

Saturday night fever in ecstasy/MDMA dance clubbers: Heightened body temperature and associated psychobiological changes

Andrew C Parrott* and Lucy Young

University of Wales Swansea; Swansea, UK

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Aims and rationale: to investigate body temperature and thermal self-ratings of Ecstasy/MDMA users at a Saturday night dance club. **Methods:** 68 dance clubbers (mean age 21.6 years, 30 females and 38 males), were assessed at a Saturday night dance club, then 2–3 d later. Three subgroups were compared: 32 current Ecstasy users who had taken Ecstasy/MDMA that evening, 10 abstinent Ecstasy/MDMA users on other psychoactive drugs, and 26 non-user controls (predominantly alcohol drinkers). In a comparatively quiet area of the dance club, each unpaid volunteer had their ear temperature recorded, and completed a questionnaire on thermal feelings and mood states. A similar questionnaire was repeated 2–3 d later by mobile telephone. **Results:** Ecstasy/MDMA users had a mean body temperature 1.2°C higher than non-user controls ($P < 0.001$), and felt significantly hotter and thirstier. The abstinent Ecstasy/MDMA polydrug user group had a mean body temperature intermediate between the other 2 groups, significantly higher than controls, and significantly lower than current Ecstasy/MDMA users. After 2–3 d of recovery, the Ecstasy/MDMA users remained significantly 'thirstier'. Higher body temperature while clubbing was associated with greater Ecstasy/MDMA usage at the club, and younger age of first use. Higher temperature also correlated with lower elation and poor memory 2–3 d later. It also correlated positively with nicotine, and negatively with cannabis. **Conclusions:** Ecstasy/MDMA using dance clubbers had significantly higher body temperature than non-user controls. This heightened body temperature was associated with a number of adverse psychobiological consequences, including poor memory.

Introduction

Feeling hot or overheated is a typical experience for many recreational ecstasy/MDMA users.^{1–6} In an early questionnaire study of recreational users, around 85–90% reported feeling hotter when clubbing on MDMA,⁷ with a similar proportion feeling sweaty and dehydrated. Dancing at clubs and raves is typically vigorous,^{8,9} and since prolonged exertion may increase body temperature, this raises the question of whether the feelings of being hot are caused by the drug itself, by dancing, or the combination of stimulant drug and physical activity. In laboratory rats, MDMA impairs thermoregulation mechanisms, causing the animals to cool down in cold environments, and overheat under hot ambient conditions.^{10–14} These pre-clinical articles also describe the various mechanisms by which stimulant drugs such as MDMA impair thermoregulation. In rats and other rodents, the tail is crucially important for thermal control.¹⁵ The absence of a tail in the 'naked ape',¹⁶ makes it difficult to translate the thermoregulation findings from laboratory species to humans¹⁴; hence the importance of empirical studies in humans.³

The effects of MDMA on thermoregulation in humans have been studied in a number of placebo-controlled laboratory studies. In an early study, Grob et al.¹⁷ found no significant effect of acute MDMA on body temperature, although the overall sample size was small, and the dosage levels were low. Mas et al.¹⁸ reported significant increases of 0.4°C following higher acute doses, of 75 mg and 125 mg oral MDMA. Tancer et al.¹⁹ administered doses of oral 2 mg/kg MDMA to a small group of experienced ecstasy users, in a double-blind placebo-controlled laboratory study. Core temperature, and skin temperature were both significantly raised, and these increases occurred under both normal and high temperature environments (18°C and 30°C respectively). Freedman et al.⁴ undertook an extended replication of the above study, and confirmed that core body temperature and skin temperature were significantly raised. For instance, 2.0 mg/kg oral MDMA led to a significant increase in core body temperature of around 0.6°C in the hot thermal environment. Other laboratory studies have also found significant increases in core body temperature in sedentary human volunteers.²⁰ In a review of these laboratory studies, it was concluded that the

© Andrew C Parrott and Lucy Young

*Correspondence to: Andrew C Parrott; Email: a.c.parrott@swansea.ac.uk

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increases in body temperature were closely related to dosage levels; low doses up to 1.0 mg/kg oral MDMA led to a overall mean increase of +0.1°C, medium doses between 1.0 mg/kg and 1.9 mg/kg MDMA led to a mean increase of +0.4°C, whereas oral doses of 2.0 mg/kg MDMA led to an overall mean peak increase of +0.7°C (Table 1 in Ref.³).

