doi:10.1111/j.1360-0443.2006.01423.x

A review of the acute subjective effects of MDMA/ecstasy

Chelsea A. Baylen & Harold Rosenberg

Bowling Green State University, Department of Psychology, Bowling Green, OH, USA

ABSTRACT

Aim Although several relatively recent reviews have summarized the neuropsychiatric effects associated with chronic ecstasy use, there is no published comprehensive review of studies on the acute subjective effects (ASEs) of MDMA/ecstasy. **Design** The present study reviewed the prevalence, intensity and duration of ASEs collected from 24 studies that provided frequency data on the prevalence of self-reported ecstasy effects and/or provided data on the intensity of ecstasy effects. **Findings** Although hundreds of ASEs have been reported following MDMA consumption, we identified a subset of effects reported repeatedly by meaningful proportions and large numbers of participants across multiple investigations, most of which were either emotional (e.g. anxiety, depression, closeness, fear, euphoria, calmness) or somatic (e.g. nausea/vomiting, bruxism, muscle aches/headache, sweating, numbness, body temperature changes, fatigue, dizziness, dry mouth, increased energy). Only one sexual ASE (sexual arousal/increased sensual awareness), one cognitive ASE (confused thought), one sensory–perceptual ASE (visual effects/changes in visual perception), one sleep-related ASE (sleeplessness) and one appetite-related ASE (decreased appetite) were reported across five or more investigations. Three factors—number of hours between ingestion and assessment, dose level, and gender—have been associated with the acute subjective experience of MDMA/ecstasy. **Conclusions** This review provides useful information for clinicians and researchers who want to understand the desirable and undesirable ASEs that may motivate and restrain ecstasy use, for public health advocates who seek to reduce biomedical harms (e.g. fainting, dehydration, shortness of breath, bruxism) associated with recreational use of MDMA/ecstasy, and for educators who wish to design credible prevention messages that neither underestimate nor exaggerate users' experiences of this drug.

Keywords acute subjective effects, ecstasy, MDMA.

Correspondence to: Chelsea A. Baylen, Department of Psychology, Bowling Green State University, Bowling Green, OH 43403, USA.
E-mail: cbaylen@bgsu.edu
Submitted 2 May 2005; initial review completed 28 September 2005; final version accepted 22 November 2005

INTRODUCTION

Reports published within the past decade reveal that the hallucinogenic stimulant MDMA—also known as 'ecstasy'—is gaining popularity among youth in countries as diverse as the United States (Strote *et al.* 2002; Boyd *et al.* 2003), the United Kingdom (Bellis *et al.* 2003), Turkey (Çorapçioglu & Ögel 2004), Estonia (Allaste & Lagerspetz 2002), Scotland (Riley *et al.* 2001), Norway (Pedersen & Skrondal 1999), Taiwan (Lua *et al.* 2003), Canada (Gross *et al.* 2002), and Australia (Lenton *et al.* 1997). The popularity of ecstasy may be explained, in part, by the desirable effects (e.g. euphoria, increased energy, sexual arousal) recreational users attribute to taking it.

However, research has demonstrated that ecstasy use is not uniformly benign. The drug has been associated with undesirable psychological effects (e.g. confusion, defensiveness, mental fatigue, anxiety, depression; Gold, Tabrah & Frost-Pineda 2001) and unhealthy medical consequences (e.g. hyperthermia, cardiac arrhythmia, hypertension; Montoya *et al.* 2002). Of special concern, Schifano *et al.* (2003) reported 202 ecstasy-related deaths occurring in England and Wales from 1996 to 2002, and ecstasy was apparently the sole drug implicated in 17% of these deaths. Ecstasy has also been associated with increased risk of engaging in unhealthy behaviors, including polydrug use and unprotected sex (Akram & Galt 1999; Topp *et al.* 1999a; 1999b). Furthermore, chronic ecstasy use may result in persistent

neuropsychiatric effects, including impaired memory, reduced concentration, impaired executive functioning, depression, anxiety, psychosis, impulsiveness, hostility and sleep disturbance (Montoya *et al.* 2002).

