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Metamemory in recreational ecstasy polydrug users: what do self-reports of memory failures mean?

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Abstract

Previous research has found relationships between self-rated memory and ecstasy use, such that heavier users report worse function. These findings have been interpreted in terms of objective memory capacity. However, research on metamemory suggests that self-reported memory may be only weakly related to objective function, with demographics, mood, and memory-related beliefs and feelings also contributing to ratings. This study examined relationships between ecstasy/other drug use and self-reported memory, controlling for effects of demographic factors and mood. Associations between self-reported memory, memory-related beliefs and feelings, and objectively-measured cognitive function were also examined. Forty-five ecstasy polydrug, 48 cannabis polydrug, and 40 legal drug users completed a battery of neuropsychological tests and questionnaire measures of metamemory, including memory-related control beliefs, memory-related anxiety, and self-reported prospective and general/retrospective memory. The combined polydrug groups reported more general/retrospective memory failures. Covariance analysis, however, suggested that this finding was confounded by general anxiety levels. A combination of objective cognitive measures contributed to prediction of self-rated prospective memory, with demographics, mood, and memory-related anxiety also contributing to variability. However, associations between objective and self-reported memory were not strong. Self-report may not be a specific methodology with which to assess objective memory capacities in ecstasy and other drug users.

Keywords

ecstasy, MDMA, cannabis, memory, metamemory, self-report

Introduction

Recreational use of ecstasy (±3,4-methylenedioxymethamphetamine, MDMA) has been associated with lowered cognitive function (e.g., Wareing *et al.*, 2000; Montgomery *et al.*, 2005). However, this body of research is subject to substantial methodological limitations (Cole *et al.*, 2002; Bedi and Redman, 2006), including issues associated with recruiting adequate sample sizes (Rodgers *et al.*, 2001).

One approach to resolving some methodological issues is to employ different techniques to assess cognitive function. For instance, self-report and web-based methodologies reduce the time commitment required for testing and increase access to subjects compared to approaches relying on standardized neuropsychological assessment (see Rodgers *et al.*, 2001).

A small body of research has employed self-report and/or web-based methodologies to assess cognitive function in ecstasy users (e.g., Rodgers *et al.*, 2001; Heffernan *et al.*, 2001a, b; Rodgers *et al.*, 2003; Parrott *et al.*, 2006), in some cases in conjunction with standardized cognitive assessments (e.g., Rodgers, 2000). Some researchers have reported no difference between ecstasy users and control participants in self-reported memory/general cognitive function (e.g., Gouzoulis-Mayfrank *et al.*, 2000; Parrott *et al.*, 2000; Rodgers, 2000; Halpern *et al.*, 2004), even where differences existed in objective cognitive performance (Gouzoulis-Mayfrank *et al.*, 2000; Rodgers, 2000). Conversely, other studies suggest that ecstasy users have worse self-rated memory performance than non-ecstasy users (e.g., Heffernan *et al.*, 2001a, b). Heavier ecstasy use has also been associated with increasing reports of memory failures (Rodgers *et al.*, 2001; Rodgers *et al.*, 2003).

Although a number of these studies have made reference to the need for future research to include objective cognitive assessments (e.g., Heffernan *et al.*, 2001a; Heffernan *et al.*, 2002), findings that ecstasy use is associated with self-reported memory difficulties have commonly been interpreted as indicative of objective memory dysfunction (e.g., Rodgers *et al.*, 2001; Heffernan *et al.*, 2001a; Rodgers *et al.*, 2003). It is unclear whether this is the case, given that no previous study has examined relationships between objective and self-report measures of cognitive function in ecstasy/other drug users.

Related research in other populations suggests that there may be limitations to the extent to which self-reports of memory function capture objective capacity. Evidence from ageing (McDonald-Miszczak *et al.*, 1995; Lane and Zelinski, 2003), medically ill (Randolph *et al.*,

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2001; Randolph *et al.*, 2004) and alcoholic populations (Shelton and Parsons, 1987) indicates that self-reports of memory function may be influenced by a number of factors other than actual memory capacity.

An alternative conceptualization of self-reported memory is presented in the metamemory literature. Metamemory, broadly defined as the awareness of memory, has been argued to include *knowledge* about how memory works, *awareness* of memory function as it occurs, *beliefs* related to memory and *feelings* about memory performance (Dixon, 2000). Under this model, self-reports of memory function are viewed as indicative of beliefs about one's memory, which may or may not be accurate. Such beliefs may be affected by objective memory capacity (McDonald-Miszczak *et al.*, 1995), but they may also reflect demographic variables such as gender (Ponds and Jolles, 1996), lowered mood (Randolph *et al.*, 2004) and objective cognitive performance across domains other than memory (Randolph *et al.*, 2004). Self-reports are further likely to be impacted by other dimensions of metamemory, such as memory-related beliefs and feelings (see Cavanaugh *et al.*, 1998; Dixon, 2000).

