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ORIGINAL INVESTIGATION

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Ecstasy (MDMA) effects upon mood and cognition: before, during and after a Saturday night dance

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Abstract Three groups of young people (aged 19–30 years) were compared: 15 regular ecstasy users who had taken MDMA (3,4-methylenedioxymethamphetamine) on ten or more occasions; 15 novice ecstasy users who had taken MDMA on fewer than ten previous occasions; and 15 controls who had never taken MDMA. Each subject completed a cognitive test and mood scale battery four times: an initial drug-free baseline, at a Saturday night dance/club (on-drug), then 2 days later, and 7 days later. On the Saturday night, regular ecstasy users took an average of 1.80 MDMA tablets, novice users took 1.45 MDMA tablets, while controls mostly drank alcohol. The consumption of cannabis and cocaine at the club was similar across groups. All three groups reported positive moods at the dance club (on-drug), although there were borderline trends ($P < 0.10$) for less sadness/depression in the MDMA subgroups. However 2 days afterwards, the ecstasy users felt significantly more depressed, abnormal, unsociable, unpleasant, and less good tempered, than the controls. Cognitive performance on both tasks (verbal recall, visual scanning) was significantly reduced on-MDMA. Memory recall was also significantly impaired in *drug-free* MDMA users, with regular ecstasy users displaying the worst memory scores at every test session. This agrees with previous findings of memory impairments in drug-free ecstasy users. Animal data have shown that MDMA can generate long-term serotonergic neurodegereration in various brain areas, including the hippocampus. The cognitive deficits in drug-free recreational ecstasy users, suggest that MDMA may also be neurotoxic in humans.

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Introduction

The synthetic amphetamine derivative MDMA (3,4-methylenedioxymethamphetamine), or "ecstasy", first became popular in the mid-1980s at acid house parties and raves. Today, it is readily available as an illicit drug at many clubs and recreational venues. It has been estimated that half-a-million ecstasy tablets are taken each weekend in the UK (Saunders 1995), with 13% of British university students reporting they had used it (Webb et al. 1996). It is also widely consumed in other westernised countries (Peroutka et al. 1988; Solowij et al. 1992; Cuomo et al. 1994; Saunders 1995; Lenton et al. 1997). Because of its illegal status, it is not possible to study its effects upon human behaviour using the traditional double-blind placebo-controlled methodology [Downing (1986) was undertaken before MDMA was scheduled in the USA]. Most information on the psychobiological effects of MDMA therefore comes from the following sources. Firstly, studies of recreational drug users, who are asked to describe their experiences on MDMA (Peroutka et al. 1988; Solowij et al. 1992; Curran and Travill 1997; Davison and Parrott 1997; Parrott and Stuart 1997). Secondly, medical case studies, following drug-induced hyperthermia, hyponatraemia convulsions, and psychiatric or neurological disorders (Dowling et al. 1987; Schmidt 1987; Henry et al. 1992; Lee 1994; Maxwell et al. 1994; Series et al. 1994; Squier et al. 1995; McCann et al. 1996; Spatt et al. 1997). Thirdly animal data, where MDMA is administered under controlled conditions in the laboratory; these studies have provided extensive information on the neurochemical and neurotoxic effects of MDMA in rats and monkeys (Ricaurte et al.

1988, 1992; Steele et al. 1994; Green et al. 1995; Frederick and Paule 1997).

Recreational durg users typically describe a range of positive moods on-MDMA: elation, energeticness, agreeableness, and closeness to others (Peroutka et al. 1988; Liester et al. 1992; Solowij et al. 1992; Davison and Parrott 1997; Parrott 1995, 1997; Parrott and Stuart 1997). However, negative moods generally develop during the period of neurochemical depletion afterwards, when feelings of lethargy, irritability, and depression predominate. This cycle of positive moods on-drug, and negative moods afterwards, was confirmed in a prospective study by Curran and Travill (1997). Twelve recreational ecstasy users were compared with 12 alcohol drinkers (controls), at a Saturday night dance/club, then 1 and 4 days later. The ANOVA group by time interaction was significant for most mood scales, with MDMA users reporting comparatively better moods on the Saturday night, and worse moods in the days afterwards (Table 2 in Curran and Travill 1997). Unfortunately, the data from each period were not separately analysed; thus it is unclear whether moods were significantly better while on MDMA, or significantly worse afterwards.

