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Differential effects of Ecstasy and cannabis on self-reports of memory ability: a web-based study

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Given the legal status of MDMA (3,4-methylenedioxymethamphetamine), or Ecstasy, face-to-face access to participants is sometimes difficult. The number of participants in studies of cognitive performance amongst Ecstasy users is variable, with the average being around 30. Access to a larger number of participants is clearly desirable. The present investigation accessed a larger sample size using a web-based design. A website 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 Drug Questionnaire assessed the use of other substances as well as Ecstasy, allowing a regression design to isolate the contribution of each substance to any variance on the cognitive measures. Preliminary findings ($N = 488$) indicate that there is a clear double dissociation between the impact of Ecstasy and cannabis. We found that cannabis was associated with reports of 'here-and-now' cognitive problems in short-term and internally cued prospective memory. In contrast, Ecstasy was associated with reports of long-term memory problems, which were more related to storage and retrieval difficulties.

KEY WORDS — Ecstasy; cannabis; everyday memory; prospective memory; Internet; web

INTRODUCTION

MDMA (3,4-methylenedioxymethamphetamine), or Ecstasy, is the drug of choice for a large number of recreational drug users. A growing body of research indicates that use of the substance can have a deleterious effect upon memory ability (Parrott and Lasky, 1998; Morgan, 1999, 2000; Rodgers, 2000). There are, however, a number of methodological issues which need to be considered when reviewing this work. One of the major challenges for researchers in this field is sample size. Given the legal status of Ecstasy, face-to-face access to participants can be problematic. The number of participants in studies of cognitive performance amongst Ecstasy users is variable, ranging from five (Reneman *et al.*, 2000) to 150 (Schifano *et al.*, 1998), with the average being around 30. Access to a larger number of participants is clearly desirable.

In addition, nearly all of the previous research in this area has focused upon retrospective memory functioning. The only investigation to date that has examined prospective memory is a self-report study by Heffernan *et al.* (2001). Prospective memory refers to the process of remembering to do things at some future point in time (e.g. remembering to attend a particular function or to carry out a particular task). Prospective memory has only recently come under empirical investigation (Ellis *et al.*, 1999). This study indicated that Ecstasy users perceived their prospective memory skills to be significantly impaired, compared with non-users. However, in line with other studies the sample size was relatively small ($N = 30$). Given the important implications of this study a

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replication with a larger population is required. Heffernan *et al.* (2001) is the only study to find that users perceive their memory ability to be impaired. Rodgers (2000) required Ecstasy users to rate day-to-day cognitive performance using the Cognitive Failures Questionnaire (Broadbent *et al.*, 1982). The results indicate that the Ecstasy users did not perceive their cognitive performance to be any worse than that of drug-free and cannabis-only control subjects. This finding is in line with other studies that suggest that despite impairment being apparent on objective measures Ecstasy users do not report their day-to-day memory functioning as impaired. The lack of a clear relationship between the objective measures and self-report measures is of concern. It could be suggested that the deficits reported on the tests should be having an impact upon daily living; however, this does not appear to be the case. This finding could be explained by the so called 'memory paradox': that individuals who are experiencing memory impairment are not able to remember and subsequently report cognitive slips. Or it may be that the Ecstasy users are employing compensatory strategies to aid day-to-day functioning that they are not able to use during the objective measures. Alternatively it may be that Ecstasy users perceive only some aspects of memory to be impaired, e.g. prospective memory (Heffernan *et al.*, 2001). What is clear is that further investigation is required.

Finally, many of the previously published studies have allocated participants to groups on the basis of a variety of factors, e.g. type, duration and frequency of use. Given that many Ecstasy users also use other drugs, it seems that this method of grouping participants may be somewhat arbitrary and make interpretation of findings problematic.

The web is increasingly being used as a medium for psychological research, especially with studies based on questionnaires. One reason for this is the very large number of participants it is possible to recruit. This is a possible solution to the problem of small sample sizes in Ecstasy research. While there are grounds for caution about some characteristics of online research (see, for example, Buchanan and Smith, 1999), there are strong indications that online studies can validly address the same psychological phenomena as traditional laboratory experiments (e.g. Krantz and Dalal, 2000).

In the current study, prospective memory ability was investigated using the Prospective Memory Questionnaire (Hannon *et al.*, 1995), and self-report of day-to-day memory performance was investigated using the Everyday Memory Questionnaire (Sunderland *et al.*, 1983). The Drug Questionnaire assessed the use of other substances as well as Ecstasy, and this allowed a regression design to isolate the contribution of each substance to any variance on the cognitive measures.