The prevalence, potentially debilitating effects and unhealthy behaviors associated with ecstasy use are of concern to researchers, clinicians and public health advocates. Although several relatively recent reviews have summarized the physiological, cognitive and psychiatric effects associated with *chronic* ecstasy use (e.g. Burgess *et al.* 2000; Morgan 2000; Montoya *et al.* 2002), to our knowledge there has not been a comprehensive review of studies on the *acute* subjective effects (ASEs) of MDMA/ecstasy. Consolidation of the results of these investigations would enhance our knowledge of the variety and prevalence of desirable and undesirable emotional, cognitive, sexual, sensory and somatic effects experienced following consumption. Therefore, we conducted a review of 24 investigations that shed light on the prevalence, intensity and duration of ASEs attributed to ecstasy by recreational users of this drug.

METHOD

Using two research databases (i.e. PSYCINFO and Medline), and the key terms 'MDMA' and 'ecstasy', we reviewed titles and abstracts of articles published in English to identify studies that provided data on self-reported effects associated with this drug. We also examined the reference sections of these articles to identify additional potentially relevant studies. Studies were included in our review (see Table 1) only if the article reported explicitly effects that were both acute (experienced while intoxicated or less than 24 hours after ecstasy consumption) and subjective (were reported by the ecstasy user versus having been reported by an observer or measured using neuropsychological or psychophysiological instruments). We identified 24 articles that met our inclusion criteria.

For studies that provided frequency data on the prevalence of self-reported ASEs, we reviewed text and tables to identify specific effects and record their prevalence. Subsequently, we assigned ASEs to one of the following categories of effects: emotional, somatic, sexual, cognitive, sensory perceptual, sleep or appetite. Listed effects that reflected two or more of the aforementioned categories of effects (e.g. cognitive *and* emotional effects), or listed effects that did not conform to one of the aforementioned categories, were classified as 'combined and miscellaneous effects'. Following category assignment, we collapsed presumably overlapping effects (e.g. 'peaceful' and 'felt calm/serene') or obvious duplicates into one ASE.

The other type of investigation we reviewed contrasted the acute subjective experience following MDMA/ecstasy with another condition. We included in our review only those 'comparison' studies in which the MDMA/ecstasy experience was contrasted with subjects' experience with placebo, subjects' experience prior to taking MDMA/ecstasy, or a non-ecstasy-using control group's experience. For comparison studies, we examined text, tables and figures to record types, intensity, duration and peak experience of ASEs.

RESULTS

Characteristics of the studies reviewed

Characteristics of the 24 studies that assessed ASEs of MDMA/ecstasy are listed in Table 1. A total of 3074 ecstasy users have been studied across a variety of geographic locations. Although women are well-represented across the 24 investigations, males have been recruited more often than females to report on the effects of ecstasy. Participants have ranged in age from 14 to 74 years (three studies did not report age ranges), but the largest proportion has been young adults ranging in age from 21 to 36 years (nine studies did not report mean age).

Participants reported a wide variety of ecstasy-use histories. Some participants had never consumed ecstasy prior to being given it by the investigator (Liechti *et al.* 2001); other participants reported using ecstasy on well over 200 previous occasions. Thirteen studies did not report the range of previous consumption experiences or reported only the minimum or maximum number of previous consumptions. Only five studies provided the average number of previous ecstasy experiences reported by their participants (Liester *et al.* 1992; Camí *et al.* 2000; Tancer & Johanson 2001, 2003; Hernández-López *et al.* 2002).

Investigators employed a variety of measures to assess the acute subjective effects of ecstasy, often combining more than one type of assessment in the same investigation (column 7, Table 1). For example, some employed previously published instruments; others employed a checklist of subjective effects devised for that investigation (often formatted as visual analog scales); and yet others employed semistructured or open-ended interviews.

Sample sizes have ranged from a low of eight to a high of 876 participants (mean = 128 participants; median = 32). In general, laboratory studies recruited small numbers of participants to whom MDMA was given prior to assessment of physiological and psychological effects. Eight of the 24 studies listed in Table 1 assessed ASEs shortly following ingestion and apparently while participants were intoxicated, either in the researchers' laboratory or *in situ* (i.e. rave/club). We refer to this methodology as concurrent assessment. Fourteen of the 24 studies assessed ASEs retrospectively; that is, some hours,

Table 1 Location, age, gender, MDMA history and mode of assessment for reviewed investigations.