The present study examined self-reported memory function in ecstasy users from the perspective of metamemory. Initially, we assessed whether ecstasy polydrug users (EP) differed from cannabis polydrug users (CP) and/or legal drug users (LD) in dimensions of metamemory. Metamemory variables examined included self-reported memory and memory-related beliefs and feelings. The memory-related belief examined was memory locus of control, which measures the degree to which individuals believe that they are in control of their own memory performance (Dixon, 2000). Memory-related anxiety (anxiety about memory task performance) was also examined. We included these variables to assess the possibility that media coverage of ecstasy-related cognitive research may affect perceived memory-related control and memory anxiety in ecstasy users (see Cole *et al.*, 2006). Relationships between ecstasy and other drug use and self-reported memory, controlling for effects of demographic factors and mood, were also examined. Finally, we assessed the degree to which self-reports of memory function are correlated with objective memory/other cognitive functions in ecstasy and other drug users. In examining these relationships, we controlled for possible effects of variables other than objective memory that may affect self-reported memory, such as demographic factors, mood, and memory-related control beliefs and anxiety.

On the basis of previous ecstasy-related research, we hypothesized that ecstasy users would demonstrate lower self-rated memory function than non-ecstasy groups and that heavier ecstasy use would be associated with worse self-reported memory function. However, on the basis of findings in other populations, it was anticipated that these relationships would be reduced or eliminated once variability associated with demographics and mood was accounted for. It was similarly anticipated that relationships between objective cognitive function and self-rated memory would not be strong, with demographics, mood and memory-related beliefs and feelings accounting for substantial variance in self-rated performance.

Methods and materials

Participants

Participants ($N = 133$) aged over 18 years were recruited using advertisements and 'snowball' sampling (Solowij *et al.*, 1992). Forty-five were EP who reported ecstasy and cannabis use on 10 or more occasions and 48 were CP who reported use of cannabis on at least 10 occasions and variable histories of other drug use. Forty participants were LD (who had used alcohol and/or nicotine) who reported either no illicit drug use at all or use of cannabis on no more than five occasions and no more than one occasion of use of any other type of illicit drug. No CP or LD participant reported any ecstasy use.

Participants were excluded on the basis of past serious medical illness, previous/current psychiatric diagnosis/treatment except mood disorders, history of regular benzodiazepine or intravenous opiate use, current regular use of alcohol, cocaine or amphetamines, current substance dependence excluding ecstasy, cannabis or nicotine, positive breathalyzer reading and insufficient English fluency as demonstrated by a Wechsler Test of Adult Reading (WTAR) raw score of less than 25. Positive urinalysis on the day of cognitive assessment was also cause for exclusion, with the exception of cannabis metabolites. We did not exclude on the basis of cannabis metabolites because these may remain in urine for days after last use and participants were requested to abstain from cannabis for 24 hours before sessions (see below; see also Simon and Mattick, 2002). Recruitment/exclusion of participants is summarized in Figure 1.

Procedure

The study used a cross-sectional cohort design, with the CP group included to allow examination of whether group differences were specific to ecstasy use (Morgan, 1999).

Participants underwent telephone screening and two face-to-face assessment sessions after providing written informed consent. They were reimbursed AU$40 according to procedures approved by the Monash University human ethics committee.

Participants were asked to abstain from alcohol for 24 hours, from ecstasy and all recreational drugs other than cannabis for ten days and from caffeine for two hours. To control acute effects of cannabis, participants were requested to abstain from cannabis for 24 hours. Participants smoked cigarettes as was customary for them.

All assessments were individually administered (by the first author). Participants supplied a breathalyzer reading in both sessions (Lion Alcometer S-D2, Lion laboratories Ltd., UK). Urine samples were collected in both sessions and participants believed that all samples would be screened. Due to resource restrictions, a randomly selected subset ($N = 40$) of Session 2 (neuropsychological assessment) samples was subjected to immunoassay screening for drugs of abuse. Assays were performed by Dorovich Pathology, Melbourne, Australia.

Measures

Demographic/drug-use information A demographic and drug-use history was taken employing a structured interview format.

