Journal of Psychopharmacology 17(4) (2003) 389–396

SAGE Publications, London, Thousand Oaks, CA and New Delhi
0269–8811[200312]17:4; 389–396; 038058

Patterns of drug use and the influence of gender on self-reports of memory ability in ecstasy users: a web-based study

J. Rodgers[1], T. Buchanan[2], A. B. Scholey[3], T. M. Heffernan[3], J. Ling[4] and A. C. Parrott[5]

[1]*Department of Clinical Psychology, University of Newcastle, Newcastle upon Tyne,* [2]*Department of Psychology, University of Westminster, London,* [3]*Human Cognitive Neuroscience Unit, Northumbria University, Newcastle upon Tyne,* [4]*Psychology Section, University of Teesside, Middlesbrough, and* [5]*Department of Psychology, University of East London, UK.*

Research indicates that the use of recreational drugs, including MDMA ('ecstasy') can result in impairments in cognitive functioning. Recent evidence, based on accounts of 'on drug' effects and cortical binding ratios suggests that women may be more susceptible to the effects of MDMA; however, no research has explored whether there are differences in the long-term behavioural sequelae of the drug between men and women. In addition, little is known about the profile of functioning of the 'typical' user. The present investigation accessed a large sample of recreational drug users, using the Internet, to obtain self-reports of memory functioning with a view to exploring any differences in self-reported ability amongst male and female users, and the level of difficulty reported by the 'typical' ecstasy user. A web site (www.drugresearch.org.uk) was developed and used for data collection. Prospective memory ability was assessed using the Prospective Memory Questionnaire. Self-report of day-to-day memory performance was investigated using the Everyday Memory Questionnaire. The UEL Drug Questionnaire assessed the use of other substances. The number of mistakes made while completing the questionnaires was also taken as an objective measure of performance errors. Findings, based on datasets submitted from 763 respondents, indicate no differences in self-reports of functioning between male and female participants. An overall dissociation between the effects of cannabis and ecstasy on self-reported memory functioning and on the likelihood of making an error during the completion of the questionnaire was found. Typical ecstasy users were found to report significantly more difficulties in long-term prospective memory and to make more completion errors than users of other substances and drug naïve controls. Whilst taking into account the fact that participants were recruited via the World Wide Web and that a number of stringent exclusion criteria were applied to the data, a number of conclusions can be drawn. Recreational drug users perceive their memory ability to be impaired compared to non-users. The type of memory difficulties reported varies depending upon the drug of choice. These difficulties are exacerbated in ecstasy users. Individuals reporting average levels of use of ecstasy are more likely to report memory problems than non-ecstasy drug users or drug free individuals. The deleterious effects of ecstasy are therefore not restricted to heavy or chronic users. No gender differences were detected, suggesting that there may be a dissociation between cognitive impairment and cortical binding worthy of further exploration.

Key words: cannabis, ecstasy, everyday memory, gender, Internet, 3,4-methylenedioxymethamphetamine, prospective memory, World Wide Web

Introduction

In the UK, between 500 000 and two million ecstasy (3,4-methylenedioxymethamphetamine, MDMA) tablets are taken each weekend (Concar, 2002). The enduring popularity of the drug in the 'rave' scene over the last 15 years has resulted in interest amongst the research community regarding the possible long-term consequences of the use of MDMA.

Much of the research has focused upon cognitive functioning, and reports of impairment in performance compared to drug-free controls are commonplace (Parrott and Lasky, 1998; Vollenweider *et al*., 1998; Morgan, 1999; Gouzoulis-Mayfrank *et al*., 2000; Morgan, 2000; Rodgers, 2000; Battachary and Powell, 2001; Fox *et al*. 2001; Rodgers, 2001). However, research in this field is prone to methodological difficulties. It is often difficult to gain access to participants, possibly due to the legal status of the drug.

The average number of participants in these studies is typically under 50, which has clear implications for statistical power. In addition, the fact that majority of ecstasy users are usually poly drug users, also possibly taking cocaine, cannabis, amphetamine, etc. (Winstock *et al*., 2001), makes it difficult to isolate the impact of ecstasy upon neuropsychological performance. Much of the work in this area has employed traditional 'laboratory' based testing of retrospective memory ability and little is known about the impact of drug use on aspects of 'everyday' functioning, including prospective memory skills. The results of the small number of studies that have attempted to investigate these factors via face-to-face methods require confirmation (Rodgers, 2000; Heffernan *et al*., 2001a,b). It remains to be seen what the real impact of ecstasy use is on the psychological health and well-being of the millions of users.