One issue which clouds interpretation of the effects of Ecstasy on psychological performance is the common co-use of cannabis. For this reason, in the current paper we focus on the relative contribution of Ecstasy and cannabis to memory performance.

METHODS

Materials

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). It consists of 27 statements. Participants respond on a 9 point scale ranging from 'Not at all in the last 6 months' to 'More than once a day'. There are no subscales within this questionnaire. 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 9 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 one's PM. 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 was slightly modified for use on the web. 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. In the online version, they were simply required to select a typical frequency from a drop-down menu. For all questions regarding illegal 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 and then resubmit the form. The number of times each participant made such a mistake was recorded.

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 e-mails 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 and so on) 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 which assured them that individual respondents would be unidentifiable and that they could select 'prefer not to answer' options where appropriate.

To continue, participants clicked on a button labelled 'I understand the nature of the study and wish to continue'. Having clicked on this, 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 page where a summary of results would be posted on conclusion of the study. An e-mail contact address was also provided for respondents who wished to give us feedback or ask questions.

Data screening and processing

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

A common way of detecting multiple submissions is to log the respondents 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). This is a relatively conservative method that may lead to deletion of some valid data. However, to ensure independence of observations, it is probably best to err on the side of caution.

Also flagged up were instances where participants indicated 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 271 of the initial 811 submissions. One possible reason for multiple submissions is the situation where the respondent clicks more than once on the submit button (perhaps through habit or impatience at

Table 1. Numbers of individuals using cannabis and Ecstasy amongst a sample of 488 people who completed online drug use and memory questionnaires. Categories are based on those used in the UEL drug use questionnaire

		Cannabis use (times per month)				
		0 Non-user	1–4	5–20	20+	Total
Ecstasy use (no. times ever)	0	250	50	21	12	333
	1–9	25	24	8	12	69
	10–99	17	14	15	20	66
	100+	4	3	4	9	20
	Total	296	91	48	53	488

a slow connection). These can be identified by the occurrence in the data file of identical sets of responses with very similar submission times, and were controlled for by deleting all but the first such set. This led to exclusion of a further 49 responses.

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 age group claiming to have post-graduate education) was excluded on these grounds. Other data provided were consistent with the view that people were answering seriously—for example, nobody selected 'Antarctica' as a location or claimed to have been recruited via a website on which we did not advertise.

Participants

Four hundred and ninety responses met our inclusion criteria. Of these, 297 (60.6%) were female. The modal age group was 21–25 (75.5%). The majority of respondents came from Europe (79.4%) or the USA (16.1%). Most were well educated, either having a higher education qualification (24.5%) or studying for one (32.0%), and 18.4 % had at least some post-graduate education. Most participants were either students of some type (53.5%) or were employed (36.9%). Nearly a third of the sample (155 people (31.5%)–all chose to answer this question) had used Ecstasy on at least one occasion, and 192 people (39.3% of those who answered this question–two chose not to) indicated that they used cannabis at least 1–4 times per month.

RESULTS

For the purposes of this preliminary report we focused on Ecstasy and cannabis use derived from the UEL drug questionnaire and the impact of use of these drugs on reported memory failures. While data about the use of other drugs were also gathered, they have not been included in the current analysis in order to maximise statistical power and hence confidence in the present findings. Potential effects of other drugs on memory will be explored in future analyses with a larger sample. The amount of use of Ecstasy and cannabis is presented in Table 1, which also allows comparison of relative frequencies of co-drug use.

Using Spearman's ρ the reported use of cannabis and Ecstasy was significantly correlated ($\rho_{(486)} = 0.478$; $p < 0.001$), although 83 respondents reported using cannabis but never having taken Ecstasy, and 46 individuals reported using Ecstasy but not cannabis (further analysis of these groups will be reported elsewhere).

The main findings are summarised in Table 2. Firstly, all questionnaire measures appeared to have adequate reliability (as determined using Cronbach's α). The lowest reliability (0.66) was found for the short-term scale of the PMQ, with all other measures being above 0.8. An initial analysis using Spearman's ρ revealed that the use of strategies to aid memory (PMQ strategies) correlated negatively with both Ecstasy use ($\rho_{(488)} = -0.093$; $p < 0.05$) and cannabis use ($\rho_{(486)} = -0.173$; $p < 0.001$). Strategy use is therefore controlled for in further analyses, given the fact that it could impact on the other aspects of self-reported memory performance.