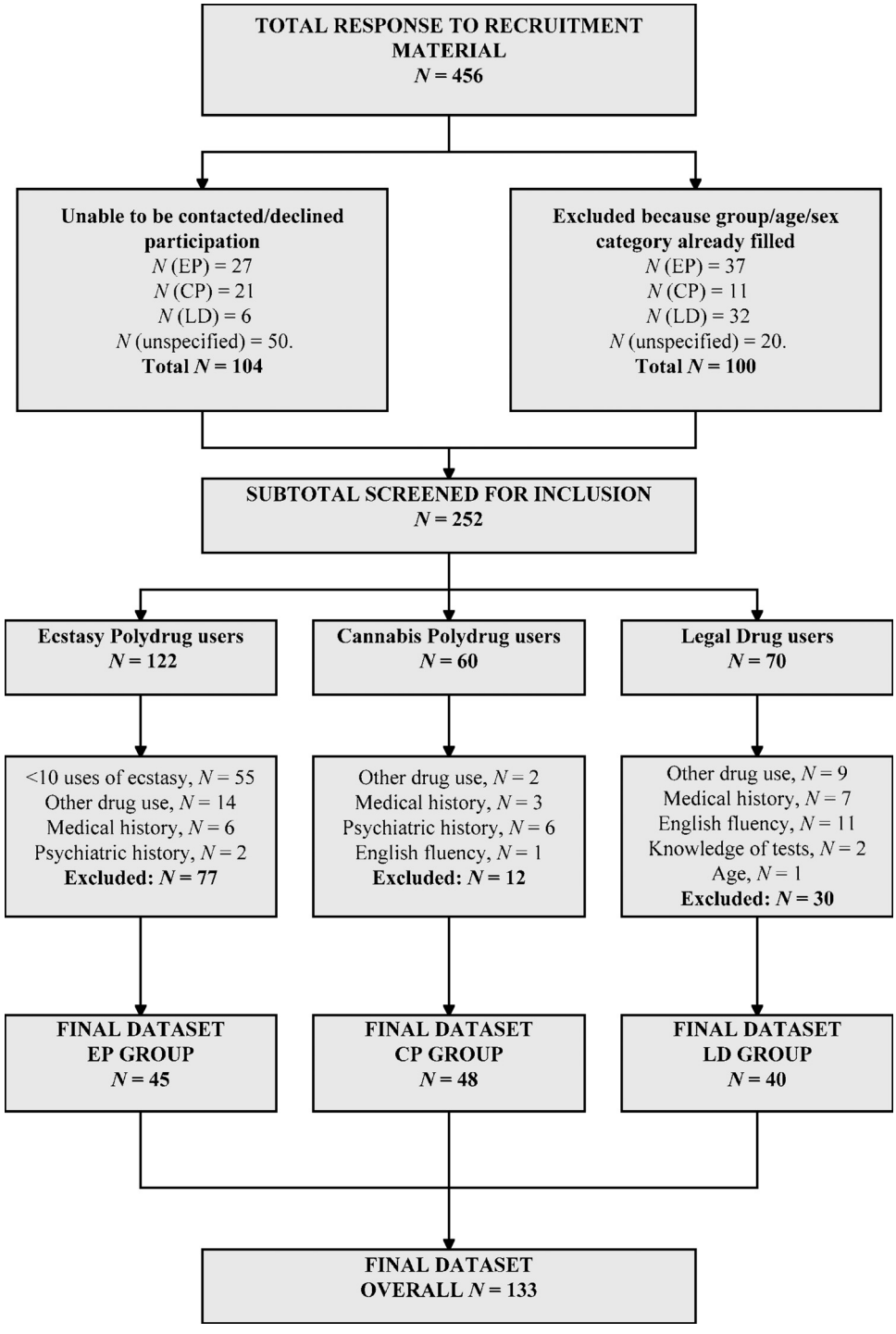

Figure 1 Flowchart of participant recruitment and exclusion.

Substance dependence was assessed using questions based on DSM-IV criteria (American Psychiatric Association, 1994). A Family of Origin Risk index was developed as a composite of participants' reports of the number of first-degree relatives diagnosed with psychiatric disorders, the number who had used illegal drugs and the number who had experienced alcohol-related problems. EP participants provided information about ecstasy-use patterns using a contextually based timeline (Bedi and Redman, 2006). Participants provided information about use of nicotine, alcohol, cannabis, stimulants, dissociatives, hallucinogens, opiates, inhalants and tranquillizers.

Metamemory variables

Self-reported prospective memory

Self-reported prospective memory, the ability to remember to do things in the future (Graf and Uttl, 2001), was measured using the Prospective Memory Questionnaire (PMQ; Hannon *et al.*, 1995). The PMQ comprises four subscales, three of which measure self-reported memory function: the Long-Term Episodic (LTE), Short-Term Habitual (STH) and Internally Cued (IC) subscales. Items consist of statements describing prospective memory failures (e.g., 'I forgot to water my plants'). Participants use a Likert scale to report how often they believe they experienced each failure in the week/month/year prior to assessment. Items included in the LTE subscale assess self-report of prospective memory behaviors that occur infrequently, whereas those contributing to the STH subscale describe perceived failures in prospective memory tasks occurring more routinely. Items in the IC subscale assess self-report of prospective memory failures in tasks where there are no external cues to task performance (e.g., 'I dialed someone on the phone and temporarily forgot who I had called'). The PMQ has previously been used in ecstasy-related research (Rodgers *et al.*, 2001; Heffernan *et al.*, 2001a; Heffernan *et al.*, 2001b; Rodgers *et al.*, 2003).

