Subacute effects of ecstasy on mood: An exploration of associated risk factors

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Abstract

Ecstasy use may result in lowered mood, anxiety or aggression in the days following use. Yet, few studies have investigated what factors increase the risk of experiencing such symptoms. Ecstasy users (at least once in the last 12 months) who subsequently took ecstasy \( n=35 \) over the next week, were compared on measures of mood, sleep, stress and drug use, with those who abstained \( n=21 \) that week. Measures were administered the week prior to ecstasy use and 1 and 3 days following use, or the equivalent day for abstainers. Mood symptoms were assessed using the Kessler-10 self-report psychological distress scale, a subjective mood rating (1-10), and the depression, anxiety and hostility items of the clinician-rated Brief Psychiatric Rating Scale. Timeline followback methods were used to collect information on drug use and life stress in the past month. Self-reported sleep quality was also assessed.

Ecstasy use was not associated with subacute depressive, anxiety or aggressive symptoms. Rather, lowered mood and increased psychological distress were associated with self-reported hours and quality of sleep obtained during the 3-day follow up. These findings highlight the importance of considering sleep disruption in understanding the short-term mood effects of ecstasy use.

Key words: ecstasy, mood, subacute, risk factors, sleep
Ecstasy (3,4-methylenedioxymethamphetamine, MDMA) is a popular recreational drug, particularly among young people. Its acute psychological effects become apparent 20 to 60 minutes following ingestion, peak at 60 to 90 minutes and last 3 to 5 hours (Green et al., 2003). MDMA leads to the release of serotonin from presynaptic vesicles, prevents reuptake of serotonin from the synaptic cleft and reduces tryptophan hydroxylase, which prevents the synthesis of new serotonin (McKenna and Peroutka, 1990). This may result in disruptions in the regulation of mood, emotion, sleep and appetite for several days (Curran et al., 2004).

Laboratory studies indicate that up to a third of healthy participants who had never or rarely used ecstasy report signs of depressed mood including irritability, brooding, difficulty concentrating, lack of energy and bad dreams, 24 hours after being administered MDMA (range: 70-150mg). A small number of participants continued to report these subacute effects three days post use (Liechti et al., 2001; Liechti and Vollenweider, 2001). Studies of recreational ecstasy users suggest even higher rates of subacute mood effects. Verheyden et al. (2003) found that 83% of participants (n=430) reported experiencing low mood in the days after ecstasy use. Similar associations have been found between ecstasy and mood (elevated depression, anxiety and aggression) in prospective studies comparing ecstasy users with non-using controls (mostly ecstasy-naïve), with subacute mood effects persisting for up to four days post ecstasy use (Curran and Travill, 1997; Parrott and Lasky, 1998; Verheyden et al., 2002; Curran et al., 2004). Given ecstasy’s ongoing popularity, its known action on the serotonergic system and the implications of this for mood regulation, it is critical to understand what factors are related to the experience of mood symptoms following ecstasy use.

A number of potential risk factors for ecstasy-induced subacute mood effects have been
identified in previous research. Females have been found to attribute a greater number of short- and long-term psychological problems (inc. depression) to ecstasy use, and are more likely to experience midweek low mood following weekend ecstasy use (Topp et al., 1999; Verheyden et al., 2002). This is consistent with research suggesting females are more sensitive to the serotonin-induced psychoactive effects of ecstasy (e.g. experiencing perceptual changes) and are more likely to experience acute adverse effects (e.g. depressive and anxiety symptoms, jaw clenching) than males (Liechti et al., 2001). In contrast, Hoshi et al. (2006) found no gender differences on subacute mood (measured by the Beck Depression Inventory).

