regression was obtained with respect to all covariates, $p>.05$ for the group by covariate interaction.

Prospective Memory (19 ecstasy users, 13 nonusers): After controlling for cannabis the main effect of ecstasy remained non-significant, $F(3,24) = 1.96$, $p>.05$. The ecstasy-related differences in long-term PM and internally cued PM were reduced to below statistical significance after control for cannabis use ($F<1$). After control for cannabis use, group differences in ST PM were now statistically significant, $F(1,26) = 6.00$, $p<.05$. Homogeneity of regression was obtained with respect to these covariates, $p>.05$ for the group by covariate interaction. In summary, cannabis use appears to mediate group differences in everyday memory.

DISCUSSION

Ecstasy-polydrug users scored significantly higher than nonusers on a number of everyday memory measures, and significantly 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 significantly 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. After controlling for gender, alcohol use, and working memory capacity, the ecstasy-polydrug related differences in ratings of cognitive failures, everyday memory and cognitive failures-for-others, and

internally cued prospective memory remained significant (although slightly attenuated after control for the last of these). Ecstasy-polydrug related differences in ratings of long-term PM were reduced to below statistical significance following control for working memory and alcohol use, although did remain significant after control for gender. The use of strategies to aid remembering on the PMQ reduced ecstasy-polydrug related differences in LT-PM to below statistical significance, although differences in internally cued PM remained significant. Surprisingly, although there was a main effect of ecstasy use on most of the measures, in terms of the relative magnitudes of the correlations, cannabis use variables emerged as the most significant predictors of everyday memory scores, and ecstasy-polydrug differences were reduced to below statistical significance following control for indices of cannabis use.

The findings of the present study provide some support for support for previous research. Firstly, we found that ecstasy-polydrug users rated themselves higher on the CFQ, indicating increased incidence of cognitive slips. This provides further support for Fox et al. (2001) who reported a higher incidence of cognitive slips in ecstasy users than in nonusers. 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 possible 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 nonusers). 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 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.

Ecstasy-related differences were also observed on two sub-scales of the PMQ: long-term episodic PM and internally cued PM. This provides some support for Heffernan et al. (2001b) in which ecstasy users reported a greater number of prospective memory slips on the internally cued subscale than the long-term subscale, and also Heffernan et al. (2001a) who found evidence for prospective memory deficits in ecstasy users: Short-term, long-term and internally cued PM were all related to ecstasy use. Cannabis use was however a considerably more important predictor than ecstasy use in the present study with all group differences being reduced to below

statistical significance following control for cannabis use variables, with the exception of ST PM. Ecstasy-related group differences in ST PM became significant after control for cannabis use. It is likely that this reflects the decrease in the number of individuals in the analyses (indeed, the sample of nonusers was reduced by over half). In view of the non-significant outcome for all other prospective and everyday memory measures following ANCOVA, this should be treated with caution. On balance it appears that cannabis use is a more important predictor of everyday memory deficits.

Control for working memory capacity slightly attenuated the everyday memory deficits (with the exception of LT-PM, which was reduced to below statistical significance). 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 & 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. There was a main effect of ecstasy use on most of the everyday memory measures, and indices of ecstasy use were associated with EMQ scores (ever used, average dose), CFQ scores (ever used, average dose), and CFQ-for-others scores (ever used, total lifetime dose). However, a number of other illicit drugs consumed by the participants tested here

appear to have produced effects on the measures that were administered. Indices of cannabis use seem to be particularly important predictors of everyday memory deficits. Indeed, having ever used cannabis, total lifetime dose and average weekly dose were significantly correlated with all everyday memory measures. Given that 40 (maximum 43) of the ecstasy users and 26 (maximum 51) of the nonusers 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 (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 summarise, 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 (2 significant) and amphetamine (6 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. An 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 mediated in part by reduced working memory capacity, although perhaps not to the same extent as in the cognitive ageing literature, so future research should also seek to investigate this relationship further.

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Table 1

Mean age, intelligence scores and other background variables

	Ecstasy Users		Nonusers	
	Mean	S.D.	Mean	S.D.
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		Nonusers	
	Mean	S.D.	Mean	S.D.
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 Ecstasy Users		
	Mean	S.D.	n	Mean	S.D.	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	-	-	-
Frequency of Use (times per week)						
Ecstasy	0.45	0.38	41	-	-	-
Amphetamine	0.09	0.11	4	-	-	-
Cannabis	2.90	2.70	31	0.84	0.85	18
Cocaine	0.54	0.48	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	-	-	-
Average Weekly Dose						
Ecstasy (tablets)	2.31	3.04	43	-	-	-
Amphetamine (grams)	0.39	0.54	10	1	0.09	1
Cannabis (joints)	13.91	16.08	30	5.84	10.03	18
Cocaine (grams)	0.34	0.43	20	-	-	-
Number Ever Used						
Amphetamine	21	-	-	2	-	-
Cannabis	40	-	-	26	-	-
Cocaine	34	-	-	5	-	-

Table 4

Correlations With Indices of Drug Use

	Ecstasy	Cannabis	Cocaine	Amphetamine
Ever Used				
EMQ	-.283*	-.328*	-.165	-.159
CFQ	-.272*	-.380*	-.170	-.225*
CFQ-others	-.333*	-.329*	-.441*	-.515*
PM-LT episodic	-.159	-.368*	-.142	-.158
PM-ST habitual	-.111	-.394*	-.190	-.186
PM-internally cued	-.276	-.465*	-.307*	-.323*
PM-strategies	-.130	-.479*	-.013	-.076
Total Lifetime Use				
EMQ	.242	.305*	.202	.214
CFQ	.215	.361*	.158	.267*
CFQ-others	.312*	.440*	.329	.389*
PM-LT episodic	.116	.416*	.122	.201
PM-ST habitual	.065	.366*	.304	.097
PM-internally cued	.224	.515*	.258	.330
PM-strategies	.053	.452*	-.017	.072
Use in Last 30 days				
EMQ	.139	.197	.061	.120
CFQ	.034	.165	.015	.064
CFQ-others	.105	.301	.044	-
PM-LT episodic	.045	.213	-.051	.161
PM-ST habitual	.004	.068	.034	-.116
PM-internally cued	.153	.380*	.095	.077
PM-strategies	-.008	.208	-.169	-.154

* Correlation significant at $p<.01$, one-tailed

[1] Those in the nonuser 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.