Self-reported general/retrospective memory

The Metamemory in Adulthood scale (MIA) measures seven dimensions of metamemory (Dixon *et al.*, 1988). The Capacity subscale of the MIA was used in these analyses as a measure of self-reported general/retrospective memory function. Participants responded to general statements about types of memory (e.g., 'I am good at remembering names') using a Likert scale. The MIA Capacity subscale has acceptable internal consistency and adequate discriminant and convergent validity (Dixon *et al.*, 1988).

The General Frequency of Forgetting (GFF) subscale of the Memory Functioning Questionnaire (MFQ; Gilewski *et al.*, 1990) was also used to measure self-report of general/retrospective memory function. Both measures were employed because the MFQ GFF subscale assesses a broader range of specific memory-related behaviors (e.g., names, faces etc.) whereas the MIA Capacity subscale focuses on general ability statements within memory-related domains (e.g., 'I am good at remembering birthdates'). Internal consistency of the MFQ GFF is high (Gilewski *et al.*, 1990).

Memory-related beliefs – memory locus of control

Memory-related control beliefs were measured with the MIA Locus of Control subscale (MIA Locus; Dixon *et al.*, 1988). This subscale assesses the degree to which participants believe that their memory performance/capacity is under their own control. Items include statements such as 'I have little control over my memory ability'. The MIA Locus has adequate internal consistency and good discriminant validity (Dixon *et al.*, 1988).

Memory-related feelings – memory anxiety

Memory-related anxiety was assessed using the MIA anxiety subscale (Dixon *et al.*, 1988), which measures anxiety about performing memory-related tasks. Items include statements such as 'I get anxious when I am asked to remember something'. The MIA anxiety subscale has high internal consistency and acceptable discriminant validity (Dixon *et al.*, 1988).

Objective cognitive variables

Prospective memory

Two objective prospective memory tasks were modified for this project. The first, designated Reminder was a modified version of the Rivermead Behavioural Memory Test (RMBT) Belonging subtest (Wilson *et al.*, 1989). As the participant and the researcher entered the testing room for the first session, the participant was asked to remind the researcher to lock the door at the end of the session. A reminder at the appropriate time scored one, whereas a failure to provide the reminder scored zero. The second prospective memory test, designated Crosses, was modified from the two-minute event-based task employed by Hannon *et al.* (1995). The modified task employed a self-report memory questionnaire as the distracter activity. While filling out this questionnaire, participants were asked to write a cross on the bottom right hand side of each page at the completion of the page. Scores reflected the number of pages marked.

Neuropsychological battery

The battery of neuropsychological tests administered in the second session included: the WTAR (The Psychological Corporation, 2001) to assess English language capacity/estimated premorbid intelligence; the Rey Auditory Verbal Learning Test (RAVLT; Schmidt, 1996) to measure verbal memory; the Behavioural Assessment of the Dysexecutive Syndrome (BADS; Wilson *et al.*, 1996) and Controlled Oral Word Association test (COWA; Lezak *et al.*, 2004) to assess executive function; and the Digit Span subtest from the Wechsler Adult Intelligence Scale Third Edition (WAIS-III; The Psychological Corporation, 1997) to measure short-term auditory memory/verbal working memory.

Mood Depressive symptomatology was rated using the Center for Epidemiologic Studies Depression Scale – Revised (CESD-R; Eaton *et al.*, 2004) and general anxiety symptoms were measured with the Beck Anxiety Inventory (BAI; Beck and Steer, 1993).

A memory-monitoring exercise and an assessment of visual memory were undertaken in the second session in addition to the tests described above. These data will be reported elsewhere.

Statistical analyses

Analyses of variance (ANOVAs), *t*-tests and chi-square tests of independence assessed for group differences in demographics, mood and drug use. Following ANOVA, *post-hoc* comparisons with Bonferroni corrections used the following strategy: (1) EP versus CP; (2) where there was no difference between EP and CP: EP + CP versus LD and (3) where there was a difference between EP and CP: EP versus CP + LD. We aimed to determine if differences were specific to EP participants, or were associated with drug use in general. Because *t*-tests and ANOVAs are relatively robust to violations of the assumption of normality (Gravetter and Wallnau, 2004), we retained non-normal data in original form.

Discriminant Function Analysis (DFA) assessed whether individual metamemory variables and/or patterns of variables differentiated the groups. The analysis was conducted in two parts: the first examined self-reported prospective memory and the second examined self-reported general/retrospective memory, memory-related locus of control and memory-related anxiety. Where the DFA yielded a function that significantly discriminated groups, stepwise DFA determined the minimum number of variables necessary to discriminate. The discriminative value of individual variables was assessed by ANOVA followed by *post hoc* comparison as necessary. Where DFA yielded a significant function, a further stepwise DFA examined the potential impact of any demographic and mood covariates. This approach examined whether metamemory variables were required to discriminate between groups, once variability associated with covariates was accounted for.