Patterns of drug use may also impact upon subacute mood changes. For example, the number of substances taken whilst ‘coming down’ from ecstasy (i.e. during the acute recovery period) has been associated with a greater number of self-reported ecstasy side effects (Topp et al., 1999). Verheyden et al. (2002) found a relationship between severity of subacute mood effects and number of ecstasy pills consumed in females. Similar positive associations between ecstasy use and mood symptoms the day after use have been found in prospective studies. Specifically, a younger age of first use, greater lifetime dose and frequency of ecstasy use per month have been associated with more severe subacute mood symptoms (e.g., more ‘irritable’, ‘aggressive’ and ‘nervous’) (Huxster et al. 2006; Pirona and Morgan, 2010), while time since last use negatively correlated with negative mood the day after ecstasy use (Huxster et al. 2006). Curran et al. (2004) also found significant positive correlations between ecstasy use (frequency of use, years of use) and self-reported aggression four days after use. However, it is possible that premorbid differences in mood symptoms may have impacted on the results of these studies as they failed to control for baseline mood differences.
In contrast to the above findings, an internet-based study by Parrott et al. (2006) found that retrospective reports of subacute effects on mood and cognition were generally independent of the amount of ecstasy consumed. Rather, they found that participants who danced ‘all the time’ while on ecstasy reported significantly more problems in the following days, including depression. In addition, those reporting feeling ‘strongly/extremely hot or overheating’ while on ecstasy reported significantly poorer concentration in the days following ecstasy use. This is consistent with the proposal that the hot, crowded conditions and limited availability of water at dance parties or raves may be associated with greater adverse side effects when taking ecstasy (Green et al., 2003; Parrott et al., 2006). Indeed, other studies indicate that ecstasy users report that ambient temperature and dancing influence the acute effects of ecstasy and some users manipulate these factors to enhance the effects (Bedi and Redman, 2006). Taken together, the above studies suggest that patterns of drug use including ecstasy dose and the ecstasy-using environment may be risk factors for subacute mood effects.

Two studies have recently examined the role of sleep disturbance on the subacute mood effects of ecstasy use. Pirona and Morgan (2010) found the effects of ecstasy use on negative mood (feeling muddled, afraid, and sad) one day after ecstasy use were no longer significant after controlling for the hours of sleep obtained. A second study by the same group, found the effect of ecstasy on cognition (self-reported concentration, memory) was no longer significant after controlling for restless sleep, although the subacute effects of ecstasy use on mood remained (Huxster et al., 2006).

Finally, we recently found that stressful life events, a history of trauma and other drug use were more robust predictors of current mood symptoms than ecstasy and genetic factors in a cross-sectional study of 184 ecstasy users (at least once in the last 12 months; Scott et al., 2010). These findings are consistent with the broader literature on depression and anxiety,
indicating that adverse life events are a significant risk factor for the onset of these disorders (Goldberg, 1994; Kendler et al., 2002, 2006). However, research is yet to prospectively determine the relative contribution of these variables on short-term changes in mood among ecstasy users.

This prospective study sought to identify risk factors for a negative mood change following ecstasy use, whilst controlling for potential confounds (such as hours of sleep and other drug use). It was hypothesised that 1) ecstasy use would be associated with a significant increase in depressive, anxiety and aggressive symptoms in the days following use; 2) an increase in these symptoms would be related to pre-existing factors (i.e. female gender, more severe baseline depressive/anxiety symptoms, personal psychiatric history), patterns of drug use (e.g., ecstasy dose and other drug use) and the ecstasy-use environment (heat/exercise), stressful life events and sleep factors; and 3) stressful life events and sleep disruption would significantly predict mood change in all participants (ecstasy users and abstainers).

Method

Participants

A subsample of 63 regular ecstasy users (at least monthly use over the last 6 months) and those planning to take ecstasy over the following week were recruited from a larger cross-sectional study of 184 ecstasy users (aged 18 to 35 years who had used ecstasy at least once in the last 12 months) (see Scott et al., 2010). Recruitment took place in Melbourne, Australia using advertisements on universities’ and dance music websites, newsletters, music magazines and newspapers. Flyers were also distributed in cafes, music stores, and at dance music events. A ‘snowballing’ technique was used to recruit friends, family and acquaintances of individuals participating in the study (Solowij et al., 1992). Exclusion criteria were current pregnancy and history of a psychotic disorder, based on participant self-
report, and poor English fluency, as identified by the researcher (R.S.) during the telephone screen or initial interview.