The effects of self-administered Ecstasy/MDMA have been investigated in several real world studies of dance clubbers and party goers. These studies were also reviewed in Parrott³, where considerable variation in the body temperature changes was noted. One complicating factor is variation in dosage level, since tablets can vary in purity and strength, although often they are around 70–80 mg per tablet.^{21,22} Secondly, recreational users vary in the amount and timing of their self-dosing, and the duration of use on each occasion.⁹ Two real-world studies found only slight thermal changes in party-goers. Irvine et al.²³ reported a non-significant trend of +0.2°C, while Parrott et al.²⁴ found an increase of +0.15°C which was statistically borderline. In contrast, 2 other real world studies found large and significant increases in body temperature. Morefield et al.²⁵ reported a group mean peak increase of 1.1°C in party-goers who had taken MDMA. Parrott et al.²⁶ found a peak increase of around 1.6°C, in experienced recreational Ecstasy/MDMA users who had taken high doses (mean 6 tablets) at a house party. The fifth real world investigation in the above review was the current study (Table 2 in Ref.³). This investigation was originally presented as a conference paper, at the Annual Conference of the British Association for Psychopharmacology in 2005.²⁷ The present report is the first journal paper of the study, and it describes the aims, methods, procedures and emergent findings, in more detail.

Methods

Participants

the participants were attendees at 3 different nightclubs in Cardiff and Swansea, the 2 largest cities in Wales, UK. The 68 unpaid volunteers consisted of 38 males and 30 females, in the age range 18–26 y (mean 21.6 years). They were categorized into 3 subgroups, according to their current and past usage of Ecstasy/MDMA. The 32 current Ecstasy/MDMA users stated that they had taken Ecstasy/MDMA that night (mean 1.9 tablets, range 0.5 to 4.0). The 10 abstinent Ecstasy/MDMA users stated that had used it in the past, but not taken it that night, although

all taken other drugs, including illicit drugs such as cocaine. The 26 nonuser control group were mostly alcohol drinkers, although a few had also taken illicit drugs.

Procedure

potential participants were approached either in the ‘chill-out’ rooms, or near the toilet areas of the dance clubs. These venues were selected because people there were talking or resting, and it was quieter than the dance floor or bar area. An initial approach was made, either by the female researcher or her male assistant after 1 am, in order to optimize the likelihood of prior dancing. The researcher explained that they were undertaking a university based research project into recreational drug usage at dance clubs. They stated that they would like to record their body temperature using an ear thermometer, ask some questions about their drug use and feeling states. If the participant expressed an interest in taking part, they were given a more detailed description of the study and its requirements, via a printed information sheet. This was either read by the participant themselves, or read out to them by the researcher. If the participant was satisfied with the study, they signed the consent form. This noted that Swansea University does not condone the use of any illicit drugs, and that taken part in the study should not be seen as providing support for the use of illegal drugs. It also noted that the participant could withdraw from the study at any time without giving any reason.

Assessment measures

The temperature of each participant was recorded using an Infrared Ear Thermometer; this took around 10–15 seconds. The questionnaire was then administered. The initial questions covered gender, age, and use of drugs that evening. The next questions covered the amount of dancing/exercise that evening, feelings of body temperature and thirst (hot, cold, thirsty), and a range of mood states including feeling energetic and feeling elated. The response format was a 5-point Likert scale, ranging from ‘not-at-all’ to ‘extremely’. Once the ‘at-club’ questionnaire was completed the researcher thanked the participant, reminded them to expect a phone call 2–3 d later for the follow-up questionnaire.

For the post-drug recovery questionnaire, the participant’s initials, gender and age were re-established. The next subsection covered the same set of thermal and mood state questions as the first questionnaire. The next subsection covered their lifetime use of legal and illicit drugs, using the University of East London

Table 1. Body temperature, self-rated thermal aspects, and self-rated feelings of energy and elation while dance clubbing: current on-drug Ecstasy/MDMA users, abstinent Ecstasy users on other drugs, and non-user controls who were predominantly alcohol drinkers. Group means, standard deviations, ANOVA group differences, and paired comparison tests