Rodgers *et al*. (2001) have attempted to address some of these methodological issues. The study accessed a larger than average sample size, and employed a web-based design that led to increased statistical power. The study concentrated on subjective views of memory functioning to allow assessment of 'real world' experiences. Information regarding the use of other substances, as well as ecstasy, was collected, allowing a regression design to isolate the contribution of each substance to any variance on the cognitive measures. Preliminary findings were based on 488 participants. As many ecstasy users also use cannabis on a regular basis (Rodgers 2000) and to maintain statistical power Rodgers *et al*. (2001) focused on the relative contribution of only ecstasy and cannabis to memory performance during their preliminary analysis. The results indicated that there is a clear double dissociation between the impact of ecstasy and cannabis on self-reports of memory ability. Cannabis was associated with reports of 'here-and-now' cognitive problems in short-term and internally cued prospective memory, and everyday memory failures. By contrast, ecstasy was associated with reports of long-term prospective memory problems, which were more related to storage and retrieval difficulties. In addition, only ecstasy use was associated with increased errors whilst completing the questionnaires. These findings are of major importance in terms of our understanding of the relative contribution of ecstasy and cannabis to memory impairment. However, it is clear that further investigations are required to take into account the possible impact of the use of other recreational drugs and to further determine what the presence of such impairment may mean for ecstasy users in their everyday lives.

Recent research indicates that there may be gender differences in both the subjective effects of and vulnerability to the neurotoxicity of a number of drugs of abuse, including cocaine, amphetamine, nicotine and alcohol (Lynch *et al*., 2002). Investigation of gender differences has recently been extended to ecstasy use. For example, Liechti *et al*. (2001) observed women to report a more intense subjective experience whilst 'on-drug', especially relating to perceptual changes, thought disturbances and fear of loss of body control. In addition, they report that acute adverse reactions were reported more frequently in female participants. The authors suggest that these findings are consistent with an increased susceptibility in women to the serotonin (5-HT) releasing effects of MDMA. Similarly, Verheyden *et al*. (2002), in an investigation examining the acute and sub-acute effects of MDMA administration on mood, found women users reporting higher levels of depression mid-week following a dose of MDMA compared to male users and male and female non-users. McNamara *et al*. (1995) found that there are slight gender differences in susceptibility to MDMA-induced changes in rats, and Reneman *et al*. (2001) found significant decreases in the densities of brain 5-HT transporters in female MDMA users compared to drug-free controls. This finding was not replicated in male users. This indicates that women may be more susceptible to the neurotoxic effects of the drug as well as to the acute psychoactive effects. If women are more susceptible to the acute psychoactive effects of the drug and are displaying significant neurochemical alterations, it is possible that female users may additionally be more vulnerable to the long-term neuropsychological sequelae associated with the drug. However, little work has been undertaken to investigate whether there are any long-term differences in neuropsychological performance between male and female ecstasy users.

The present investigation had three aims. The first was to explore sex-related alterations in self-reports of cognitive function. The second was to extend previous work and establish that findings reported previously (Rodgers *et al*., 2001) of a dissociation between the effects of ecstasy and cannabis on memory performance still remain when the use of other drugs is controlled for. The third was to provide a profile of the difficulties reported by the 'typical' ecstasy user. The use of an extended dataset will allow a more detailed investigation of the possible contribution of a number of psychoactive substances to the presence of self-reported neuropsychological difficulties.

Methods

Procedure

A website was created for the purposes of data acquisition. It was hosted on the University of Westminster web server, and could be accessed via a number of different addresses (e.g. www.drugresearch.org.uk).

Memory was assessed using two self-report questionnaires. The first was the Everyday Memory Questionnaire (EMQ). This is a valid and reliable self-report measure of common memory lapses in everyday activities (Sunderland *et al*., 1983) comprising of 27 statements. Participants respond on a nine-point from one scale ranging from 'Not at all in the last 6 months' to 'More than once a day'. There are no subscales within this questionnaire. The higher the score, the more that forgetting is evident. Statements include 'finding a television story difficult to follow', 'telling someone a story or joke that you have told them once already', 'forgetting where things are normally kept or looking in the wrong place for them', and 'having to go back and check whether you have done something that you meant to do'.

Prospective memory (PM) was assessed using the Prospective Memory Questionnaire (PMQ), which is a valid and reliable self-report measure (Hannon *et al*., 1995). The PMQ provides measures of three aspects of PM on a series of nine-point scales. 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'). The PMQ provides a measure of self-reported errors in the previous week (or

month or year), the greater the score, the more faulty is an individual's prospective memory. The scale ranges from 1 (where least forgetting is evident) to 9 (where there is a great deal of forgetting). Additionally, 14 questions make up the 'Techniques to Remember' scale, providing a measure of the number of strategies used to aid remembering. The Techniques to Remember Scale ranges from 1 (few strategies used) to 9 (a high number of strategies used).