Study	*Country*	*n (MDMA users)*	*Age (years)*	*Gender*	*MDMA history*	*Mode of assessment*[a]	*Retrospective versus concurrent*	*Amount(s) of MDMA given*
Camí *et al.* (2000)	Spain	8	Mean = 27 (range 21–30)	Males only	Mean = 23 previous experiences (range 5–50)	ARCI, VAS checklist of effects, POMS	Concurrent	75 mg and 125 mg regardless of body weight
Cohen (1995)	USA	500	No mean; range 18–25	336 males, 164 females	> 50% had maximum of three previous experiences (range 1–250)	Q	Retrospective	NA
Curran & Travill (1997)	UK	12	No mean; range 20–27[b]	8 males, 4 females	2 used ecstasy once/ week; 6 used ecstasy approximately once/ month; 4 used ecstasy only 'occasionally'	MRS, BSS	Concurrent	NA
Davison & Parrott (1997)	UK	20	No mean; range 18–31	11 males, 9 females	5 had one experience; 9 had 2–9 experiences; 6 had ≥ 10 experiences (max = 200)	EEQ, POMS	Retrospective	NA
Downing (1986)	USA	21	Median = 39 (range 20–58)	13 males, 8 females	Median = 8.5 previous experiences (range 1–15)	Q	Combination of concurrent and retrospective	Mean = 1.14 mg/lb (range 0.8–1.9 mg/lb)
Greer & Tolbert (1986)	USA	29	No mean; maximum = 74	Both (% not specified)	Not specified	Q, OEI	Not explicit; seems to be both concurrent and retrospective	Range 75–150 mg; offered second dose of 50 mg or 75 mg when effects began to subside
Harris *et al.* (2002)	USA	8	No mean; range 24–39	5 males, 3 females	Range 5–200 previous experiences	VAS checklist of effects, modified SDEQ, PANSS, OEI	Concurrent	0.5 mg/kg and 1.5 mg/kg
Hernández-López *et al.* (2002)	Spain	9	Mean = 23 (range 19–36)	Males only	Mean = 26 previous experiences (range 5–100)	ARCI, VAS checklist of effects	Concurrent	100 mg regardless of body weight
Liechti *et al.* (2001)	Switzerland	74	Mean = 27 (range 20–49)	54 males, 20 females	All but 5 reported no previous experiences; max = 2	AM, OAV, LC	Concurrent	1.6 ± 0.12 mg/kg; range 1.35–1.8 mg/kg

Table 1 *Cont.*

Study	*Country*	*n (MDMA users)*	*Age (years)*	*Gender*	*MDMA history*	*Mode of assessment*[a]	*Retrospective versus concurrent*	*Amount(s) of MDMA given*
Liester *et al.* (1992)	USA	20	Mean = 36 (range 28–55)	18 males, 2 females	Mean = 4 previous experiences (range 1–25)	SI	Retrospective	NA
Parrott & Lasky (1998)	UK	15[c]	Mean = 21	7 males, 8 females	10 or more previous experiences	VAS checklist of effects	Concurrent	NA
Parrott & Stuart (1997)	UK	21	No mean; range 17–34	Not specified	Not specified	Modified POMS	Retrospective	NA
Pereira de Almeida & Silva (2003)	Brazil	52	Mean = 24 (range 15–37)	32 males, 20 females	All reported ≥10 experiences; In the 3 months prior to testing, 37% used 1/month, 42% used 1/week, 21% used > 1/week	Q	Retrospective	NA
Siliquini *et al.* (2001)	Italy	145	All = 18	Males only	52% had one previous experience; 17% reported 'regular'; 32% reported 'occasional' consumption	Q	Retrospective	NA
Solowij *et al.* (1992)	Australia	100	Mean = 27 (range 16–48)	61 males, 39 females	32% had 1–3 previous; 68% > 3 previous	Q	Retrospective	NA
Tancer & Johanson (2001)	USA	15	Mean = 24[d]	8 males, 14 females[d]	Mean = 14 previous experiences (range 3–40)	POMS, VAS checklist of effects, ARCI, HRS	Concurrent	75 mg/70 kg, 110 mg/70 kg, or 145 mg/70 kg
Tancer & Johanson (2003)	USA	12	Mean = 22 (range 18–31)	6 males, 6 females	Mean = 14 .5 previous experiences (range 4–40)	POMS, VAS checklist of effects, ARCI, HRS, Multiple Choice Procedure	Concurrent	1 mg/kg, 2 mg/kg