**Study design**

The study used both a mixed and correlational design. Participants who subsequently took ecstasy over the course of the study \( n=35 \) were compared with those who abstained \( n=21 \). Ecstasy was the between-subjects factor, time (baseline, Day 1 and Day 3) the repeated measure and mood the dependant variable. In initial analyses, demographic and drug use variables, sleep and stressful life events were included as control variables, where appropriate. In subsequent correlational analyses, change in mood between baseline and Days 1 and 3 were correlated against demographic, drug use, sleep and stress variables.

Baseline measures

- **Demographics and lifetime drug use.** Participants provided information on age, occupation, education, ethnicity, personal psychiatric history, including treatment and current medication. Participants provided substance use information including age at first use, lifetime polydrug use (the total number of drugs tried; maximum possible score=12), and the most frequent use (never used, less than monthly, monthly, 2-3 times a month, weekly, daily or almost daily) of alcohol, tobacco, cannabis, ecstasy, amphetamines, cocaine, hallucinogens, inhalants, opiates, benzodiazepines/sedatives, ketamine, and gamma-hydroxybutyric acid (GHB). A context-based timeline method was used to estimate total lifetime number of ecstasy pills consumed (Bedi and Redman, 2006). The Timeline Followback (TLFB; Sobell and Sobell, 1992) was used to retrospectively assess frequency and quantity of substances used over the past 28 days and over the course of the study.

**Mood symptoms: Self report**

- **Mood and Anxiety Symptom Questionnaire - Short Form (MASQ; Watson and Clark**
This 62-item self-report measure of general distress and depressive and anxiety symptoms has excellent convergent and discriminant validity between anxiety and depressive symptoms in both clinical and non-clinical samples (Watson et al., 1995). Participants indicated how much they had experienced each symptom over the past week (1 = not at all to 5 = extremely).

Kessler-10 (K10; Kessler et al., 2002). The K10, is a 10-item self-report measure of psychological distress and has been found to reliably detect the presence of depressive and anxiety disorders at a cut-off score of \( \geq 17 \) (Andrews and Slade, 2001). The timeframe of the K10 was modified from the past month to the present day.

Subjective mood. Participants rated their mood on a scale from one to ten (1 = worst they have ever felt, 10 = best they have ever felt) for the present day.

Mood symptoms: Clinician rated

Brief Psychiatric Rating Scale (BPRS) (Ventura et al., 1993). The anxiety, depression and hostility items of the BPRS were used to provide a clinician rating of mood symptoms for the present day (1=not present to 7=extremely severe). The BPRS has been found to have excellent inter-rater reliability (Ventura et al., 1993) and to be an effective measure of psychiatric symptoms in various substance-using populations (Steer and Schut, 1979; Westermeyer et al., 1995).

Stressful life events. Participants were asked to report any stressful life events that had occurred in the last 28 days and between each testing point (Baseline, Day 1, Day 3). Stressful life events could relate to any area of life including employment and study (e.g., lost job; university exams), finances (e.g., went off benefits), relationships and family (e.g., break up
of romantic relationship; family conflict), residence (e.g., moved house), health (e.g., physical illness) and crime and legal matters (e.g., victim of assault). Life events were only included if participants reported finding the event stressful. Events were tallied to provide a total recent stressful life events score for Day 1 and Day 3 (events occurring since baseline). Participants also gave a subjective rating of stress for the present day (1=not stressed at all to 10=extremely stressed).

Sleep. Hours of sleep for the preceding night were calculated based on participant self-reports of the time they fell asleep and woke up. If participants reported periods of being awake within this timeframe, the duration of wakefulness was subtracted from the hours of sleep. Participants also rated how restless their sleep was the previous night compared to normal (1 = not restless at all to 10 = extremely restless).

Medication. Participants were asked if they were currently on psychiatric medication, if they had made any changes to their medication in the last 28 days or if they had made any changes to or had missed any medication over the follow up.