Drug use was assessed using a version of the UEL Recreational Drug Use Questionnaire (Parrott, *et al*. 2000) which asks respondents to estimate their level of use of ecstasy, amphetamines, cocaine, LSD, barbiturates/benzodiazepines, opiates, magic mushrooms, anabolic steroids, solvents, cannabis, alcohol and tobacco. This was slightly modified for web use (i.e. some drug descriptions were amended to make it more suitable for an international sample). Also, in the original questionnaire, participants were required to write down estimates of their use of various substances whereas, for the online version, they were simply required to select a typical frequency from a drop-down menu. For all questions regarding drugs, a 'prefer not to answer' option was also included. Participants also answered a number of demographic questions (age, sex, location, occupation and education) and questions relating to their participation (how they found out about the study, whether they were currently under the influence of any substance, and whether there was any reason their data should not be used in analyses). All of these instruments were presented as interactive forms on a single web page. Different response formats (clicking on radio buttons or selecting options from a drop-down menu) were used to replicate the characteristics of the paper-and-pencil versions of the questionnaires as closely as possible. The final variable measured was mistakes made when completing the questionnaire. If participants submitted an incomplete form (i.e. left one or more questions blank), they were automatically informed of this and requested to supply the missing data then resubmit the form. The number of such omissions (if any) made by each participant was recorded.

Ethical approval for the study came via the University of Westminster, where data collection was based. Participants read a brief introduction to the study, outlining its nature and the type of questions that would be asked, then those who wished to continue clicked on a button reading 'I understand the nature of the study and wish to continue' as an indicator of their informed consent. It was emphasized that no information from which they could be personally identified would be requested at any stage, and that they were free to withdraw if they wished.

Procedure

Participants were recruited using a variety of methods. These included messages posted to relevant Internet discussion groups (e.g. alt.drugs.ecstasy), links from other online experiments, notices on web pages and announcements in our home institutions, and emails to personal contacts. Different web addresses were given in different recruitment methods (e.g. www.drugresearch.org.uk and survey.drugresearch.org.uk). The address used by each respondent to access the site was automatically logged, so we were able to differentiate between participants coming from various sources. Participants first saw an informed consent page. Via this page, participants were informed that the study was designed to investigate everyday behaviour and recreational drug use. They were informed that the study aimed to look at the potential effects of using various drugs (such as tobacco, cannabis, ecstasy, etc.) and that the study focused on those who use various drugs and those who do not use any of these such drugs. There was also a link to a statement on anonymity and confidentiality. This assured participants that individual respondents would be unidentifiable and that they could select 'prefer not to answer' options where appropriate.

Having entered the site, participants then saw a page bearing brief instructions, demographic items, the EMQ, PMQ and drug use questionnaires, and questions about their participation. Having completed all the items, they then clicked on a button labelled 'Finished' at the bottom of the page.

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

Data screening and processing

World Wide Web research has a number of potential attendant problems (Buchanan and Smith, 1999; Buchanan, 2000). These include multiple submissions of data by the same people, and the possibility of mischievous data entry. Accordingly, responses submitted by participants were screened and a number of inclusion criteria applied.

A common way of detecting multiple submissions is to log the respondent's IP address (the unique Internet address of their computer) and delete multiple responses from the same IP. We recorded all IP addresses of participants accessing the site, and those which duplicated previous addresses were automatically flagged in the data file (for ethical reasons IP addresses were not stored in the same file as information about drug use). It could be the case that more than one respondent may have used the same PC, but with no way of knowing this, we therefore felt that it was appropriate to be cautious in our data screening and remove all multiple entries. This is a relatively conservative method that may lead to deletion of some valid data. However, to ensure independence of observations, it was felt best to err on the side of caution and to exclude all such submissions from analysis. Another technique for screening multiple submissions comprised scrutinizing the datafile for identical sets of responses with very similar submission times (which may result from participants clicking the 'submit' button twice). This was also performed. Also flagged up were instances where participants indicated that they were under the influence of some substance, or that there was some reason their data should not be used. Application of these criteria led to the exclusion of 435 of the initial 1199 submissions

Fraudulent or mischievous data entry is harder to control for. One technique often employed is to use demographic information to screen out clearly implausible responses (e.g. very young respondents claiming to have doctoral degrees). One response (a person in the 16–20-years age group claiming to have postgraduate education) was excluded on these grounds. Other data provided were consistent with the view that people were answering seriously (e.g. nobody selected 'Antarctica' as a location, or claimed to have been recruited via a website on which we did not advertise).

Participants

Seven hundred and sixty-three responses met our inclusion criteria. Of these, 465 (60.9%) were female. The modal age group was 21–25 years (32%). The majority of respondents came from Europe (71%). Many were well educated, having received some University or college education (31%). Two hundred and eighty-two people (37% of the sample; all chose to answer this question) had used ecstasy on at least one occasion. Three hundred and nine people (41% of those who answered this question; two chose not to) indicated that they used cannabis at least 1–4 times a month.

Results

A number of inclusion criteria were applied to ensure sample validity. Exploratory analyses suggested that a discrete group of 84 respondents (recruited through a harm–reduction orientated website, which hosted much information and discussion of possible negative effects of ecstasy and possible ways to mitigate them) had different response patterns from the rest of the sample ('multiple site entry' technique for detecting biased responding to web questionnaires) (Reips, 2000). They were thus excluded from the regression analyses reported here, leaving 199 ecstasy users in the sample. This decision, and the reasons for it, are discussed later.