	Non-user controls (N)	Abstinent Ecstasy polydrug users (A)	Ecstasy/MDMA current users (E)	Anova	Group	NvA	NvE	AvE
Temperature °C	36.5 ± 0.5	37.1 ± 0.8	37.7 ± 0.8	***	*	***	*	
Feeling hot	2.9 ± 1.0	3.9 ± 1.1	3.9 ± 1.0	***	**	***	.	
Feeling cold	1.0 ± 0.2	1.0 ± 0.0	1.1 ± 0.2	
Thirsty	2.1 ± 0.8	2.2 ± 1.1	3.1 ± 1.3	***	.	***	*	
Dancing extent	2.9 ± 1.0	3.1 ± 1.1	3.5 ± 1.0	.	.	*	.	
Feeling energetic	3.0 ± 0.8	3.4 ± 1.0	3.7 ± 1.1	*	.	**	.	
Feeling elated	2.9 ± 1.0	4.0 ± 0.8	3.9 ± 1.1	***	**	***	.	

Table 2. Self-rated thermal aspects and mood states 2–3 d after dance clubbing: for current Ecstasy/MDMA users, abstinent Ecstasy users on other drugs, and alcohol drinking nonuser controls. Group means, standard deviations, ANOVA group differences, and paired comparison tests

	Non-user controls	Abstinent Ecstasy/MDMA users	Ecstasy/MDMA current user	Anova	NvA	NvE	AvE
Feeling hot	1.6 ± 0.8	2.0 ± 1.1	1.7 ± 0.9				
Feeling	1.5 ± 0.6	2.0 ± 1.2	1.7 ± 0.9				
Thirsty	1.9 ± 1.0	2.6 ± 1.3	2.6 ± 1.2			*	
Feeling energetic	2.8 ± 0.8	2.1 ± 1.1	2.5 ± 1.1				
Feeling elated	2.5 ± 0.9	2.2 ± 1.0	1.5 ± 0.9	***		***	*

Recreational Drug Use Questionnaire.²⁸ The third subsection covered personal experiences the previous 6 months (when drug free): depression, happiness, memory problems, hot-cold flushes, mood fluctuations, tremors/ twitches, and poor concentration. The fourth subsection applied only to those who had used Ecstasy/MDMA, and covered: first time of usage, last time of usage, number of ecstasy tablets typically taken per occasion, largest number of tablets taken on a single occasion, and total number of Ecstasy/MDMA tablets lifetime.

Results

The group mean scores for the dance club findings from all 3 drug groups are presented in Table 1. The equivalent findings for the assessments given 2–3 d later are outlined in Table 2. Each table presents the one way ANOVA findings across the 3 groups, followed by Tukey paired-comparison tests between groups. Table 3 shows the Pearson correlations between body temperature at the dance club, and those dependent variables with significant associations.

Discussion

This real world study of dance clubbers was designed as an extended replication of Parrott and Lasky²⁹, through the addition

Table 3. Summary of significant correlations between core body temperature at the club, and other dependent variables (viz: Ecstasy/MDMA usage, other drug usage, and subjective feeling states)

Variable	Body Temperature	Significance level
Ecstasy/MDMA usage		
Ecstasy/MDMA use at club	r = +0.45	P < 0.001
Age first time took Ecstasy/MDMA	r = -0.32	P < 0.05
Last time took Ecstasy	r = -0.35	P < 0.05
Feeling states		
Feeling Hot at club	r = +0.34	P < 0.01
Feeling Energetic 2–3 d later	r = -0.24	P < 0.05
Feeling Elated 2–3 d later	r = -0.34	P < 0.01
Feeling Tired 2–3 d later	r = +0.35	P < 0.01
Poor memory 2–3 d later	r = +0.34	P < 0.01
Mood fluctuations in past 6 months	r = +0.30	P < 0.05
Other drug usage		
Cigarette use at club	r = +0.48	P < 0.001
Cigarette daily (general usage)	r = +0.55	P < 0.001
Cannabis use at club	r = -0.21	P < 0.10
Cannabis monthly (general usage)	r = -0.51	P < 0.001