Ecstasy factors. Those who went on to take ecstasy provided ecstasy-specific information including what the tablet(s) looked like, what time they were consumed, what drugs were taken in combination with ecstasy, and rated how much they believed they had taken MDMA after being described the common psychological and physiological effects of MDMA (1 = definitely not MDMA to 10 = definitely was MDMA). Participants were also asked to rate how positive their ecstasy experience was (1=extremely negative to 10=extremely positive), how much time they spent dancing or doing exercise whilst on ecstasy (1=not at all to 5=all the time) and if they felt hot or were over heating while on ecstasy (1=not at all to 5=extremely).
Statistical analyses

All data were analysed with PASW version 18 (SPSS Inc., 2009). Following initial data screening, logarithmic transformation was used on lifetime ecstasy use to reduce skewness and kurtosis and improve normality. Individuals with missing data (i.e. those who were not contactable at Day 1 or Day 3) were compared to those with a full data set on baseline variables including demographics, lifetime ecstasy and other drug use, and psychopathology, to ensure there were no significant differences between the two groups. Ecstasy users and abstainers were also compared on these variables to determine if there were any group differences that needed to be controlled for in the subsequent analyses. Tests for group differences were conducted using independent samples t-tests for parametric continuous data, Mann-Whitney U tests for nonparametric data and Pearson Chi Square analysis for categorical data.

Two-way repeated measures ANCOVAs with ecstasy use group (ecstasy use on Day 0: yes/no) as the between subjects factor and time (baseline, Day 1, Day 3) as the repeated measure were conducted on K10 and subjective mood ratings. Potential confounding variables were treated as covariates. Kruskal-Wallis tests for group differences were conducted on the BPRS change scores for the depression, anxiety and hostility items (baseline score minus follow up score). Separate analyses were conducted for Day 1 and Day 3 for all between-subjects comparisons due to the presence of missing data.

K10 and subjective mood change scores were calculated by subtracting each individual’s Day 1 and Day 3 scores from their baseline scores. Pearson’s correlations were then calculated to explore relationships between potential pre-existing, drug and environmental risk factors and change in mood between baseline and Days 1 and 3, respectively. To account for multiple
testing, a modified bonferroni correction was made by estimating the number of independent variables in the correlation matrix using the program matSpD (Matrix Spectral Decomposition; http://gump.qimr.edu.au/general/daleN/matSpD/) with their VeffLi estimates (Li and Ji, 2005) used to establish an alpha level of .001 for the correlational analyses.

Procedure

The study was approved by the Monash University Human Ethics Committee. Participants in the original study were requested to abstain from ecstasy use for at least seven days prior to baseline testing, other recreational drugs for at least 24 hours (with the exception of tobacco and caffeine), and alcohol for at least 12 hours. The face-to-face baseline assessment was conducted by a doctoral candidate in clinical psychology (R.S.) over approximately one hour. All participants were then asked if they were planning on taking ecstasy over the next week (Yes/No). If yes, the researcher arranged to contact the participant the day following planned ecstasy use (Day 1) and again two days later (Day 3). Consequently, the majority of Day 1 and 3 interviews were conducted on Sunday and Tuesday, respectively. For consistency, if participants were not planning on taking ecstasy, they were telephoned on Sunday (Day 1) and again on Tuesday (Day 3). Telephone interviews were conducted between 6pm and 8pm unless the participant was unavailable at this time. All participants were reimbursed AUD$25 for their time and travel-related expenses for the baseline interview.

Results

Sample characteristics and follow up

Of the 63 participants who provided informed consent, 56 were contactable and provided follow up data for Day 1 (n=55, 98.2%) and/or Day 3 (n=47, 83.9%). Thirty-five of the 56 participants voluntarily took ecstasy following the baseline assessment (ecstasy users) and 21
chose to abstain from taking ecstasy (abstainers). The characteristics of the final sample are presented in Table 1. At Day 1, one ecstasy user could not be contacted. At Day 3, five ecstasy users and four abstainers could not be contacted.