Cronbach's alpha values were high, demonstrating good reliability, for PMQ long-term (α = 0.85) and techniques to remember scales (α 0.89) and the EMQ (α = 0.94). Exploratory factor analyses indicated that these scales were psychometrically satisfactory. However, analyses of factor structure and reliability for the PMQ short-term and internally cued scales suggested they were not psychometrically satisfactory (the substantial loadings for these items were scattered across three different factors in each case, indicating that they did not address coherent constructs) with the current sample, and these scales were not included in the analysis (Buchanan *et al*., 2002).

Co-use of other drugs

It is widely acknowledged that people who take ecstasy are also likely to take a variety of other psychoactive substances (Winstock, 2001), and it is possible that the psychobiological problems of recreational ecstasy users found by some MDMA researchers may actually be attributable to these other drugs. These patterns of polydrug use are apparent in the current data: among the 199 people who had taken ecstasy on at least one occasion, Spearman's correlations revealed significant positive associations between level of ecstasy use and level of use of amphetamines (r_s = 0.266, n = 199, $p < 0.0005$), cocaine/crack (r_s = 0.354, n = 199, $p < 0.0005$), LSD (r_s = 0.224, n = 199, p = 0.001), magic mushrooms (r_s = 0.260, n = 199, $p < 0.0005$) and also frequency of cannabis (r_s = 0.143, n = 198, p = 0.044). [Sample sizes for analyses involving cannabis are slightly lower as two people chose not to report their level of cannabis use. Further details of polydrug use in our sample are provided by Scholey *et al*. (2003).] In these analyses, and all subsequent analyses, unless otherwise specified, cannabis use is expressed in terms of frequency (non-user, 1–4, 5–20 or more than 20 times per month) and other drugs (including MDMA) in terms of estimated lifetime total instances of use (never, 1–9, 10–99, 100+ occasions).

Association of other drugs with memory in MDMA-using sample

If any of the substances co-used with MDMA affect memory or cognitive performance, an observed correlation between ecstasy use and one of the memory test scores could actually reflect the association with this other co-used substance (note that the reverse is also true, an observed association between, for example, amphetamine use and memory could actually be an artefact of a relationship between MDMA use and memory). Any other drugs that affect the dependent variables in this study should therefore be controlled for in the main analysis so that the independent effect of each can be isolated. Accordingly, correlations between the use of these other substances and EMQ, PMQ-LT, and errors made were computed for those participants who had taken ecstasy on at least one occasion (Table 1).

Of the illegal drugs we asked about, only two had significant associations with these measures. Frequency of cannabis use correlated significantly with the number of errors made completing the form (r_s = –0.204, n = 198, p = 0.004); whereas level of LSD use correlated significantly with both PMQ-LT (r_s = –0.166, n = 199, p = 0.019) and EMQ (r_s = –0.166, n = 199, $p <$ 0.019). It should be noted that both these correlations are negative: people taking more of these substances reported experiencing fewer failures. These findings indicate that cannabis and LSD use should be controlled for in further analyses.

PMQ techniques to remember scale should also be included in analyses as a covariate, given that the use of memory strategies may affect memory performance (or at least self-reported perceived memory ability) and that previous work (Rodgers *et al*., 2001) has indicated that use of such strategies is (negatively) associated with drug use.

Self reports of memory impairment

The effect of level of ecstasy use and frequency of cannabis use on each of the memory scales that were psychometrically satisfactory (EMQ, PMQ long-term scale) and the number of mistakes made completing the questionnaire were examined by linear regression

Table 1 Spearman's correlations between co-used substances and scores on Everyday Memory Questionnaire (EMQ), Prospective Memory Questionnaire–Long-term subscale (PMQ-LT) and errors among ecstasy users

	EMQ			PMQ-LT			Errors		
Substance	r_s	p	n	r_s	p	n	r_s	p	n
Amphetamine	–0.044	0.534	199	0.092	0.196	199	0.042	0.552	199
Cocaine/crack	0.048	0.505	198	0.130	0.067	198	0.030	0.672	198
LSD	**–0.166**	**0.019**	**199**	**–0.166**	**0.019**	**199**	–0.022	0.760	199
Magic mushrooms	–0.078	0.274	199	–0.120	0.090	199	–0.057	0.421	199
Cannabis	0.104	0.146	198	–0.029	0.686	198	**–0.204**	**0.004**	**198**

Table 2 Effects of ecstasy and cannabis on the Everyday Memory Questionnaire (EMQ), Prospective Memory Questionnaire–Long-term subscale (PMQ-LT) and number of errors made whilst completing the questionnaires