Topp *et al.* (1999a)	Australia	213	Mean = 22 (range 15–46)	102 males, 111 females	Minimum of 3 previous occasions; median of 12 previous within preceding 6 months (range 1–100)	SI	Retrospective	NA
Topp *et al.* (1999b), based on Topp *et al.* (1998)	Australia	329	Mean = 23 (range 15–46)	161 males, 168 females	Minimum of 3 previous occasions; median of 10 previous within preceding 6 months (range 1–100)	SI (i.e. National Survey of Ecstasy and Other Party Drugs)	Retrospective	NA
van de Wijngaart *et al.* (1999), based on van de Wijngaart *et al.* (1998)	Netherlands	876[e]	Median = 20 (range 14–46)[f]	796 males, 325 females[f]	Minimum of 1 previous occasion	Checklist of effects not otherwise specified[g]	Apparently retrospective	NA
Verheyden *et al.* (2003)	UK	428	Mean = 24 (range 17–36)[h]	238 males, 192 females[h]	Minimum of 6 previous occasions	SI	Retrospective	NA
Williamson *et al.* (1997)	UK	82	Mean = 30 (range 14–59)[i]	98 males, 60 females[i]	Minimum of 1 previous occasion (mean number of days used in last month = 4)	SI	Retrospective	NA
Zemishlany *et al.* (2001)	Israel	35	No mean; range 21–48	20 males, 15 females	Not specified	SI	Retrospective	NA
Zervogiannis *et al.* (2003)	South Africa	50	Mean = 21 (range 15–26)	29 males, 21 females	18% had 1–3 previous occasions; 82% had more than 3	SI	Retrospective	NA

[a]ARCI = Addiction Research Center Inventory (Haertzen *et al.* 1963); VAS = visual analog scales; AM = Adjective Mood rating scale (Janke & Debus 1978); OAV = Altered State of Consciousness rating scale (Dittrich 1998); LC = List of Complaints (Liechti *et al.* 2001); SDEQ = Subjective Drug Effects Questionnaire (Katz *et al.* 1968); PANSS = Positive and Negative Syndrome Scale (Kay *et al.* 1987); OEI = open-ended interview; POMS = Profile of Mood States (Lorr & McNair 1980); HRS = Hallucinogen Rating Scale (Strassman *et al.* 1994); MRS = Mood Rating Scale (Bond & Lader 1974); BSS = Bodily Symptoms Scale (Sarason 1984); EEQ = Ecstasy Effects Questionnaire (Davison & Parrott 1997); Q = questionnaire developed by author(s); SI = Structured (or semistructured) interview. [b]Age range based on entire sample of 24 participants, only 12 of whom used ecstasy. [c]*n* based on 15 'regular' users; data from 'novice' users not included in review. [d]Mean age and gender composition based on sample of 22 participants, some of whom were not given MDMA by experimenters. [e]Authors' reports provided three different *n*s (876, 883, 908); we elected to record the smallest of these three. [f]Median age and gender composition based on total sample of 1121 study participants, only 81% of whom reported having used MDMA. [g]Also conducted in-depth interviews with some participants; however, authors did not describe in detail ASEs reported during interviews. [h]Age and gender composition based on sample of 430 participants (2 did not complete ASE component of study). [i]Age and gender composition reported for entire sample of 158 participants, only 82 of whom used ecstasy.

days or weeks following ingestion and often after intoxication had subsided. Finally, two studies listed in Table 1 appeared to combine concurrent and retrospective assessment of ASEs; specifically, in these investigations, participants consumed MDMA (provided by the investigators) at their homes or an investigator's beach house, and described their experience while intoxicated and 'afterward' (Downing 1986, p. 336) or 'soon after the session' (Greer & Tolbert 1986, p. 320).

For the six laboratory studies (Camí *et al.* 2000; Liechti *et al.* 2001; Tancer & Johanson 2001, 2003; Harris *et al.* 2002; Hernández-López *et al.* 2002) and two *in situ* studies (Downing 1986; Greer & Tolbert 1986) in which MDMA was given to participants, dose levels are listed in the final column of Table 1. The dose and purity of MDMA taken by participants in the remaining 16 retrospective studies were either not known or not reported by investigators. Although the diversity of ages, consumption histories, geographic locations and methodologies enhances generalizability of the results, this diversity also impedes direct comparison across the two types of investigations. Therefore, first we summarized results for those studies reporting the prevalence of specific ASEs, and then we summarized those studies comparing the effects of MDMA to placebo experience, pre-ingestion functioning, or the experiences of a non-ecstasy-using comparison group.