Relationships between drug-use variables and self-reported memory were examined in the whole sample. Principal Components Analysis (PCA) reduced the number of dependent self-reported memory variables. Hierarchical multiple regressions separated contributions of demographic, mood and drug-use variables to variability on the metamemory factor scores yielded. The demographic, mood and drug-use variables most likely to contribute to prediction of each factor score were initially identified using backward regression analyses. We entered the variables retained in preliminary backward regressions into the final regression models, with demographic variables entered first, mood variables second, and measures of drug use last.

Relationships between objective cognitive function and self-reported memory were examined in the whole sample using the PCA-generated metamemory factor scores. Using a similar approach to that described above, hierarchical regression analyses separated contributions of demographic variables, mood and objective cognitive function variables to variability on the metamemory factor scores. In addition, because associations between objective cognitive function and self-reported memory may not be independent of memory-related beliefs and feelings, memory-related anxiety and memory-related locus of control were also entered into analyses. Variables retained in preliminary backward regression analyses were entered into the final regression models, with demographic variables entered first, mood variables entered second, memory-related beliefs and feelings entered third, and objective cognitive function variables last. All analyses were performed using SPSS 12.0 (SPSS Inc., Chicago, USA).

Results

Drug screening

No positive blood alcohol reading was detected. One EP urine sample tested positive for opiates and one recorded a low creatinine level, indicating the possibility of a diluted urine sample (both datasets were excluded). Three EP samples tested positive to cannabis metabolites, as did two CP samples. No urine sample tested positive for MDMA.

Demographics

Demographic features of the sample are presented in Table 1. Groups did not differ significantly in gender, age or premorbid intelligence. The combined polydrug group endorsed more symptoms of anxiety and depression and had higher rates of familial risk than did LD controls.

Drug use

As shown in Table 2, groups did not differ on lifetime dose of alcohol, but the combined polydrug group had smoked more cigarettes than LD controls. EP and CP groups did not differ in lifetime use of LSD or cannabis or cannabis use in the month before participation. EP participants had higher lifetime use of amphetamine and had used more recreational drugs than CP users.

Metamemory – group analyses

Table 3 shows mean scores on metamemory variables. The prospective metamemory analysis did not yield a function that differentiated the groups. For the retrospective/general metamemory analysis, the first function significantly discriminated between-groups (Wilks' $\lambda = 0.88$, $\chi^2(8) = 15.79$, $P = 0.046$), accounting for 59% of between group variability. When stepwise DFA was undertaken, MFQ GFF emerged as the only variable required to differentiate the groups (Wilks' $\lambda = 0.94$, $\chi^2(2) = 7.47$, $P = 0.02$). *Post hoc* comparisons indicated that EP users did not differ from CP on the MFQ GFF ($t(90) = 1.15$, $P = 0.25$), but that the combined polydrug group scored lower on this measure than did the LD group (signifying worse self-reported memory function in the polydrug users, $t(130) = 2.52$, $P = 0.01$). Entry of three demographic/mood variables that were found to significantly correlate with MFQ GFF and to differ between groups into a further stepwise DFA indicated that BAI score (the measure of general anxiety) was the only variable required to discriminate (Wilks' $\lambda = 0.93$, $\chi^2(2) = 9.53$, $P = 0.01$). As noted previously, EP and CP groups were equivalent in their self-rated anxiety symptoms, whereas the combined polydrug group had higher BAI scores than LD users. The follow up analysis, therefore, suggested that the discriminative utility of scores on the MFQ GFF might be due to overlapping variance with scores on a measure of general anxiety symptomatology.

Table 1 Demographic features of participants

	Ecstasy polydrug $N = 45$	Cannabis polydrug $N = 48$	Legal drug $N = 40$	Group differences		
	N (%)	*N* (%)	*N* (%)	χ^2 *(df = 2)*		
Sex, female	21 (47)	22 (46)	19 (48)	0.02		
				Overall differences	*EP vs CP*	*EP + CP vs LD*
	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	*F (df)*	*t (df)*	*t (df)*
Depression – CESD-R	12.2 (9.7)	14.0 (9.0)	9.4 (6.3)	3.38* (2,130)	0.94 (91)	2.39* (131)
Anxiety – BAI	8.6 (7.9)	8.1 (6.0)	4.7 (4.0)	4.99* (2,130)	0.32 (91)	3.89* (121.49)
Index of family risk	2.1[a] (1.8)	2.3[b] (1.7)	0.6[c] (1.0)	13.93* (2,117)	0.27 (82)	6.52* (108.62)
Age	22.8 (3.0)	21.7 (3.5)	23.1 (3.7)	2.13 (2,130)	-	-
WTAR raw score/ standard score[d]	38.6/109 (6.1)	38.5/109 (5.1)	37.3/107 (5.7)	0.79 (2,130)	-	-

[a]$N = 37$ due to missing data.
[b]$N = 47$ due to missing data.
[c]$N = 36$ due to missing data.
[d]Standard scores were calculated from mean raw scores using U.S. norms and are presented in Table 1 to facilitate interpretation. Raw scores are used in subsequent analyses because Australian norms are not available for this test.
*$P < 0.05$, assessed with ANOVA and *post hoc* comparisons with Bonferroni corrections where necessary.