The effect of Ecstasy use and cannabis use on each of the remaining memory scores (EMQ, PMQ short-term, PMQ long-term and PMQ internally cued) and the number of mistakes made completing the questionnaire were examined by means of multiple linear regression. For the reasons outlined above, PMQ strategy use was also included as a predictor in each of these regressions. In each case, either Ecstasy or cannabis use was a significant and unique predictor of the dependent variable. These results are summarised in Table 2.

Table 2. Summary of regression analyses incorporating amount of cannabis and Ecstasy use as predictors. Reliabilities are reported from the Cronbach's α statistic. Significant effects are represented in bold

	Reliability	ρ	Ecstasy			Cannabis		
			β	t	p	β	t	p
EMQ	0.94	0.399	0.013	0.273	0.785	0.181	3.766	$<$ **0.001**
PMQ long-term	0.85	0.331	0.115	2.339	**0.02**	0.037	0.743	0.458
PMQ short-term	0.66	0.214	− 0.001	− 0.025	0.98	0.109	2.131	**0.034**
PMQ internally cued	0.86	0.413	0.054	1.140	0.255	0.121	2.532	**0.012**
Errors	N/A	0.105	0.108	2.088	**0.037**	− 0.014	− 0.260	0.795

EMQ, Everyday Memory Questionnaire; PMQ long-term, PMQ short-term and PMQ internally cued refer to scores from the appropriate three subscales of the Prospective Memory Questionnaire.

From the regression analyses it is clear that cannabis and Ecstasy differentially affected aspects of memory. The level of cannabis use, but not Ecstasy, predicted higher scores (more self-reported errors) on the EMQ, the PMQ short-term scale and the PMQ internally cued scale. 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.

DISCUSSION

These findings are the first to empirically distinguish the memory effects of cannabis from those of Ecstasy, which here reveal a clear double dissociation between the effects of the two drugs (Table 2). We found that cannabis was associated with reports of 'here-and-now' cognitive problems in short-term and internally cued prospective memory. This is consistent with previous findings of short-term cognitive/memory impairments in regular cannabis users (Schwartz *et al.*, 1989). In contrast, Ecstasy was associated with reports of long-term memory problems, which were more related to storage and retrieval difficulties. Again this supports previous findings on retrospective memory, where delayed recall is often the most impaired memory function in Ecstasy users (Rodgers, 2000). These storage deficits may be due to serotonergic neural damage in the hippocampus, induced by repeated use of MDMA in hyperthermic conditions (McCann *et al.*, 2000; Parrott, 2000; Reneman *et al.*, 2000).

Previously, Ecstasy use has been shown to be associated with significantly more errors on all subscales of the PMQ (Heffernan *et al*., 2001). However in the Heffernan study a smaller sample size was used and comparison was made between groups who were allocated to either a 'user'or 'non-user' category. It would appear that here the availability of a large dataset, allowing regression analyses incorporating the level of chronic drug use, has revealed more subtle effects of Ecstasy on aspects of PM.

Perhaps the most striking finding relates to the errors made in completing the questionnaire, an effect that was selectively associated with a history of Ecstasy use. This could be a manifestation of greater impulsivity and less reflective behaviour, which is often found in abstinent Ecstasy users (Morgan, 1998), and may be related to serotonergic axonal loss in the frontal cortex (McCann *et al.*, 2000; Parrott, 2000). Such a proposal is supported by reported impairments in central executive processes amongst Ecstasy users (Wareing *et al.*, 2000), a finding which is consistent with compromised frontal lobe functioning.

The clear dissociation between the impact of Ecstasy and cannabis on aspects of self-reported memory function begs the question as to underlying mechanisms. Cannabis use appeared to target everyday memory, as well as short-term and internally cued PM. These effects are reasonably consistent with functional impairment within the hippocampus–an area that is known to be rich in cannabinoid receptors (Herkenham *et al.*, 1990). Similarly it is tempting to speculate that the increased number of errors made in completing the questionnaire associated with Ecstasy use results from frontal lobe serotonergic deterioration and a consequent increased impulsivity. Additionally, it is possible that the reported Ecstasy-related impairments to long-term PM may be mediated by similar damage to widespread cortical regions. However, it would be premature to draw such conclusions, for a variety of reasons. Firstly, there are numerous reports of other neurotransmitter systems being targeted by both cannabis and Ecstasy, and there are rich, reciprocal interactions between such systems. Therefore any interpretation based on the assumption

of neurotransmitter specificity should be viewed with some suspicion. Secondly, a large number of brain regions are affected to some extent by chronic exposure to cannabis (Loeber and Yurgelun-Todd, 1999) and Ecstasy (McCann *et al.*, 1999), including cortical regions. Thirdly, the neurobiological substrates of PM are not presently known, and their location has thus far been postulated only on the evidence of co-performance on other tasks (e.g. Heffernan *et al.*, this volume). Substantial further investigation is therefore needed before the neurobiological substrates of the effects observed here can be delineated.