			Level of MDMA use		Frequency of cannabis use	
	Cronbach's alpha	*r*	Beta	*p*	Beta	*p*
EMQ	0.94	0.414	0.077	0.084	0.193	**0.0005**
PMQ-LT	0.85	0.348	0.147	**0.001**	0.066	0.114
Errors made by respondent	N/A	0.106	0.112	**0.010**	–0.084	0.051

Table 3 Percentage of men and women who had used ecstasy on at least one occasion reporting each level of use

	Men	Women[a]
Lifetime use		
1–9 times	37.8%	51.0%
10–99 times	50.0%	34.7%
100+ times	12.2%	14.3%
Normal dose		
1–2 tablets	82.7%	90.8%
3–4 tablets	12.2%	6.1%
Over 4 tablets	5.1%	3.1%
Highest dose		
1–2 tablets	43.9%	57.1%
3–9 tablets	45.9%	34.7%
10 or more	10.2%	8.2%

[a]One woman indicated that she had taken ecstasy, but answered 'never' to the normal dose/highest dose questions, and has not been included in these figures.

for each outcome variable. For the reasons outlined above, the use of strategies to aid memory (PMQ techniques to remember subscale) was included as a predictor in all three analyses, and the level of LSD user in those pertaining to EMQ and PMQ-LT, to partial out their influence on the dependent variables. Relationships between strategy use, LSD and the dependent variables will be reported elsewhere.

In each case, either ecstasy or cannabis use was a significant and unique predictor of the dependent variable. These results are summarized in Table 2.

From the regression analyses, it is clear that cannabis and ecstasy differentially affected aspects of memory. The frequency of cannabis use, but not ecstasy, predicted higher scores (more self-reported errors) on the EMQ. On the other hand, the amount of ecstasy use, but not cannabis use, predicted higher scores (more self-reported errors) on the long-term scale of the PMQ and the number of errors actually made while completing the questionnaires.

Gender effects

Among ecstasy users, Mann–Whitney tests indicated that level of use did not differ significantly for men and women (U = 4402.5, n = 199, p = 0.140). Differences between men and women in normal (U = 4413, n = 197, p = 0.067) and highest ever (U = 4196.5, n = 198, p = 0.052) number of pills taken approached but did not reach significance (with scores being higher for men in each case). Levels of use for men and women are summarized in Table 3.

To simultaneously test for any gender-differentiated effects of ecstasy in terms of the outcome variables that it significantly predicted in the regression analysis (PMQ-LT and errors), a two-way multivariate analysis of variance (MANOVA) (gender by ecstasy user status, user versus non-user) with cannabis, LSD and PMQ techniques to remember scores as covariates was performed. There was a significant main effect due to user status [Wilks' Lambda = 0.991, F(2,668) = 3.057, p = 0.048], but no main effect due to gender [Wilks' Lambda = 1.0, F(2,668) = 0.099, p = 0.91] or interaction between user status or gender [Wilks' Lambda = 0.995 F(2,668) = 1.513, p = 0.22]. The current data therefore provide no evidence that the unique effects of recreational ecstasy use on self-reported long-term prospective memory or errors made in completing the questionnaire differ for men and women. Mean scores on these variables for men and women are summarized in Table 4.

'Typical' use

We were also interested in determining the implications of our findings for 'typical' drug users. A subsample of 81 'typical' recreational ecstasy users was selected comprising of those participants who had used ecstasy at least 10 times, taken ecstasy at least once within the past year, and had first taken ecstasy more than 1 year ago. Levels of performance relative to 'controls', and effect size indicators (Glass's d) for those comparisons, were computed.

The group of 'typical' users reported long-term prospective memory (PMQ-LT) as 14% worse than the 480 people who had never taken ecstasy (d = 0.31) and 23% worse than the 242 completely drug-free participants (d = 0.49). In addition the 'typical' ecstasy users made 21% more errors completing the form than non-ecstasy users (d = 0.10) and 29% more errors than completely drug-free participants (d = 0.14).

With regard to the use of cannabis, the regression analyses indicated that use of cannabis (irrespective of use of any other substance) significantly predicted self-reported everyday memory

Table 4 Mean Prospective Memory Questionnaire–Long-term subscale (PMQ-LT) and errors for men and women who had taken ecstasy at least once

	Men (n = 98)			Women (n = 101)		
	Mean	SD	95% CI	Mean	SD	95% CI
PMQ-LT	2.46	1.17	2.22–2.69	2.56	1.21	2.33–2.80
Errors made by respondent	0.40	0.69	0.26–0.54	0.51	0.80	0.35–0.66

problems. For the entire sample, a one-way ANOVA revealed a significant effect of cannabis use on EMQ scores [$F(3,756) = 5.887$, $p = 0.001$]. On average, compared to the 451 non-users, the 69 people using cannabis 5–20 times per month reported 10.37% more memory problems ($d = 0.26$) and the 82 people using cannabis more than 20 times per month reported 18.78% more memory problems than non-users ($d = 0.46$).