A series of analyses were conducted to determine if there were group differences between the ecstasy users and abstainers, in order to identify covariates for the subsequent analyses. No group differences between ecstasy users and abstainers on ethnicity, education, lifetime diagnosis of unipolar depression and/or an anxiety disorder, or on any of the baseline mood measures (see Table 2 for mood measures) were found. There were significant group differences in age ($t(54)=-3.07, p=.004$) and gender ($\chi^2(1,56)=4.31, p=.04$), in which ecstasy users were older and had a greater proportion of males than abstainers.

Table 3 summarises ecstasy and polydrug use information at baseline. No significant group differences were found between ecstasy users and abstainers on log lifetime ecstasy use, lifetime ecstasy frequency of use, typical or greatest ecstasy dose, time since last ecstasy use or lifetime polydrug use. However, significant differences were found in the duration of ecstasy use ($t(54)=-2.25, p=.03$), with those that took ecstasy reporting a longer duration of ecstasy use. Table 4 summarises the lifetime and last month prevalence rates of use for other substances for both groups. Ecstasy users were significantly more likely to have tried cocaine ($\chi^2(1,56)=5.53, p=.02$). Significant group differences were also found for the lifetime frequency of cannabis ($U=236.00, N_1=21, N_2=35, p=.02$) and cocaine use ($U=221.00, p=.01$), with those that took ecstasy reporting a higher frequency of use of these substances.

**Follow up drug use and sleep**

Rates of other drug use and sleep data for the follow up period are summarised in Table 5. Ecstasy users consumed an average of 1.91 ecstasy pills ($SD=1.23$; range: 0.5-5). There was
no significant gender difference in number of ecstasy pills taken at Day 0 (females $M=1.70$, males $M=2.08$). The mean time since last ecstasy use was 21.74 hours ($SD=6.64$; range: 12.5-40). Two participants were assessed two days post ecstasy use due to not being contactable at Day 1. Group comparisons of the amount of alcohol and cannabis consumed at Day 0 revealed trends towards the ecstasy users consuming more alcohol ($t(54)=-1.88, p=0.07$) and cannabis ($t(54)=-1.81, p=0.08$). Group comparisons of other individual drugs were not conducted due to the low rates of use.

Similarly, significant group differences were found in amount of alcohol ($t(47)=-2.02, p=0.05$) and cannabis consumed ($t(47)=-2.32, p=0.03$) between Days 1 and 3 with ecstasy users consuming more alcohol and cannabis than abstainers over these three days. Given that the ecstasy users had taken a significantly greater number of substances at Day 0 and between Days 1 and 3, and had obtained significantly fewer hours of sleep at Day 0, these variables were treated as covariates.

**Group comparisons: Mood**

**K10.** K10 scores showed no main effect of group or group X time interaction. There was a significant main effect of time at Day 1 ($F(1,53)=4.94, p=0.03$) but not at Day 3, with participants reporting lower K10 scores at Day 1 compared to baseline. However, this main effect was no longer significant after controlling for covariates including gender, age, hours of sleep at Day 0, total drugs taken at Day 0 and the duration of ecstasy use. Secondary analyses of the individual items ‘depressed’ and ‘nervous’ on the K10 revealed no significant group differences.

**Subjective mood.** There were no main effects of group or group X day interaction. There was a significant main effect of time with participants reporting lower scores at Day 1
(F(1,52) = 4.60, p = 0.04) and Day 3 compared to baseline (F(1,45) = 6.52, p = 0.01).

The time effect for Day 1 remained significant after controlling for gender (F(1,51)=5.53, p=0.02), age (F(1,51)=5.59, p=0.02) and duration of ecstasy use (F(1,51)=7.76, p=.007), but was no longer significant after controlling for hours of sleep at Day 0. At Day 3, the time effect remained significant after controlling for gender (F(1,44)=5.59, p=0.02), duration of ecstasy use (F(1,44)=6.98, p=0.01), but not after controlling for age, hours of sleep at Day 2 or other drug use (p>0.05). Following the addition of the covariates, there continued to be no main effect of group or group X day interaction. However, there was a significant age X time interaction (F(1,51)=3.93, p=0.05), with younger participants reporting lower subjective mood ratings, particularly at Day 1.

**BPRS clinician ratings.** Consistent with the self-report data, there were no significant group differences on BPRS depression, anxiety and hostility change scores (p>.05).