Reported effects from prevalence studies

Somatic

Table 2 lists the 16 types of somatic ASEs reported across three or more investigations ($k \geq 3$). Participants in the reviewed studies apparently experienced a wider variety of somatic effects following ingestion of ecstasy than any other type of effect (e.g. emotional, sexual, cognitive, etc.). Given the wide range and low proportions recorded in many of these studies, we made special note of those somatic effects experienced by at least 80% of participants in one or more studies: bruxism/teeth problems, body temperature changes, fatigue or mental fatigue, accelerated heart/heartbeat, sweating/sweaty palms, dry mouth/thirst, increased energy and dilated pupils (this last ASE was not listed in Table 2 because $k < 3$).

However, it is important to note that the meaningfulness of such apparently large proportions is tempered by the relatively small number of participants in some of the investigations in which those effects were noted. With two exceptions (dilated pupils and increased energy), the effects reported by 80% or more of participants were recorded in investigations consisting of no more than 21 participants. Furthermore, although the prevalences of other somatic effects appeared relatively low or were reported in fewer than three investigations, meaningful numbers of participants reported such effects (i.e. stomach and/or intestinal pain, inability to urinate, shortness of breath, motor tics/shakiness, nausea and/or vomiting, headache, dizziness and/or vertigo, and muscle aches or tightness). Although they are not listed in Table 2, we also recorded 14 primarily negative and relatively rare somatic ASEs reported by only one investigation (a full list of all somatic and other types of effects is available upon request).

Emotion

Table 3 lists the eight types of emotional ASEs reported across three or more investigations ($k \geq 3$). Given the wide range of frequencies with which these emotional effects were reported, some of which were notably low for one or more studies, we made note of those emotional effects experienced by at least 80% of participants in one or more investigations: tenderness/affection, peaceful/calm, euphoria or improved mood, decreased defensiveness, and mood swings/moodiness (this last ASE was not listed in Table 3 because $k < 3$). Although the experience of one of these emotional ASEs—euphoria or improved mood—was reported by 98% of participants in a sample of 876 (van de Wijngaart *et al.* 1998), reflecting a notably large number of people, the meaningfulness of other large proportions reporting other emotional effects is tempered by the much smaller number of participants included in those investigations. For example, although participants experienced either mood swings/moodiness or decreased defensiveness with notable frequency (85% and 80%, respectively), neither study reporting these prevalence rates included more than 20 people (Liester *et al.* 1992; Davison & Parrott 1997). Therefore, although several of these effects were apparently prevalent in at least one study, these proportions do not represent a large absolute number of participants.

Furthermore, for other emotional ASEs, the proportions reporting a particular effect may appear low, but in fact represent a meaningful number of participants (i.e. anxiety or nervousness, fear/paranoia, omnipotence, greater self-confidence or self-acceptance, and insecurity). Also not listed in Table 3 are 16 relatively rare emotional ASEs that were reported by only one investigation and experienced by fewer than 20 participants (with the exception of insecurity, which was reported by 280 participants in van de Wijngaart *et al.* 1998). Approximately half these rare ASEs reflected presumably desirable emotions (e.g. hopefulness, satisfaction, feel less guilty).

Cognitive

We recorded 13 different types of effects we considered cognitive ASEs. Three of those effects were recorded by three or more investigations: confused thought ($k = 5$; prevalence = 3–50%), loss of memory/forget-

Table 2 Prevalence of reported somatic acute subjective effects across 15 studies where k ≥ 3.