Several studies have found that drug-free recreational ecstasy users display significant memory impairments, whereas their performance on other cognitive tests is generally normal (Krystal et al. 1992; Spatt et al. 1997; Morgan 1998; Parrott 1998; Parrott et al. 1998). Animal studies have shown that MDMA can lead to serotonergic (5-HT) neurodegeneration, in the hippocampus and other brain areas (Ricaurte et al. 1988, 1992; Steele et al. 1994; Green et al. 1995). This suggests that the memory decrements in humans may reflect serotonergic neurodegeneration (Parrott and Stuart 1997; Parrott et al. 1998; Spatt et al. 1997; Szabo et al. 1997; Morgan 1998). The current study was designed to provide further data on the cognitive skills and mood states of recreational ecstasy users. The first aim was to assess the acute effects of MDMA self-administration upon mood and cognition. Previously, this has only been reported by Curran and Travil (1997), but they did not have a pre-drug baseline. The second aim was to monitor the time course of the mood/cognitive changes, during the neurochemical recovery period afterwards. Finally, the study investigated whether drug-free ecstasy users would again demonstrate a cognitive profile of selective memory impairments.

Materials and methods

Subjects

Forty-five unpaid subjects were obtained using the "snowball" technique, developed for illicit drug research (Solowij et al. 1992; Parrott and Stuart 1997). Word of the study was spread amongst friends and acquaintances who regularly visited a large nightclub in the Epping Forest area of north-east London. Three subgroups were tested: 15 regular ecstasy users who stated that they had taken MDMA (3,4-methylenedioxymethamphetamine) on ten or more previous occasions; 15 novice ecstasy users who had taken MDMA on one to nine previous occasions; and 15 controls who stated that they had never taken MDMA. The ages of each group were similar (21.4, 22.8, 21.3 years, respectively; overall range 19–30 years); as was their gender distribution (8/7, 8/7 and 10/5: females/males per group, respectively). Drug use at the dance/club was recorded on a self-rating questionnaire, where each user noted the drugs they had taken that night. The regular ecstasy users took slightly more MDMA than the novice users (1.80 compared to 1.45 MDMA tablets), while none of the control group took any MDMA. Three other illicit drugs were taken: cannabis, cocaine, and amphetamine. Cannabis was smoked by: three non-user controls, one novice MDMA user, and two regular MDMA users. Cocaine was taken by: two controls, two novice MDMA users, and four regular MDMA users. One novice MDMA user took amphetamine. Alcohol was taken by ten controls, five novice MDMA users, and six regular MDMA users. The number of alcoholic drinks consumed by each drinker was somewhat higher in the controls: 5.0 drinks per control group drinker, 2.7 drinks per novice MDMA group drinker, 3.7 drinks per regular MDMA group drinker.

Assessment measures

These comprised auditory word recall, visual search, and a mood scale battery. Auditory recall involved lists of 16 words, presented at one word every 2 s, over headphones from a portable tape recorder. The subject listened to the word list, waited 30 s, and when instructed by the experimenter, wrote down all the words they could remember in any order. Each word list was matched for frequency of everyday occurrence and overall word length. Two word lists were given at each test session. Eight word lists were varied across sessions. This "supraspan" word recall task has been shown to be sensitive to the amnesic effects of scopolamine (Parrott 1986).