**Follow up mood: clinically significant symptoms**

Raw scores indicated that five ecstasy users (14.3%) at baseline, four at Day 1 (11.8%) and seven at Day 3 (23.3%) had scores indicative of current psychological distress (K10≥17).

Among the abstainers, four participants (19.0%) scored above this cut-off score, compared to three (14.3%) at Day 1 and two (11.8%) at Day 3 with one abstainers’s score indicating a high level of psychological distress (≥30) at Day 3.

**Correlational analyses: Exploration of potential risk factors**

Change scores for self-reported mood and psychological distress (baseline score - Day 1 score; baseline score - Day 3 score) were correlated against the following potential risk factors. As stated previously, alpha is set at .001. Trends are reported where p < .01.

*Demographics and baseline mood and psychopathology.* No associations were found
between short-term mood change and gender, age, lifetime history of unipolar depression and/or an anxiety disorder or baseline MASQ mood symptoms, with either the combined sample or when only those who took ecstasy were included. Within the entire sample, there was a trend towards an association between higher baseline GD depressive symptoms and self-reported improved mood at Day 1 ($r=-.35$, $p=.009$), and within the ecstasy users, there was a trend towards a relationship between higher baseline score on the Anxious Arousal MASQ subscale and a drop in self-reported mood at Day 1 compared with baseline ($r=.51$, $p=.002$).

**Lifetime drug use factors.** Short-term mood change did not significantly correlate with log lifetime ecstasy use, duration of ecstasy use, age at first ecstasy use, lifetime polydrug use, or frequency of drug use, when looking at the total sample and at the ecstasy users alone. However, when looking at the entire sample, there was a trend towards an association between more frequent lifetime use of amphetamine and increased psychological distress (K10) at Day 1 ($r=.36$ $p=.008$).

**Days 0, 1 and 2 drug use.** When looking at the combined sample and the ecstasy users alone, no significant associations between short-term mood change and any drug use variables at Day 0 were found, including number of ecstasy pills taken, total number of drugs used or amount of alcohol or cannabis consumed. Similarly, no correlations were found between mood change and amount of alcohol and cannabis used between Day 1 and Day 3. However, trends were observed between the total number of drugs taken between Day 1 and 3 and a self-reported drop in mood at Day 3, when looking at the entire sample ($r=.37$, $p=.01$) and the ecstasy users only ($r=.55$, $p=.002$), with a greater number of substances used being associated with a drop in self-reported mood.
Ecstasy factors at Day 0. Of those that did take ecstasy, no significant associations were found between short-term mood change and feeling hot/over heating or time spent dancing/doing exercise while on ecstasy, rating of ecstasy experience, or how confident the participant was that they had consumed MDMA.

Sleep. Across the entire sample, a significant negative correlation was found between hours slept the night preceding Day 3 and Day 3 K10 change score ($r=-0.49, p=0.001$), with fewer hours of sleep being associated with increased psychological distress. Similarly, restless sleep positively correlated with Day 3 subjective negative mood change ($r=0.45, p=0.001$). Within the ecstasy users, there was a similar significant negative correlation between restless sleep and change in K10 score at Day 3 ($r=-.59, p=.001$) with greater reported restless sleep being associated with an increase psychological distress at Day 3. Two trends were also observed, restless sleep and self reported mood at Day 3 ($r=.55, p=.002$) and hours slept the preceding night and change in self-reported mood at Day 3 ($r=-.46, p=.01$) with greater restless sleep and fewer hours of sleep being associated with a drop in self–reported mood at Day 3. Stress. No significant correlations were found between stressful life events reported over the follow up and short term changes in mood.

Summary of main findings. The group comparisons indicated no significant group differences on mood. There was a significant main effect of time with participants from both groups reporting lower subjective mood at Day 1 compared with baseline, after controlling for covariates. Younger participants also tended to report lower mood overall, particularly at Day 1. Main findings from the correlational analyses were that fewer hours of sleep obtained on the night preceding Day 3 were associated with an increase in psychological distress, as measured by the K10, while restless sleep was associated with a lower subjective mood rating.
at Day 3, when looking at the entire sample. Within the ecstasy users only, there was a significant negative correlation between restless sleep and change in K10 score at Day 3 with greater reported restless sleep being associated with an increase in psychological distress.