Clearly some consideration needs to be given to the methodology of the current study. Web research methodology confers many potential benefits (for discussions of these e.g. see Buchanan and Smith, 1999; Buchanan, 2000a; Reips, 2000). The benefit rated as most important in a survey of web experimenters was the high sample sizes and resulting statistical power available in online research (Musch and Reips, 2000). In a field where sample sizes are a problem, this is a compelling reason to explore the utility of the web as a research medium.

Another problem faced by Ecstasy researchers is the legal status of the drug. People may, for good reasons, be unwilling to disclose their status as users of Ecstasy or other illegal substances. There is evidence to suggest (e.g. Buchanan, 2000b) that participants in online studies may be more candid and willing to disclose sensitive information (a possible reason for this being their real or perceived anonymity). This idea is consistent with evidence that 'under the protective cloak of anonymity on the Internet, individuals can admit to having marginalized or non-mainstream proclivities that they must hide from the rest of the world' (McKenna and Bargh, 2000, p. 64). This suggests that the Internet is a good medium for research on sensitive topics that people might for various reasons be unwilling to provide information about in face-to-face settings—such as use of illegal drugs.

It has been argued (e.g. Krantz and Dalal, 2000) that while online studies generally do address the same phenomena as offline equivalents, and online questionnaires can be valid and reliable measures of the constructs they are intended to address (Buchanan, 2000a), equivalence of web-mediated and traditional forms of the same questionnaire cannot be taken for granted (Buchanan, 2001). Other than the data we present concerning reliability, and the fact that findings presented here are consistent with those reported by traditional studies, there is no evidence that the online versions of the EMQ and PMQ have satisfactory psychometric properties. Accordingly, until data on psychometric properties of these online instruments is presented (a study that will provide such data is currently underway), these findings must be considered preliminary in nature. This objection does not, of course, apply to the measure of errors made by participants when completing the questionnaire.

It is important to note that participants in the present study appeared to be very willing to disclose information online about illegal activities. All participants included in the analysis were willing to report information regarding their Ecstasy use and only two preferred not to report information about cannabis consumption. This supports previous findings (Buchanan, 2000b; McKenna and Bargh, 2000) and also indicates the suitability of the web as a medium for self-report drug research.

Nevertheless the present study is vulnerable to the same methodological shortcomings as pencil-and-paper equivalents: namely, that the measures rely on self-report, and it is not possible to determine the accuracy of responses. While this may be true, it seems unlikely, given the stringent screening procedure described earlier, that cannabis or Ecstasy users would deliberately seek to exaggerate their cognitive failures. Furthermore, it is difficult to imagine how inaccurate reporting of memory failures could lead to the clear double dissociation in types of failures found here.

The relatively high educational level of the participants could be an artefact of the web-based design. It could be suggested that self-perceived memory deficits may be less pronounced in a less educated sample, with educational level acting as a mediating variable in terms of memory awareness and therefore the detection of memory impairment. Whilst this needs to be taken into account it is unlikely that this factor could explain the clear dissociation between the effects of Ecstasy and cannabis found in this sample.

Finally, cannabis use was associated with the adoption of fewer strategic memory aids (a similar, though weaker, association with Ecstasy use needs further investigation). Thus, unlike many elderly people, these young recreational drug users do not (or can not) adopt practical strategies to help them compensate for their everyday memory problems. It is not clear at present the extent to which this reflects a lack of 'metacognition' within this population.

In summary the results of the present study indicate that there is a clear dissociation between the perceived effects of Ecstasy and cannabis use upon memory ability and therefore add to and extend the growing body of knowledge that has catalogued the sequelae associated with recreational drug use. Clearly it is

important to be mindful of the fact that the data presented here represent self-reports of memory performance amongst users and that the information gained is (at present) not supported by objective assessment (other than the results relating to completion errors). Logically the next step is to introduce objective measures of prospective memory ability to research this population. It would appear that web-based designs may be one way forward here, allowing as they do access to large samples sizes. Further research taking into account these issues is currently being developed alongside additional analysis of the current data.

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