The visual search task was presented on a hand-held minicomputer (Apple Newton Messagepad; Tiplady 1996). A target letter "L" was embedded in an array of distractor letters in different orientations. The subject was required to press the target letter with a light pen as rapidly as possible. In the easy discrimination condition, the distractor letters were all "X"s. In the hard discrimination condition, the distractor letters were "T"s. Four sizes of matrix array were presented: 2×2, 3×3, 4×4, and 5×5. Only the 2×2 and 4×4 data were analysed/presented here, since we were only interested in visual scanning at two levels of difficulty. This task has been shown to be sensitive to the disruptive effects of alcohol (Newman et al. 1996; Tiplady 1996).

Visual analogue mood scales were presented on the Newton Messagepad (Newman et al. 1996; Tiplady 1996). For each unipolar mood state, one end of the linear scale was marked "Do not feel at all" (0), while the other end was marked "Feel completely" (100). The subject indicated their current mood state by marking the line with a light pen (initial responses could be amended). Sixteen mood states were covered; they are listed in Table 2.

Procedures and ethics

The baseline data were collected either at the subject's home, or the home of the experimenter. Each subject arranged a time for this initial baseline test when they were drug free, had not taken MDMA for at least 1 week, or any other illicit drug for over 24 h. The baseline session preceded when the subjects stated they were going clubbing, and when the MDMA users were planning to take ecstasy. The second test session was undertaken at the dance club venue. This was noisy and crowded, but a comparatively quiet area was

Table 1 Summary of ANOVA findings

Cognitive tests	ANOVA factors			
	Group	Session	Group × session	Others
Memory recall (total words)	***	***	**	
Visual search × 2 (response time)	**	***	***	(Difficulty*)
Visual search × 4 (response time)	*	***	**	(Difficulty**)
Mood scales				
Abnormal	***	***	***	
Calm	·	·	·	
Clearheaded	·	***	·	
Depressed	+	***	***	
Drowsy	·	**	·	
Energetic	·	·	·	
Good tempered	·	***	*	
Ill	·	·	·	
Interested	·	*	·	
Quick witted	·	***	·	
Sad	*	***	***	
Sober	+	***	**	
Steady	·	*	*	
Unpleasant	+	***	**	
Unsociable	·	***	**	
Well co-ordinated	*	***	·	

Two-tailed probabilities: $^{+}P < 0.10$, $*P < 0.05$, $**P < 0.01$, $***P < 0.001$

Others: covers the three-way ANOVA factors (involving difficulty level) for the visual search task only

arranged for testing. Each subject arranged to meet the experimenter 2–8 h after they had taken their MDMA tablets, or equivalent times for control subjects.

Unfortunately, not every subject was seen as planned, and eight of the 30 MDMA subjects (four from each group), were tested 8–16 hours after taking their MDMA. The third and fourth test sessions were undertaken 2 days and 7 days later, at venues similar to the first session.

The aims and objectives of the study were fully described to each individual beforehand. It was emphasised that neither the experimenters nor the University condoned the taking of illicit drugs such as MDMA. Thus the study should not be seen as providing approval or encouragement for the use of ecstasy or other illegal drugs, particularly since they could have serious side effects. It was stated that taking part in the study was voluntary, that they could withdraw at any time without giving a reason, that the data would be treated as strictly confidential, and that subject names would not be divulged outside the study. Those who agreed to take part were required to sign an informed consent form. The study was approved by the University Ethics Committee.

Results

Each mood scale was analysed by a two-way ANOVA, with subgroup and test session as the two factors (Table 1). The memory task was subjected to a similar two-way ANOVA, while visual search was analysed by three-way ANOVA, with difficulty level as the third factor (Table 1). The group means for the cognitive tasks and mood scales are shown in Table 2. The data from each test session were also subjected to a series of one-way ANOVAs, followed by Duncan paired comparison tests. The Duncan test comparisons between the control group and MDMA subgroups, are presented in Table 2. Selected findings are also presented graphically (Figs. 1–3).