Discussion

The primary aim of the current investigation was to determine whether there were gender differences in self-reports of memory difficulties in our sample. Research indicating gender differences in susceptibility to MDMA-induced changes (McNamara *et al*., 1995; Reneman *et al*., 2001), and acute and subacute effects on mood (Liechti *et al*., 2001; Verheyden *et al*., 2002), suggests that women may be more vulnerable to the long-term deleterious effects of the drug. In the present study, we found that frequency of use did not differ significantly, nor did differences between men and women in terms of the average and highest ever number of pills taken. In addition, we found no differences in self-reports of memory impairments comparing male and female participants. This implies that although 'on-drug' effects may vary and cortical binding ratios may be affected differently in men and women, women are not more vulnerable to the long-term impact of use. This intriguing apparent dissociation between acute and long-term cognitive effects of ecstasy needs further exploration, not least to examine whether the dissociation holds for other cognitive domains.

A further aim was to extend findings from a preliminary analysis of the data that had focused on the impact of cannabis and ecstasy on memory ability (Rodgers *et al*., 2001). The results of that study were considered to be preliminary in nature, pending investigation of the psychometric properties of the online memory questionnaires. To this end, an exploratory factor analysis was performed on the current extended dataset (Buchanan *et al*., 2002). This indicated that the PMQ Long-term and Techniques to Remember scales were psychometrically satisfactory, with items from each subscale clustering together, as predicted by the four-factor model presumed to underlie the questionnaire. However, the items of the short-term and Internally Cued subscales did not load together on the expected factors (indeed they did not delineate any clear factors at all), leading to the conclusion that these scales did not measure any coherent or meaningful constructs in the current sample.

This analysis has implications for the findings reported by Rodgers *et al*. (2001). We now have increased confidence in the finding of a link between ecstasy use and long-term prospective memory. However, the previously reported links between cannabis use and short-term and internally cued prospective memory must be regarded with caution. Given that these scales did not prove to be satisfactory, very little can be suggested about links between cannabis use and these aspects of memory (the reported link between cannabis use and everyday memory stands, given that the online EMQ was found to be reliable).

The failure to find the expected factor structure for the PMQ could be attributed to a number of causes, including the Internet methodology and the nature of the sample tested. This finding therefore does not affect the conclusions of studies (Heffernan *et al*., 2001a,b) performed using the pencil-and-paper version of the PMQ: there is no reason to suggest the IC and ST subscales should be unsound in those studies. However, it would seem prudent to examine the latent structure of the PMQ in offline samples also.

Data from the current study confirm that ecstasy users typically consume a range of recreational substances, particularly amphetamine, cocaine, LSD, psylocibin mushrooms and cannabis (Scholey *et al*., 2003). With this extended dataset, and thus the statistical power to investigate the impact of a range of substances, we can provide support for previous findings (Rodgers *et al*., 2001). The present investigation established that there is still a clear dissociation between the impact of ecstasy and cannabis on the types of memory failure reported by users when the use of additional substances is taken into account. We found cannabis use to predict self-reports of failures in everyday memory, with greater use corresponding with more reported problems. By contrast, ecstasy use predicts self-reports of long-term prospective memory failures where, again, greater use is associated with more difficulties. In addition, the use of ecstasy was found to predict the number of errors made while entering data, cannabis use was not. Those respondents with the greatest use of ecstasy made the most errors. Given that use of a range other recreational drugs was assessed and controlled for in analyses, it appears likely that these effects are actually due to ecstasy and cannabis rather than any other drug respondents might have previously taken. Nevertheless, we cannot rule out the possibility that statistical control, however rigorous may mask the psychobiological effects of interactions between neural systems following chronic polydrug use.

While these findings held for the majority of respondents in the study, there was one group whose responses were somewhat different: the subsample of 84 people recruited through a harm-reduction website who were excluded from the main analysis. This exclusion was a result of applying a technique that can be used to detect biased responding in Internet research. The 'multiple site entry' technique (Reips, 2000) involves recruiting participants via a number of different channels, and comparing findings for each subsample. If any subsample appears to show different patterns of responses, there may be grounds for suspecting a systematic bias (arising perhaps from self-selection or manipulated self-presentation). The aforementioned subsample of 84 people appeared to fall into this category. While their ecstasy use levels were among the highest, their self-reported levels of long-term prospective memory problems were lower than the rest of the sample, as were the average number of incomplete questionnaire submissions. An ANCOVA indicated that even when MDMA use was controlled for, this group differed significantly from the rest of the sample in their PMQ-LT scores [$F(1,760) = 14.38$, $p < 0.0005$]. The website through which these people were recruited presents a very large amount of information about ecstasy, advice on possible techniques to protect oneself against harmful effects of drug use, and discussion forums where extensive (and well-informed) debates on these topics occur. There was also discussion of our research on these forums, with people who had just participated posting comments about it. Taken together, all these observations suggest that there might be something unusual about this group of participants. One possibility is that their self-reports were biased (e.g. keen ecstasy users might wish to downplay any harmful effects it might have). Another is that they were implementing some of the potentially neuroprotective strategies discussed on the website, and that these were actually working. On

the basis of the current data, there is no way to test these propositions. However, there were sufficient indications that this group were not representative of ecstasy users, and that inclusion of their data may have biased the results of the current study. It was therefore felt that exclusion of their data from the current analysis was warranted. The possible impact of the use of neuroprotective strategies is currently being explored in a follow-up study.