of measures for body temperature and thermal self-ratings. The core finding was that the recreational Ecstasy/MDMA had significantly higher core body temperatures. Dance clubbers who had taken Ecstasy/MDMA that evening, had a core body temperature +1.2°C higher than the non-user control group ($P < 0.001$), and +0.6°C higher than the abstinent Ecstasy/MDMA polydrug group ($P < 0.05$; Table 1). The extent of this heightened temperature agrees with 2 other studies of party goers. Parrott et al.²⁶ reported a group-mean peak temperature increase of +1.6°C in an investigation of experienced Ecstasy/MDMA users. Morefield et al.²⁵ reported a mean peak body temperature increase of +1.1°C in Australian party-goers who had taken MDMA. However these pronounced increases in body temperature, contrast with 2 other real-world studies where the thermal changes were much smaller. Irvine et al.²³ found a slightly raised group mean core body temperature of +0.2°C which was non-significant compared to baseline; although the correlation between MDMA in blood plasma, and the increase in body temperature, was statistically borderline ($r = +0.38$, $p = 0.058$, 2-tailed). Parrott et al.²⁴ found that body temperature decreased significantly in the off-MDMA group, which is consistent with normal circadian temperature reductions during the night. Whereas in the on-MDMA group, body temperature showed a slight but non-significant increase; whereas group difference in temperature was statistically borderline ($p = 0.08$, 2-tailed). Several factors may contribute to the variation in thermal findings across real world studies, including dosage, extent of dancing, the control groups, and sample sizes; these factors are debated more fully in Parrott.³

In terms of thermal self-ratings, the Ecstasy/MDMA users felt significantly hotter than non-user controls at the dance club (Table 1). This agrees with previous research, since ‘feeling hot’ has been noted in many real-world studies of recreational Ecstasy/MDMA users.^{1,7,24,30} Self-rated feelings of thirst were also significantly higher in Ecstasy/MDMA users than controls (Table 1). This is an important new finding, since few previous studies have investigated thirst. Davison and Parrott⁷ reported that 85% of users reported feeling dehydrated while dance clubbing, although feelings of thirst were not questioned directly. Parrott et al.²⁴ noted a trend for increased ratings of thirst in dance clubbers on-MDMA, although this was not statistically significant. Thirst is medically important due to the possible development of hyponatraemia. This disorder is caused by excessive fluid intake (due to thirst), which causes a dilution of sodium levels in blood serum.^{31,60} Rosenson et al.³² summarized and reviewed around 540 cases of Ecstasy related hyponatraemia, which had been reported to the California Poisons Unit. Van

Dijken et al.³³ found that 25% of female MDMA users had lowered sodium levels indicative of mild hyponatraemia, in a study of dance clubbers in the Netherlands (compared with 3% of males). Both studies reported a significant gender bias, with females more at risk of developing hyponatraemia, and suffering from associated complications (viz: coma). Hyponatraemia can be fatal in recreational MDMA users, as in teenager Leah Betts in 1995, who drank a large volume of water and died from hyponatraemia. Excessive drinking at raves may have other adverse consequences. Hyperthermia can lead to water accumulation in brain tissue, or vasogenic edema, resulting in a disturbance to ionic homeostasis; indeed this has been demonstrated with both MDMA-induced and methamphetamine-induced hyperthermia.^{34,35} Na⁺ levels can also be dramatically increased within the brain tissues, leading to further adverse health effects. Hence the common suggestion to consume large amounts of liquids may not be helpful during MDMA-induced hyperthermia. The optimal medical treatment of these and co-related medical emergencies, are described in several articles.^{36,60,61}

The polydrug control group comprised past Ecstasy/MDMA polydrug users, who had not taken Ecstasy/MDMA that particular night. They had however taken some other illicit drugs, including some users of cocaine. Their group mean body temperature significantly lower than those dance clubbers who had taken Ecstasy/MDMA, and significantly higher than nonuser controls (Table 1). There are 2 potential explanations for these findings. It may be that the use of these other CNS stimulants had led to the increase in body temperature. In Parrott et al.³⁷ we compared recreational Ecstasy/MDMA users with recreational cocaine users, and both groups reported feeling significantly overheated while partying on-drug. The other explanation was that the past use of MDMA had adversely affected their thermal control ability, which led them to overheat in the hot thermal environment (note: both explanations may be partially correct). However in order to test these alternative hypotheses – further empirical studies are required. In particular the following subgroups need to be assessed: firstly, abstinent Ecstasy/MDMA users who drug-free while partying, and secondly party-goers on cocaine (with no past history of Ecstasy/MDMA usage).