Discussion

Recreational MDMA users displayed significantly worse memory scores than controls at every test session (Fig. 1). On the Saturday night, ecstasy users recalled 60–70% of the words remembered by controls; thus an acute dose of MDMA markedly reduced memory ability (Fig. 1). Memory impairments were also evident at the other sessions, including the initial baseline and final test periods, when ecstasy had not been taken recently (Fig. 1). These memory decrements were evident in both groups of ecstasy users, but were most pronounced in the regular users (Table 2; Fig. 1). Several previous studies have found memory decrements with ecstasy users. Curran and Travill (1997) compared the prose recall and serial subtraction of numbers (working memory task), of recreational ecstasy users and alcohol drinkers on three occasions: during a Saturday night dance while on-drug, 1 day later, and 4 days later. Overall performance levels were comparatively lower in the MDMA users (ANOVA group effect: $P < 0.01$ for serial subtraction; $P < 0.06$ for prose recall). However, the data for each test session were not analysed separately; thus it is unclear whether performance was significantly impaired while on-drug, or during the days afterwards. Poor memory performance has also been reported with drug-free MDMA users. Krystal et al. (1992) found low memory scores, but normal scores on other cognitive tasks, in nine recreational ecstasy users who not had taken MDMA for an average of 66 days. Parrott et al. (1998) found significantly lower immediate word recall and delayed word recall in drug-free novice and regular MDMA users compared to non-user controls, whereas performance on the other cognitive tasks was similar across groups. Morgan (1998) found significant memory impairments in ecstasy users, in comparison with to polydrug users who had never taken MDMA. Possible reasons for these poor memory scores are discussed below.

Visual search task performance was also impaired following the acute self-administration of MDMA. In particular, the visual scanning of regular MDMA users was significantly slower than controls, while novice MDMA users were impaired to a lesser extent (Table 2; Fig. 2). In contrast, visual search performance was not generally impaired in the off-drug sessions, although the controls displayed superiority under some

Table 2 Cognitive test and mood scale group means for regular MDMA users, novice MDMA users, and non-user controls

	Pre-club baseline			At club (on-drug)			2 days after			7 days after		
	Non-user controls	Novice MDMA users	Regular MDMA users	Non-user controls	Novice MDMA users	Regular MDMA users	Non-user controls	Novice MDMA users	Regular MDMA users	Non-user controls	Novice MDMA users	Regular MDMA users
Cognitive tests												
Memory word recall	15.1	13.9^{+}	12.0**	13.5	9.6**	8.1**	12.9	11.9	11.1*	13.4	11.7*	11.4*
Visual search × 2 (easy)	1.2	1.9**	1.8*	2.8	4.1	6.8*	1.9	2.2	2.2	2.7	2.9	2.6
Visual search × 2 (hard)	1.7	1.8	2.1	2.9	4.7	7.4**	2.6	2.6	2.7	2.7	3.1	2.9
Visual search × 4 (easy)	1.7	2.0	2.2*	4.1	6.4	8.4^{+}	2.5	2.9	3.3*	2.9	3.2	3.0
Visual search × 4 (hard)	2.5	2.7	2.7	4.1	6.9^{+}	8.9**	3.2	3.0	3.5	3.6	3.6	3.5
Mood scales												
Abnormal	9	8	7	36	64**	74**	6	23*	26**	6	6	5
Calm	83	86	80	80	77	77	77	73	77	84	85	81
Clearheaded	86	92*	94*	49	48	44	93	93	88	91	94	95
Depressed	36	45^{+}	34	31	22	20^{+}	36	59**	48^{+}	37	37	39
Drowsy	44	43	27^{+}	57	41	40	23	33	35^{+}	38	28*	25**
Energetic	60	60	68	51	62	64	72	62	56*	67	70	70
Good tempered	89	84	93	85	90	88	85	65*	72^{+}	86	84	87
Ill	15	21	13	27	22	17	14	22	17	18	17	14
Interested	65	65	67	68	80	82	67	67	70	70	73	73
Quick witted	75	66	76	58	59	52	82	79	78	77	74	84
Sad	22	31*	18	20	9^{+}	9^{+}	22	56**	53**	22	25	21
Sober	96	94	92	46	78*	67	95	96	96	96	96	96
Steady	91	92	93	50	76*	71^{+}	95	93	90*	90	91	93
Unpleasant	11	14	9	12	9	10	15	36**	28^{+}	14	18	16
Unsociable	21	27	15	17	12	17	16	39**	33*	22	18	18
Well co-ordinated	77	89	85	53	66	69	86	93	92	82	87	91^{+}