It is interesting to note that cannabis use and the use of LSD are negatively correlated with the number of errors made while filling out the form and self-reports of long-term prospective memory problems and everyday memory function, respectively. It could be tentatively argued that cannabis use results in a slower processing speed**,** leading to a shift in speed/accuracy trade off and a reduced potential for error. However, we were unable to explore this suggestion further due to the absence of a speed of completion measure. Further investigations of this finding are required. With regard to the negative correlation between LSD use and self-reports of poor performance, it is likely that this is an artefact of the low scores for the very small number of people reporting very high LSD use. While further research on the possible impact of LSD on cognitive performance may be required, it is important to note that exploratory analyses indicated that the LSD findings are probably attributable to those LSD users with the highest levels of use (nine people). When the regression analyses are repeated with these nine excluded, LSD no longer significantly predicts EMQ and PMQ-LT scores (whereas MDMA and cannabis still do).

The focus of the present investigation was to determine the unique effects of individual substances upon self-reports of neuropsychological performance. However, as stated previously, most drug users regularly ingest a range of substances. Obviously, this raises the possibility that one or several of these other drugs, either singly or in combination, could be responsible for the sequelae witnessed in the literature. Studies that systematically take into account the relative contribution of combinations of various substances on performance are therefore required. The impact of drug use upon functioning may vary dependent upon the type and combination of drugs consumed (Schifano *et al*., 2003). Whilst beyond the scope of the current study, this suggests that differing patterns of drug use may lead to distinct patterns of presentation/dissociations and highlights the need for detailed assessment of the interactions and patterns of polydrug use in future studies.

A further aim of this investigation was to determine what the impact of drug use would be on day to day experiences outside of a highly controlled laboratory based environment. The findings indicate that 'typical' use of ecstasy will result in a user experiencing (and reporting) difficulties with memory much more frequently (14%) than users of other recreational substances. When compared to drug free individuals, the ecstasy users were almost 25% more likely to report compromised memory ability. These self-report data are further supported when we examine the number of errors made when completing the questionnaire. Here, we find that a 'typical' ecstasy user is much more likely to make an error than either other drug users or drug free individuals. The effect sizes for this analysis can be seen to be generally small to medium in size. However, despite being small, these effect sizes are of a magnitude that have real world implications (Cohen, 1992; for a demonstration of the profound real-life effects which may arise from small effect sizes found in psychological research, see Rosenthal, 1986). This can be further illustrated through an examination of the percentage scores of the number of mistakes people in the different groups were found to make. The relatively moderate use of ecstasy (i.e. having taken the drug at least 10 times, at least once within the last 12 months and at least 12 months since first use) appears to result in tangible and significant decrements in reported memory performance. In addition, an examination of the self-report of memory ability from cannabis users reveals an additional worrying finding. We found that, compared to non-users, individuals who used cannabis moderately (5–20 times per month) were reporting 10% more memory problems, and those individuals who were using slightly more cannabis (more that 20 times per month) were reporting almost 20% more memory difficulties. It is well established that the co-use of ecstasy and cannabis is a common phenomenon (Rodgers, 2000) and the present findings suggest that users of both substances may be particularly vulnerable to a myriad of memory deficits. More research using controlled, objective measures of memory function is necessary before drawing firm conclusions about these findings.

Clearly, on the basis of the present data, we cannot say whether those individuals who are taking ecstasy and or cannabis were functioning within the normal range in terms of memory ability before the onset of their drug use. Only a longitudinal study would be able to address that question. However, the finding that the number of reports of memory difficulties increases with the amount of use does suggest that there is a relationship between drug use and declining performance. Further investigations, including the use of objective measures of prospective memory and longitudinal studies, are needed.

Address for correspondence

J. Rodgers
Department of Clinical Psychology
University of Newcastle
Newcastle upon Tyne
NE1 7RU
UK
Email: Jacqui.rodgers@ncl.ac.uk

References

Battachary S, Powell J H (2001) Recreational use of 3,4-methylenedioxymethamphetamine (MDMA) or 'ecstasy': evidence for cognitive impairment. Psychol Med *31*: 647–658

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

Buchanan T (2000) Potential of the internet for personality research. In Birnbaum M (ed.), Psychological experiments on the internet, pp. 121–140. San Diego: Academic Press

Buchanan T, Ali T, Heffernan T M, Ling J, Parrott A, Rodgers J, Scholey A B (2002) Psychometric properties of online self-report memory questionnaires: the EMQ and PMQ. Poster session presented at German Online Research 2002, Hohenheim, Germany