Table 2 Patterns of drug use

Lifetime Dose	Ecstasy polydrug $N = 45$	Cannabis polydrug $N = 48$	Legal drug $N = 40$	Overall differences	*EP vs CP*	*EP + CP vs LD*
	Mean (S.D)	Mean (S.D.)	Mean (S.D.)	*F (df)*	*t (df)*	*t (df)*
Alcohol (standard drinks)	4033.8 (5746.8)	3175.0 (3249.4)	1990.8 (3865.1)	2.87 (2,130)	–	–
Nicotine (cigarettes)	12266.2 (20510.7)	8845.4 (20005.9)	1204.0 (3637.1)	5.52* (2,130)	1.03 (91)	4.60* (102.02)
Amphetamines (grams)	23.5 (68.4)	0.3 (1.1)	0 (0)	–	2.68* (44.02)	–
LSD (tabs)	76.9 (328.4)	22.1 (146.7)	0 (0)	–	1.50 (91)	–
No. of recreational drugs ever used	12.2 (4.4)	5.2 (3.2)	1.9 (0.8)	–	9.00* (76.3)	–
Cannabis (grams)	355.6 (616.9)	360.4 (634.2)	0.1 (0.3)	–	0.01 (91)	–
	N (%)	*N* (%)	*N* (%)			
Regular cannabis use in preceding month[a]	4 (9)	5 (10)	0 (0)	–	Fisher's test $P = 1.00$	–
Use of cannabis in preceding month[b]	30 (67)	29 (60)	1 (3)	–	$\chi^2(1) = 0.39$	–
			Mean (S.D.)	Range		
Age of first ecstasy use[c]			18.6 (2.2)	15 – 27		
Lifetime total ecstasy dose (pills)[c]			170.6 (362.8)	13.5 – 2407		
Time since last ecstasy use (days)[c,e]			79.2[d] (108.5)	10 – 425		

[a]Defined as use 4 or more times per week.
[b]Last reported use of cannabis within 30 days of participation.
[c]In EP group, $N = 45$.
[d]$N = 44$ due to missing data.
[e]Prior to neuropsychological assessment session.
*$P < 0.05$, assessed with ANOVA/post-hoc comparisons, independent samples *t*-tests or chi square tests of independence/Fisher's test, with Bonferroni corrections where necessary.

Table 3 Metamemory in EP, CP and LD Users

	EP ($N = 45$)		CP ($N = 48$)		LD ($N = 40$)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
PMQ long-term episodic[a]	2.9	1.1	2.9	0.9	2.5	0.9
PMQ short-term habitual[a]	1.5	0.5	1.6	0.6	1.4	0.5
PMQ internally cued[a]	2.9	1.4	2.9	1.0	2.4	1.1
MFQ general frequency of forgetting[b]	159.8[e]	21.4	154.9	19.2	166.9	20.2
MIA capacity[b]	57.6	7.8	56.5	8.6	59.0	7.6
MIA locus[c]	32.1	4.8	29.7	4.7	30.6	4.1
MIA anxiety[d]	40.7	6.8	41.7	8.0	41.0	7.4

[a]Higher scores on these measures indicate more self-reported memory failures.
[b]Higher scores on these measures indicate better reported memory capacity.
[c]Higher scores indicate a more internal memory-related locus of control orientation.
[d]Higher scores indicate higher levels of memory-related anxiety.
[e]$N = 44$ due to missing data.

Data reduction

All of the five self-reported memory function subscale scores were factorable, and PCA using oblique rotation resulted in the extraction of two factors, with the first factor representing self-reported prospective memory (PMQ LTE, PMQ STH and PMQ IC) and the second encompassing self-reported general/retrospective memory (MIA Capacity and MFQ GFF).

Relationships between drug-use variables and self-reported memory

As shown in Table 4, drug-use variables added to prediction of each of the two self-reported memory factor scores, over and above the effects of demographics and mood. In each case, use of cannabis in the month prior to participation was weakly associated with self-reported memory function, such that those who consumed cannabis recently reported worse memory functioning (self-reported prospective memory: $sr = 0.18$, $sr^2 = 0.03$; self-reported general/retrospective memory: $sr = -0.19$, $sr^2 = 0.04$). In addition, higher lifetime doses of alcohol were associated with worse self-rated general/retrospective memory ($sr = -0.17$, $sr^2 = 0.03$). Inspection of relationships between mood symptoms and self-reported memory indicates that CESD-R score was weakly correlated with self-reported prospective memory function ($sr = 0.22$, $sr^2 = 0.05$), such that higher ratings of depression were associated with more self-reported memory failures. BAI score was weakly associated with scores on the self-reported general/retrospective factor ($sr = -0.20$, $sr = 0.04$), with higher self-rated anxiety associated with worse self-reported memory function.