Duncan test two-tailed comparisons between controls and MDMA users, at each test seesion: $+P < 0.10$, $* P < 0.05$, $**P < 0.01$

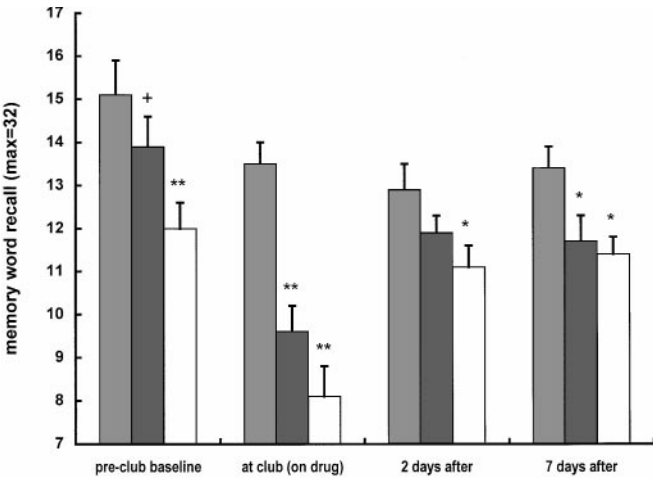

Fig. 1 Memory word recall (+ SE) in regular MDMA (ecstasy) users, novice MDMA users, and non-user controls. ▒ Non-user control, ■ novice MDMA user, □ regular MDMA user

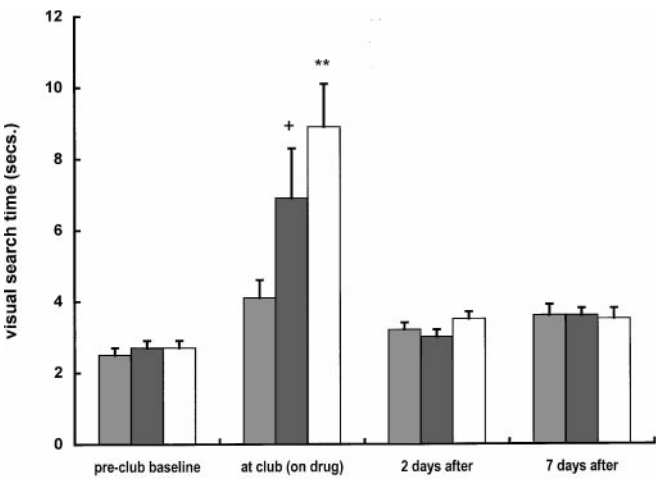

Fig. 2 Visual search times (+ SE) for regular MDMA (ecstasy) users, novice MDMA users, and non-user controls (4 × 4 matrix, hard discrimination condition. ▒ Non-user control, ■ novice MDMA user, □ regular MDMA user