Concar D (2002) Ecstasy on the brain. New Scientist *2339*: 26–33

Cohen J (1992) A power primer. Psychol Bull *112*: 155–159

Fox H C, Parrott A C, Turner J D (2001) Ecstasy use: cognitive deficits related to dosage rather than self-reported problematic use of the drug. J Psychopharmacol *15*: 273–281

Gouzoulis-Mayfrank E, Daumann J, Tuchtenhagen F, Pelz S, Becker S, Kunert H-J, Fimm B, Sass H (2000) Impaired cognitive performance in drug-free users of ecstasy (MDMA). J Neurol Neurosurg Psychiatry *68*: 719–725

Hannon R, Adams P, Harrington S, Fries-Dias C, Gibson MT (1995) Effects of brain injury and age on prospective memory self-rating and performance. Rehabil Psychol *40*: 289–297

Heffernan T M, Ling J, Scholey A B (2001a) Prospective memory deficits in 'ecstasy' users. Hum Psychopharmacol Clin Exp *16*: 339–344

Heffernan T M, Jarvis H, Rodgers J, Scholey A B, Ling J (2001b) Perceptions of everyday memory impairments and central executive functions in recreational users of 'ecstasy'. Hum Psychopharmacol Clin Exp *16*: 607–612

Liechti M E, Gamma A, Vollenweider F X (2001) Gender differences in the subjective effects of MDMA. Psychopharmacology *154*: 161–168

Lynch W J, Roth M E, Carroll M E (2002) Biological basis of sex differences in drug abuse: pre-clinical and clinical studies. Psychopharmacology *164*: 121–137

McNamara M G, Kelly J P, Leonard B E (1995) The effect of acute MDMA administration on body-temperature, serum corticosterone and neurotransmitter concentrations in male and female rats. Hum Psychopharmacol Clin Exp *10*: 373–383

Morgan M J (1999) Memory deficits associated with recreational use of 'ecstasy' (MDMA). Psychopharmacology *141*: 30–36

Morgan M J (2000) Ecstasy (MDMA): a review of its possible persistent psychological effects. Psychopharmacology *152*: 230–248

Parrott A C (2000) Human research on MDMA (3,4-methylenedioxymethamphetamine) neurotoxicity: cognitive and behavioral indices of change. Neuropsychobiology *42*: 17–24

Parrott A C, Lasky J (1998) Ecstasy (MDMA) effects upon mood and cognition: before, during and after a Saturday night dance. Psychopharmacology *139*: 261–268

Reips U-D (2000) The web experiment method: advantages, disadvantages, and solutions. In Birnbaum M H (ed.), Psychological experiments on the internet, pp. 69–117. San Diego: Academic Press

Reneman L, Booji J, de Bruin K, Reitsma J B, de Wolff F A, Gunning W B, den Heeten G L, van den Brink W (2001) Effects of dose, sex and long-term abstention from use on toxic effects of MDMA (ecstasy) on brain serotonin neurons. Lancet *358*: 1864–1869

Rodgers J (2000) Cognitive performance amongst recreational users of 'ecstasy'. Psychopharmacology *151*: 19–24

Rodgers J, Buchanan T, Scholey A B, Heffernan T M, Ling J, Parrott A C (2001) Differential effects of ecstasy and cannabis on self-reports of memory ability: a web-based study. Hum Psychopharmacol Clin Exp *16*: 619–625

Rosenthal R (1986) Media violence, antisocial behaviour, and the social consequences of small effects. J Soc Issues *42*: 141–154

Schifano F (2003) Ecstasy and polydrug abuse: clinical aspects, pharmacological issues and post-mortem findings. Presented at the British Psychological Society Annual Conference, Bournemouth, UK

Scholey A B, Parrott A C, Buchanan T, Heffernan T M, Ling J, Rodgers J (2003) Increased intensity of Ecstasy and polydrug usage in the more experienced recreational Ecstasy/MDMA users: a WWW study. Addictive Behaviours. In press

Sunderland A, Harris J E, Baddeley A D (1983) Do laboratory tests predict everyday memory? J Verbal Learning Verbal Behav *22*: 341–357

Verheyden S L, Hadfield J, Calin T, Curran H V (2002) Sub-acute effects of MDMA (+/–3,4-methylenedioxymethamphetamine, ecstasy) on mood: evidence of gender differences. Psychopharmacology *161*: 22–31

Vollenweider F X, Gamma A, Liechti M, Huber T (1998) Psychological and cardiovascular effects and short-term sequelae of MDMA ('ecstasy') in MDMA-naïve healthy volunteers. Neuropsychopharmacology *19*: 214–251

Winstock A R, Griffiths P, Stewart D (2001) Drugs and the dance music scene: a survey of current drug use patterns among a sample of dance music enthusiasts in the UK. Drug Alcohol Depend *64*: 9–17