Somatic acute subjective effects (k)	*Prevalence rates reported*
Nausea and/or vomiting; small amount of vomiting; felt sick/vomited (12)	2%,[j] 3%,[d] 5%,[b] 6%,[°] 10%,[c*] 15%,[h] 15%,[k] 15%,[g] 18%,[r] 22%,[a] 24%,[d] 25%,[b] 30%,[l] 34%,[n] 58%[r]
Bruxism; tight jaw muscles; jaw clenching and/or the grinding of teeth; jaw tension or shaking or teeth clenching; trismus; I chewed my mouth/my jaw shook; teeth problems (bruxism, hypersensitive teeth, mouth ulcers from excessive chewing); biting cheek during sleep/difficulty opening jaws wide (10)	3%,[d] 23%,[l] 30%,[h] 40%,[°] 50%,[h] 54%,[a] 58%,[g] 63%,[f] 64%,[r] 76%,[d] 80%,[c**] 85%[b]
Headache (9)	3%,[d] 3%,[°] 5%,[h] 12%,[g] 13%,[e] 35%,[b] 35%,[l] 36%,[n] 50%,[f] 60%[c**]
Body temperature changes; heat waves; hot and/or cold waves/sensations; increased body temperature; pleasantly warm; feeling cold; hot/cold flushes; being cold (8)	2%,[j] 3%,[d] 7%,[d] 23%,[i] 24%,[g] 34%,[g] 39%,[l] 50%,[e] 60%,[r] 75%,[f] 90%[b]
Accelerated heart/heartbeat; increased heart rate; increased pulse; heart palpitations; heartbeat increased/felt faster (8)	13%,[e] 25%,[i] 35%,[g] 37%,[l] 51%,[n] 57%,[°] 63%,[f] 70%,[r] 100%[b]
Muscle aches or tightness; muscle cramps; body tense; lower back pain; muscle hypertonicity (7)	1%,[g] 8%,[r] 13%,[f] 28%,[d] 32%,[a] 38%,[e] 50%,[f] 58%,[l] 76%[n]
Fatigue or mental fatigue; lethargy; weakness; exhaustibility; loss/lack of energy (6)	3%,[d] 6%,[j] 8%,[p] 15%,[g] 15%,[g] 26%,[g] 26%,[g] 61%,[l] 79%,[d] 90%[b]
Dizziness and/or vertigo; fainting; felt faint/about to collapse during last bad experience; fainting/pass out (6)	3%,[d] 4%,[p] 5%,[l] 10%,[n] 25%,[n] 31%,[l] 38%,[g] 50%,[e] 75%,[f]
Dry mouth/thirst; I felt thirsty; dehydration; throat or mouth dry (6)	25%,[e] 29%,[i] 32%,[r] 53%,[g] 74%,[°] 85%,[b] 88%[f]
Increased energy; energized; full of energy; hyperactive; activation or increased energy (6)	14%,[d] 74%,[r]85%,[l] 87%,[n] 88%,[n] 91%,[a] 95%[b]
Sweating/sweaty palms; perspiration; diaphoresis; profuse sweating (6)	3%,[d] 5%,[h] 31%,[g] 39%,[l] 50%,[f] 85%,[b]
Numbness/tingling; tingling skin; numb hands and face; paresthesias (5)	3%,[d] 22%,[g] 38%,[e] 42%,[l] 75%,[b] 75%[f]
Heavy legs or 'no legs'; difficulty walking; ataxia; impaired balance; unsteadiness (4)	3%,[d] 10%,[d] 27%,[g] 30%,[r] 49%,[g] 65%[b]
Motor tics; shakiness; tremors/shakes (4)	3%,[d] 5%,[h] 23%,[g] 30%[l]
Restlessness/agitation; restless legs; restlessness (desire to dance) (3)	13%,[f] 34%,[g] 35%,[h] 41%[g]
Eyelid twitches; nystagmus (3)	10%,[h] 20%,[c**] 56%[r]

[a]Cohen 1995 (*n* = 500); [b]Davison & Parrott 1997 (*n* = 20); [c]Downing 1986 (**n* = 10, ***n* = 21); [d]Greer & Tolbert 1986 (*n* = 29); [e]Harris *et al.* 2002 (0.5 mg/kg; *n* = 8); [f]Harris *et al.* 2002 (1.5 mg/kg; *n* = 8); [g]Liechti *et al.* 2001 (*n* = 74); [h]Liester *et al.* 1992 (*n* = 20); [i]Pereira de Almeida & Silva 2003 (*n* = 52); [j]Siliquini *et al.* 2001 (*n* = 145); [k]Solowij *et al.* 1992 (*n* = 100); [l]Topp *et al.* 1998 (*n* = 329); [n]van de Wijngaart *et al.* 1998 (*n* = 876); [°]Verheyden *et al.* 2003 (*n* = 428); [p]Williamson *et al.* 1997 (*n* = 82); [r]Zervogiannis *et al.* 2003 (*n* = 50).

fulness (k = 4; prevalence = 3–28%) and increased alertness/attention focused on here-and-now (k = 3; prevalence = 7–100%). The maximum prevalence rates of the two former effects appear considerably lower compared to the maximum prevalence rate of increased alertness; however, notably larger numbers of participants reported confusion (Topp *et al.* 1998; Verheyden *et al.* 2003) and memory problems (Topp *et al.* 1998).