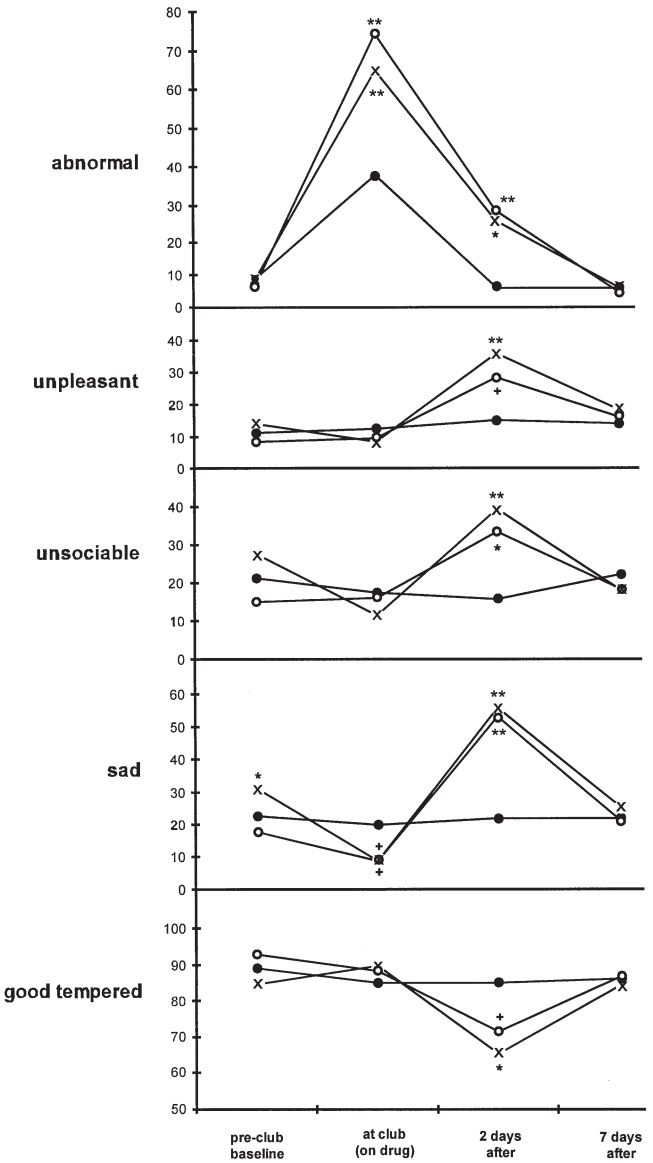

Fig. 3 Mood profiles over the week in regular MDMA (ecstasy) users, novice MDMA users, and non-user controls. Comparison between controls and MDMA users Duncan's multiple range test: $^{+}P < 0.10$, $^{*}P < 0.05$, $^{**}P < 0.01$. ● Non-users, × novice MDMA users, ○ regular MDMA users

conditions (Table 2). Previous studies have generally found unimpaired performance in drug-free recreational ecstasy users, across a range of (non-memory) cognitive tasks: simple reaction time, choice reaction time, number vigilance, and visuo-spatial ability (Krystal et al. 1992; Spatt et al. 1997; Morgan 1998; Parrott et al. 1998). Overall, therefore, drug-free ecstasy users do not seem to be impaired in basic (non-memory) cognitive skills, although Morgan (1998) has found evidence for deficits in tests of higher executive functioning.

The difficulty of processing cognitive information while under the influence of MDMA, was illustrated in the tape-recorded interviews. One novice MDMA user admitted: "When I was trying to complete the memory task my mind kept wandering". Another commented upon the visual search task: "The shapes seemed to keep moving and I knew that they shouldn't because they didn't the first time I did it. I really had to concentrate to pick the right one… The memory test was also difficult because I just couldn't remember any of the words." Another MDMA user noted: "The whole evening goes so quickly. The next day I try and think back to the evening, I can't remember anything". Another regular user recalled how they used to be strongly against drug taking, but then decided to try it: "I read this article about ecstasy being safer than aspirin… I now take 2–3 in the course of an evening… The shape task was extremely difficult…it is like there is a scene going on in your head, and I had

to keep reminding myself to stop watching and keep on with your experiment…there was the same problem with the memory test". Yet another regular MDMA user admitted finding the memory task difficult, but commented: "I have got a bad memory anyway".