Relationships between objective cognitive function and self-reported memory

Table 5 shows the contributions of demographic, mood, memory-related beliefs/feelings and objective cognitive function variables to prediction of self-reported memory. MIA anxiety was weakly correlated with scores on the self-reported prospective memory factor score ($sr = 0.23$, $sr^2 = 0.05$) and moderately associated with scores on the self-rated general/retrospective factor ($sr = -0.51$, $sr^2 = 0.26$). In each case, higher ratings of memory-related anxiety were associated with more self-rated memory failures.

Independent of the effects of demographics, mood and MIA anxiety, a combination of objective cognitive variables contributed 16% to prediction of the self-reported prospective memory factor. Inspection of semi-partial correlations indicated that relationships were small (explaining between 1 and 5% of variance). Although

Table 4 Demographic, mood and drug-use variables as predictors of self-reported memory using hierarchical multiple regression analyses

Self-Reported Prospective Memory Factor Score ($N = 132$)

Model	R	R^2	Adj. R^2	P	Change R^2	P[d]
1[a]	0.22	0.05	0.04	0.01	0.05	0.01
2[b]	0.32	0.10	0.09	0.00	0.05	0.01
3[c]	0.36	0.13	0.11	0.00	0.03	0.05

Self-Reported General/Retrospective Memory Factor Score ($N = 130$)

Model	R	R^2	Adj. R^2	P	Change R^2	P
1[e]	0.21	0.04	0.04	0.02	0.04	0.02
2[f]	0.32	0.10	0.08	0.00	0.06	0.02

[a]Predictors: Age.
[b]Predictors: Age, CESD-R.
[c]Predictors: Age, CESD-R, use of cannabis in past month.
[d]To 2 decimal places.
[e]Predictors: BAI.
[f]Predictors: BAI, use of cannabis in past month, lifetime total dose of alcohol.

Table 5 Demographic, mood, memory-related beliefs/feelings and objective cognitive function variables as predictors of self-reported memory using hierarchical multiple regression analyses

Self-reported prospective memory factor score ($N = 123$)

Model	R	R^2	Adj. R^2	P	Change R^2	P
1[a]	0.22	0.05	0.04	0.01	0.05	0.01
2[b]	0.32	0.10	0.09	0.00	0.05	0.01
3[c]	0.40	0.16	0.14	0.00	0.06	0.00
4[d]	0.57	0.32	0.26	0.00	0.16	0.00

Self-reported general/retrospective memory factor score ($N = 131$)

Model	R	R^2	Adj. R^2	P	Change R^2	P
1[e]	0.20	0.04	0.03	0.03	0.04	0.03
2[f]	0.53	0.28	0.27	0.00	0.25	0.00
3[g]	0.56	0.31	0.29	0.00	0.03	0.10

[a]Predictors: Age.
[b]Predictors: Age, CESD-R.
[c]Predictors: Age, CESD-R, MIA Anxiety.
[d]Predictors: Age, CESD-R, MIA Anxiety, RAVLT recognition – correct negatives, BADS rule shift, BADS action program, BADS zoo map, COWA FAS, COWA animals, Digit span total, Crosses.
[e]Predictors: BAI.
[f]Predictors: BAI, MAI Anxiety.
[g]Predictors: BAI, MIA Anxiety, RAVLT immediate recall, RAVLT delayed recall.

some of these correlations were in the expected direction (i.e., better performance on the objective test was associated with fewer self-reported memory failures), some correlations indicated that people who reported more memory failures scored *better* on objective cognitive measures. Objective cognitive variables did not add to prediction of the self-reported general/retrospective memory factor, after accounting for the effects of demographics, mood and MIA anxiety.

Discussion

The results did not support the hypothesis that ecstasy users would report worse memory function than would controls. In addition, there was no difference between ecstasy-users and the two non-ecstasy-using groups on memory-related locus of control or anxiety. Group-level findings, therefore, did not support a specific effect of ecstasy on the dimensions of metamemory assessed.

This finding is in keeping with some earlier research indicating that ecstasy users are not differentiable from non-users on measures of self-reported memory (e.g., Gouzoulis-Mayfrank *et al.*, 2000) and self-rated cognitive function in general (e.g., Halpern *et al.*, 2004). However, it is not consistent with other findings that ecstasy users report lowered prospective memory function compared with controls (e.g., Heffernan *et al.*, 2001a, b).

Although there was no evidence of an ecstasy-specific effect, there was some indication of a relationship between illicit drug use in general and lowered self-rated memory. The three groups were differentiated by one of the general/retrospective self-reported memory scales, with the combined polydrug group scoring lower on this measure than the legal drug group. However, inclusion of demographic and mood variables into the equation altered this outcome, with the measure of general anxiety symptoms found to be the only variable necessary to discriminate. The group-level association between use of illegal drugs and lowered self-reported memory appears, therefore, to be due to common variance with anxiety symptoms.