The psychobiological correlates of the heightened body temperatures are summarized in Table 3, which only lists the significant findings (Table 3). As expected the amount of Ecstasy/MDMA taken at the club was significant, with higher doses leading to higher body temperatures ($P < 0.001$). This finding was as expected, and provides empirical support for the construct validity of the UEL Recreational Drug Usage Questionnaire.^{28,38} Recent Ecstasy/MDMA usage was also associated with higher temperature, suggesting that any adverse effects on hypothalamic thermal control mechanisms takes time to dissipate. This is a novel empirical finding, which should be investigated further. Another significant drug factor was age of first Ecstasy/MDMA usage, with lower age associated with higher temperature. Age of initiation has become a topic of great interest for all types of illicit recreational drug, particularly cannabis. This novel finding from the current study, similarly indicates that age of first usage may be important for young Ecstasy/MDMA users.

Body temperature at the club was significantly associated with the self-ratings feelings of being hot, as expected (Table 3). Pre-clinical research has shown that MDMA is more reinforcing in the heat, both to monkeys³⁹ and rodents.⁴⁰ Hence it may be predicted that higher temperatures would generate more intensive moods in MDMA-using dance clubbers²; however self-rated elation did not correlate significantly with body temperature ($r = +0.17$, $p = 0.16$). One possible reason for this is that each person titrates they own physical state, via periods of dancing and rest, to optimize their mood state. Some individuals may need higher temperatures to achieve this. The significant positive association between higher temperature and greater past usage (Table 3), may indicate that the more experienced users need to heat up their body/brain to a greater extent. If so, this would be consistent with chronic tolerance.⁴¹ It would also help explain why temperature was not associated with mood change. As with many of the other novel findings from the study, this hypothesis needs further empirical investigation.

In relation to the post-drug recovery period, higher temperature while clubbing was associated with poorer moods afterwards, with significantly lower elation, greater tiredness, and less energy (Table 3). Adverse mood states during the post-MDMA recovery phase are well documented.^{1,29,62} Previous research has also indicated that these post-Ecstasy deficits are significantly associated with higher thermal self-ratings while on-drug.⁴² However this is the first study to show a significant association between heightened body temperature on-drug, and poorer mood states afterwards (Table 3). Finally it also emerged that higher temperature on Ecstasy/MDMA, was associated with poorer self-rated memory in the post-drug recovery period, and more mood fluctuations during the past 6 months (Table 3). These novel memory findings need to be added to the extensive literature on neurocognitive deficits of Ecstasy/MDMA.^{30,43-47}

MDMA impairs thermal control in laboratory animals. The extensive empirical literature is summarized in a number of pre-clinical research articles and review papers.^{11-13,63} In hot thermal conditions the animals can overheat, with each increase in ambient temperature leading to more neuropsychobiological damage.^{48,49} MDMA-induced overheating may also be causing similar neuronal damage in humans,³⁰ possibly due to similar basic mechanisms.⁴⁵ The medical treatment of hyperthermia in drug using dance clubbers, has become a routine part of emergency room treatment, especially on weekend club nights.^{6,50-53} Rapid body cooling and fluid replacement, saves numerous lives every year, although severe hyperthermia and related complications cause further fatalities every year.⁵⁹

Hyperthermia is sometimes portrayed as an unusual or extreme abreaction. However the current findings indicate that hyperthermia is a typical consequence of taking Ecstasy/MDMA while dance-clubbing. The thermal effects of MDMA in humans, may be broadly similar to its thermal consequences in laboratory animals.^{3,4,10-12,14} Overheating can have a range of adverse functional consequences in humans, and drugs which impair thermoregulation can have adverse cognitive effects – which are further heightened in hot thermal environments.⁵⁴ MDMA can also stimulate the HPA axis, and the 800% acute increase in cortisol

levels found in dance clubbers^{24,26}; see also,⁵⁵ may contribute to its acute thermal effects.^{56,57} The energetic stress model for humans has been outlined in a series of previous articles.^{31,43,45,46,58} The current findings provide further empirical data on the energetic stress model for humans (Tables 1–3). They confirm that MDMA is not a safe drug, since the

combination of bodily overheating and metabolic overstimulation can be damaging to both laboratory animals and humans.

Discloser of Potential Conflicts of Interest

The authors have no conflicts of interest to declare.

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