There are several possible explanations for the poor memories of drug-free ecstasy users. It may be due to chance, but this is unlikely given the number of studies where memory deficits have now been shown (Krystal et al. 1992; Spatt et al. 1997; Morgan 1998; Parrott et al. 1998). Alternatively, it may reflect subject self-selection, with only people having poor memories deciding to take MDMA. However, this post-hoc explanation lacks a clear rationale, particularly given the near-normal scores of ecstasy users on other cognitive tasks (i.e. they are not cognitively impaired). A third possibility is that the memory problems are caused by other illicit drugs, particularly cannabis. Although this explanation is initially plausible, the empirical evidence is against it. Every subject in the study of Curran and Travill (1997) was a cannabis user, yet the controls still displayed better cognitive performance than the ecstasy users. The three groups in the current study took similar amounts of other illicit drugs at the club, yet their memory scores were quite different (Table 1). Morgan (1998) attempted to match their MDMA users and polydrug user controls, on the past use of other illicit drugs, but still found relative memory impairments in the MDMA group. Thus the memory deficits in ecstasy users do not seem to be an artefact of other drug use, although this issue remains currently unresolved [the long-term cognitive effects of all illicit psychoactive drugs (e.g. cannabis, LSD, cocaine) need to be properly studied, but this is difficult because of their illegal status]. The final explanation is that the memory deficits (Fig. 1) are directly caused by MDMA.

Laboratory studies with rats and monkeys have shown that MDMA produces serotonergic neurodegeneration; this has been demonstrated in various brain areas including the hippocampus, which is important for memory functioning (Ricaurte et al. 1988, 1992; Steele et al. 1994; Green et al. 1995). Serotonergic neurotoxicity following MDMA administration has been shown in numerous studies; moreover, the neural damage seems to be long-lasting: "In nonhuman primates MDMA-induced serotonin neurotoxicity is prolonged and possibly permanent…. The dose of MDMA that damages serotonin neurones in monkeys is close to that typically taken by recreational users, and smaller than that taken by some MDMA abusers in the setting of raves" (McCann et al. 1996, p. 112). There is also clinical evidence for brain damage in humans. Spatt et al. (1997) described a recreational MDMA user who presented with anterograde amnesia and marked impairments in episodic memory, but normal performance on other neuropsychological tests. An MRI brain scan revealed bilateral lesions in the serotonin-rich globus pallidus, similar to that reported in an earlier MDMA/polydrug fatality (Squier et al. 1995). PET scans of recreational ecstasy users have also demonstrated reduced levels of 5-HT transporter binding, in various brain regions (Szabo et al. 1997). There is therefore consistent evidence that these memory deficits may reflect serotonergic neurodegeneration, directly caused by MDMA self-administration (Fig. 1). This raises the question: how much ecstasy needs to be taken before cognitive deficits develop? Our regular users were comparatively more impaired than the novice users, providing some support for the (arbitrary) split between those who have taken ecstasy on less than, or more than, ten occasions. However, the relationship between cognitive performance and MDMA consumption (both frequency and intensity), need to be investigated more fully.

Turning to the mood state data, all three groups reported surprisingly similar moods on the Saturday night. Thus each subgroup reported high ratings for feeling "good tempered" at the nightclub (Fig. 3). Ecstasy users did report a borderline trend for lower sadness and less depression than controls ($P < 0.10$; Fig. 3), together with greater abnormality (Table 2). In contrast, the controls were significantly less sober and less steady, probably because of their alcohol consumption (Table 2). In retrospective surveys, ecstasy users typically describe feelings of euphoria, elation, and greater acceptance of others (Peroutka et al. 1988; Liester et al. 1992; Solowij et al. 1992; Davison and Parrott 1997; Parrott 1995; Parrott and Stuart 1997), probably due to an acute boost of serotonin activity (Steele et al. 1994; Green et al. 1995). The absence of superior moods in our ecstasy users was therefore unexpected (Table 2; Fig. 3). Various factors may, however, have contributed to this. Firstly, previous studies have generally not included non-user controls (except Curran and Travill 1997), and most dancers/clubbers would be expected to experience good feelings on their Saturday night out. Secondly, our controls had taken a range of other psychoactive drugs which may have contributed to their positive moods (Table 2; Fig. 3). Future studies should include a drug-free group, although the majority of clubbers do seem to take psychoactive drugs [Lenton et al. (1997) found that only 8% of clubbers had *not* consumed any psychoactive substance]. A related problem was ceiling/floor effects. Thus "good tempered" ratings were already high in the control group, making it difficult to generate significant mood superiority in the other groups.