Discussion

The current study aimed to identify potential risk factors for subacute mood symptoms following ecstasy use. Contrary to previous research, ecstasy use was not associated with self-reported mood symptoms or clinician-rated subacute depressive, anxiety or aggressive symptoms in the days following use (Curran and Travill, 1997; Parrott and Lasky, 1998; Curran et al., 2004). In fact, the average K10 scores of ecstasy users who used ecstasy in the next week and those who abstained were comparable to normative Australian data (K10 mean score =14.2; Andrews and Slade, 2001), suggesting that any subacute mood effects following ecstasy use are likely to be modest. In addition, current results are consistent with a more recent study using an ecstasy-using control group, finding no difference between ecstasy-users who used ecstasy in the next few days and those who abstained on self-reported mood symptoms (measured on the Beck Depression Inventory) (Pirona and Morgan, 2010).

Negative mood symptoms among this community sample of ecstasy users were associated with self-reported quality and hours of sleep, consistent with recent studies reporting that the subacute effects of ecstasy use on mood and cognition no longer remained, after controlling for hours and quality of sleep (Huxster et al., 2006; Pirona and Morgan, 2010). This suggests that the negative subacute mood effects of ecstasy found in previous studies may be confounded by sleep factors. Indeed, sleep deprivation alone can cause negative mood effects (Keane and James, 2008), and ecstasy users report experiencing sleep disturbance following use in both field (Curran et al., 2004) and laboratory studies (Liechti et al., 2001). Given that ecstasy is most commonly consumed at raves or all night dance parties, future research using a control group of non-ecstasy using rave attendees is required to determine if ecstasy use
mediates the impact of sleep disturbance on subacute mood symptoms.

Contrary to our second hypotheses, negative mood symptoms during follow up among this sample of ecstasy users, were not associated with pre-existing risk factors for mood symptoms (i.e. severity of baseline depressive and anxiety symptoms, a history of depression and/or anxiety disorders, being female) or patterns of ecstasy use (i.e. ecstasy dose or ecstasy-related environmental factors). However, it is possible that the experience of subacute mood symptoms following ecstasy use relates to a complex interaction of variables not captured by the correlational analyses in this study. The low rates of lifetime depression and/or anxiety disorders reported in the current sample may have limited the power available to detect potential relationships. Further prospective studies with larger sample sizes are required to further understand the relationships between these variables. Similarly, the low likelihood of experiencing significant stressful life events during such a short follow up period may explain the lack of association between stressful life events and short term mood change, contrasting with our previous cross-sectional finding of an association between stressful life events and current mood symptoms in the full sample of 184 ecstasy users (Scott et al., 2010).

The trends observed in the current study, including nonsignificant associations (using strict bonferroni adjustment) between baseline mood and anxiety symptoms and self–reported mood change (interestingly in both directions) and more frequent lifetime amphetamine use and increased psychological distress at follow up, provide an important foundation for further research looking at potential vulnerability factors to experiencing short-term mood effects following substance use. Secondly, the trend observed between greater number of substances used and a drop in self-reported mood highlights the importance of controlling for other drug use when looking at ecstasy subacute effects.
Although the use of an ecstasy-using control is a strength of the current study, the groups differed significantly on a number of baseline as well as drug use variables over the follow up. Ecstasy users were older, were more likely to be male, had used ecstasy for longer and other drugs more frequently in their lifetime. In the abstainer group, there was also an underrepresentation of males. Over the follow up, the ecstasy users consumed a greater number of substances and greater amounts of alcohol and cannabis. These findings again highlight the importance of controlling for other drug use when exploring subacute mood effects following ecstasy use. However, no associations were found between negative mood effects and the pattern of drug use, including ecstasy dose at Day 0. This contrasts with the finding by Verheyden et al. (2002), who reported an association between ecstasy dose at Day 0 and mid-week mood in females. Secondary analyses with females only in the current sample continued to find no association between ecstasy dose and subacute mood. However, as Verheyden et al. (2002) did not control for baseline mood, this finding may reflect pre-existing mood differences (Allott and Redman, 2007). A further strength of the current study was the use of multiple measures of mood including self-report and clinician-rated measures. Although these measures differ from those employed in other studies (eg. BDI), they were selected as the symptoms measured are not directly affected by ecstasy use (sleep, appetite) which may artificially inflate depression scores (Sumnall and Cole, 2005).