The apparent involvement of mood symptoms in the discriminative utility of self-reported memory is consistent with reports in other populations that mood influences memory self-ratings (e.g., Randolph *et al.*, 2004), even in the absence of effects on objective function (Shelton and Parsons, 1987; Wong *et al.*, 2000). In the present sample, although there were relationships between mood and self-rated memory, there was no comparable effect of mood on any of the objective measures. This would suggest that mood symptoms impacted on self-reports of memory function through the pessimistic self-appraisals characteristic of negative affect (see Lane and Zelinski, 2003), rather than through an effect on objective function. No previous research that has identified a relationship between self-reported memory and ecstasy use has assessed for impacts of mood symptoms. The present results, therefore, underscore the importance of adequate control for mood symptoms in future research employing self-rating memory instruments in young adult, illicit drug-using populations.

Previous research has found that expectancy effects, possibly associated with media reporting of cognitive problems in ecstasy users, may contribute to deficits in objective cognition observed in some ecstasy-using groups (Cole *et al.*, 2006). It is possible that such expectancy effects might have even more pronounced effects on self-reported memory in drug users. The present data do not appear to support such an effect, with no difference between the three groups on memory-related anxiety, which would be expected to be more pronounced in drug users if they had altered memory-related expectancies as a result of media coverage. However, the possibility of expectancy effects cannot be completely ruled out because neither drug-specific memory expectancies nor exposure to relevant media coverage were assessed.

Although there was no relationship between ecstasy-use variables and self-rated memory, recent use of cannabis made significant, small contributions to prediction of prospective and general/retrospective self-reported memory. This suggests that questionnaire measures of memory may be vulnerable to acute/subacute drug effects. The questionnaires used asked participants to report on their memory failures in general, or within specific time periods in the past. Although participants reported being drug free at the time of participation, they are likely to have been drug affected for at least a portion of the time that they were reporting on, which may account for the relationship between self-rated memory and recent use of cannabis.

Lifetime dose of alcohol also added weakly to prediction of self-reported general/retrospective memory. Relationships between alcohol use and self-rated memory have previously been reported (e.g., Heffernan *et al.*, 2002). However, previous research has

assessed self-rated prospective memory, whereas in the current sample alcohol doseage contributed weakly to prediction of general/retrospective memory function. As such, replication is required.

The final hypothesis was that correlations between self-reported memory and objective cognitive function would not be strong, once the effects of demographics, mood and memory-related beliefs and feelings were accounted for. This hypothesis was supported, with a combination of objective cognitive variables contributing a small/moderate amount to prediction of self-reported prospective memory scores and no corresponding relationship for general/self-reported memory. This is consistent with previous research in other populations, which has found only weak relationships between laboratory tests of cognitive function and self-reported memory (e.g., Hannon *et al.*, 1995; Randolph *et al.*, 2004).

The objective cognitive variables that were associated with self-reported prospective memory included measures of memory, attention/working memory and executive function. This is consistent with understandings of successful prospective memory performance as reliant on a range of cognitive capacities, rather than reflecting 'pure' memory processes (Ellis, 1996). Although this is the case, some relationships between individual executive function variables and self-reported prospective memory were in the opposite direction to that which would be expected, with better objective performance associated with more self-rated memory failures. Even though weak, the existence of such relationships supports the idea that people with impaired executive function may have reduced awareness of their own difficulties (Manchester *et al.*, 2004).

The main limitation of this study was the failure to include an objective measure of everyday memory function. It is possible, therefore, that the low correspondence between objective and self-report measures occurred because the laboratory measures of cognitive function were not ecologically valid. However, a variety of evidence suggest that traditional neuropsychological measures are at least moderately valid indicators of everyday function (e.g., see Chaytor and Schmitter-Edgecombe, 2003; Crowe, 2005). In addition, conclusions about chronic effects of drugs appear best made on the basis of cognitive capacity, rather than everyday function, which is more vulnerable to non-cognitive factors such as variations in level of environmental cognitive demand (Chaytor and Schmitter-Edgecombe, 2003).

Although this is the case, day-to-day cognitive function in ecstasy and other drug users has important practical implications (Heffernan *et al.*, 2001b). Future research could, therefore, valuably address everyday memory function in relation to ecstasy use, potentially employing objective cognitive assessment occurring within the working week, an approach previously used to assess everyday functioning in cannabis users (Wadsworth *et al.*, 2006).

Results of the present study suggest that self-report of memory function may not be a specific methodology with which to assess objective memory capacities in relation to ecstasy and other drug use. The findings, further, support a metamnemonic approach to the study of self-reported memory in ecstasy and other drug users, with rating of one's own memory performance emerging as a complex process involving a variety of psychological characteristics in addition to one's objective memory performance.

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Conflict of interest statement

None.

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