Two days afterwards, the ecstasy users reported a range of deleterious moods: depression, sadness, unsociability, unpleasantliness, and abnormality (Table 2; Fig. 3). Negative moods tend to develop during the period of serotonin depletion which follows an ecstasy trip. Thus lethargy, depression, moodiness, and irritability, are often reported in the days post-MDMA (Peroutka et al. 1988; Solowij et al. 1992; Davison and

Parrott 1997). In their prospective study, Curran and Travill (1997) found a range of positive moods in active ecstasy users, but mid-week blues afterwards. It is therefore clear that MDMA can lead to marked mood swings. Feelings of depression, sadness, calmness, pleasantliness and sociability, fluctuated markedly over the week in our ecstasy users, whereas these moods were fairly stable over time in the controls (Fig. 3). Curran and Travill (1997) found that some of their ecstasy users developed clinically borderline levels of midweek depression. This was confirmed in the interviews here, where depression was recognised as an occupational hazard of regular ecstasy use: "My other friends that do a lot more drugs than me are sometimes really moody, and some cry quite often for no reason"... "I definitely do get depressed sometimes"... "I had the occasional mid-week depression, and occasionally found myself crying for no real reason".

Although this study was not designed to monitor the medical or physiological effects of MDMA, several of the interviews confirmed its dangerous side-effects (e.g. hyperthermia, hyponatraemia, convulsions, catatonic stupor, vomiting, motor tics: Dowling et al. 1987; Schmidt 1987; Henry et al. 1992; Maxwell et al. 1993; Lee 1994; McCann et al. 1996). One regular MDMA user admitted to vomiting after each period of drug taking; another to paranoid feelings; a third to repetitive tingles and spontaneous arm movements: "Half the time I do even realise I am moving my arm, until my friend tells me stop...may be there is some permanent damage or something". Two severe medical emergencies were also described: "My boyfriend had a really bad time...he was getting more and more worked up and really sweating badly. His face looked mad and his eyes were practically poping out of his head. In the end they had to take him to hospital...He wasn't right for days afterwards and now won't touch pills. I still do them occasionally, but never more than two". Another regular user recalled: "On holiday... I took two at once and after about 45 minutes I couldn't move a single muscle and basically just collapsed on the dance floor. My mates took me back to the hotel, and I was sick all night long, and kept having really bad hallucinations. My mates were more scared than me because the next day I couldn't remember a lot at all. I felt terrible for a couple of days, but after that I was fine. It hasn't put me off taking them".

In summary, the current study was the first to investigate the acute effects MDMA self-administration upon mood and cognitive performance, in comparison with pre-drug baseline. As expected, the recreational ecstasy users reported very good feelings on-MDMA; however, the other clubbers/dancers also reported good moods, even though they had not taken any ecstasy. The good moods of all the Saturday night clubbers, illustrate the importance of context and expectacy for generating positive feelings. It might be argued that our questionnaire was insensitive to the unique mood elevating properties of ecstasy; thus questions on "elation" or "empathy" might have generated significant group differences. However, the current mood scales were certainly sensitive to the negative feelings which developed in the days afterwards, during serotonergic depletion. Thus our MDMA users reported considerable mood swings during the week they had used ecstasy (Fig. 3). The cognitive test findings indicated that the acute self-administration of MDMA markedly impaired information processing ability (Figs. 1, 2), and emphasised the dangers of undertaking skilled activities like car driving under its influence (Schifano 1995). However, the most worrying finding was the poor memory scores of the drug-free ecstasy users, particularly those who had taken MDMA on more than ten occasions (Fig. 1). When combined with the animal data on serotonergic neurotoxicity (Ricaurte et al. 1992; Green et al. 1995; Frederick and Paule 1997), they suggest that serotonergic nerve damage may also be occurring in humans (Spatt et al. 1997; Szabo et al. 1997). This is obviously very worrying, given the widespread use of MDMA.

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