The follow up rate (84%) at Day 3 is a limitation of the current study, but was similar across both the ecstasy users (86%) and abstainer (81%) groups. Nevertheless it is possible that participants who were not contactable at Day 1 and 3 (n=7) or at Day 3 only (n=5) were less willing to complete the follow up phone call due to subacute mood symptoms. Similarly, it is possible that the abstainers were more sensitive to subacute mood effects than those who chose to take ecstasy creating a self-selection bias. However, the lack of significant differences in lifetime number of pills consumed and frequency of recent use suggests this
was unlikely. It is possible that the ecstasy users did not consume MDMA, as the tablets consumed were not analysed for content. In the state of Victoria, the most recent published data (for the period 2004-2007) indicate that MDMA is the most frequently identified drug in tablets seized by police (Quinn et al., 2007) and the majority of ecstasy users in the current sample (91.4%) thought it was ‘highly likely’ or ‘definitely likely’ they had consumed MDMA. Although participants were required to abstain from ecstasy use for 1 week prior to the baseline assessment, it is possible that subacute effects may have affected the data as the MASQ asks about mood symptoms in the past week (see Scott et al., 2010 for a more detailed discussion of this issue). Future research would benefit from including standardised and/or objective measures of sleep, rather than the self-report sleep measures used in the current study.

Despite these limitations, the study has a number of strengths. These include the use of an ecstasy-using control group, which reduces potential premorbid differences between ecstasy users and abstainers. The study was also well controlled as potential confounding variables such as self-reported sleep and other drug use over the follow up were entered as covariates in the main analyses.

This is the first prospective study to investigate the potential role of pre-existing risk factors for mood symptoms, as well as ecstasy-environment factors on the experience of subacute mood effects following ecstasy use. Results indicated that self-reported hours and quality of sleep were more strongly associated with short-term negative mood effects among ecstasy users than ecstasy use per se. These findings also suggest that pre-existing risk factors for mood symptoms, ecstasy use or ecstasy-use environment factors did not increase the likelihood of subacute mood effects following ecstasy use. However, further research using larger sample sizes is required to replicate these results, due to the inconsistencies between
the results of recent research finding little evidence for the subacute mood effects of ecstasy use (Huxster et al., 2006; Pirona and Morgan, 2010), and earlier research reporting a link between ecstasy use and clinically significant depressive symptoms (e.g. Curran and Travill, 1997).
References

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Table 1

Demographic and substance use information

<table>
<thead>
<tr>
<th></th>
<th>Ecstasy users (n=35)</th>
<th>Ecstasy abstainers (n=21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (m/f)</td>
<td>20/15*</td>
<td>6/15*</td>
</tr>
<tr>
<td>Age mean (SD)</td>
<td>24.17 (5.19)**</td>
<td>21.14 (2.08)**</td>
</tr>
<tr>
<td>Caucasian n (%)</td>
<td>29 (82.9)</td>
<td>16 (76.2)</td>
</tr>
<tr>
<td>Post secondary school education n (%)</td>
<td>30 (85.7)</td>
<td>18 (85.7)</td>
</tr>
<tr>
<td>History of depression/anxiety disorder n (%)</td>
<td>7 (20.0)</td>
<td>4 (19.0)</td>
</tr>
<tr>
<td>Currently(^a) on psychiatric medication</td>
<td>0 (0)</td>
<td>1 (4.8)</td>
</tr>
</tbody>
</table>

\(^a\)Within the last month, * \( p \leq .05 \), ** \( p \leq .01 \)