Two additional cognitive effects were experienced by at least 80% of participants in one investigation—difficulty concentrating (Harris *et al.* 2002) and thinking seems to be clearer/enhanced presence of mind (Harris *et al.* 2002)—although these proportions did not represent more than 10 participants each. However, difficulty concentrating was reported by 44 participants (59%) of Liechti *et al.*'s (2001) sample. We also recorded eight apparently rare cognitive ASEs reported by only one investigation, all of which were experienced by 26 or fewer participants. Of special note, although suicidal thoughts following ingestion of ecstasy were reported by only 8% of participants in only one study (Topp *et al.* 1998), this relatively small proportion represented 26 people experiencing this potentially dangerous effect.

Sex

We recorded 13 different types of effects that we considered sexual ASEs reported by the reviewed studies. Only two such effects—sexual arousal/increased sensual awareness (k = 8; prevalence = 7–100%) and decreased sexual desire (k = 4; prevalence = 3–45%)—were listed

Table 3 Prevalence of reported emotional acute subjective effects across 14 studies where k ≥ 3.

Emotional acute subjective effects (k)	*Prevalence rates reported*
Anxiety or nervousness; I felt anxious/panicky; panic attacks; brooding (10)	1%,[p] 6%,[j] 6%,[o] 8%,[p] 8%,[r] 10%,[l] 11%,[g] 16%,[a] 16%,[g] 17%,[d] 25%,[h] 33%,[l] 40%[b]
Depression; feeling lonely or sad; mild depression; down/depressed (9)	3%,[d] 4%,[j] 7%,[d] 7%,[k] 9%,[p] 10%,[h] 12%,[a] 34%,[n] 50%,[l] 55%[b]
Tender; affectionate; warm and friendly; close to others and/or more intimate with anyone present; feeling of intimacy; decreased sense of separation or alienation from others; sense of unity with people, with the world, or with 'being'; like having people around; greater feeling of love for others; increased ability to interact with or be open with others; increased closeness and/or enhanced communication (8)	10%,[d] 10%,[h] 25%,[e] 38%,[e] 60%,[h] 63%,[f] 63%,[f] 64%,[o] 71%,[n] 79%,[i] 83%,[i] 84%,[r] 85%,[h] 88%,[n] 100%,[b] 100%,[d] 100%[d]
Fear and/or paranoia; I felt paranoid/persecuted; felt paranoid during last bad experience (8)	3%,[d] 4%,[o] 5%,[p] 7%,[p] 8%,[r] 15%,[h] 20%,[a] 31%,[l] 35%[b]
Euphoria or improved mood; euphoric rush; happy; elated; exhilarated; get into party mood; positive mood state or an overall sense of well-being (7)	17%,[d] 64%,[r] 88%,[n] 92%,[i] 92%,[n] 92%,[o] 94%,[r] 97%,[a] 98%,[n] 100%,[b] 100%[b]
Peaceful; calm and/or relaxed; I am at ease; feeling blessed or peace; felt calm/serene; unconcerned; feeling more relaxed, calm, detached, serene, and/or less anxious or agitated; at peace with the world (5)	7%,[d] 20%,[o] 23%,[i] 38%,[d] 48%,[i] 54%,[i] 58%,[i] 63%,[e] 75%,[f] 80%[b]
Irritability (4)	8%,[g] 10%,[p] 60%,[b] 60%[l]
Decreased defensiveness; defenses lowered; easier to receive compliments and criticism; open-minded (3)	10%,[d] 25%,[i] 35%,[d] 80%[h]

[a]Cohen 1995 (*n* = 500); [b]Davison & Parrott 1997 (*n* = 20); [d]Greer & Tolbert 1986 (*n* = 29); [e]Harris *et al.* 2002 (0.5 mg/kg; *n* = 8); [f]Harris *et al.* 2002 (1.5 mg/kg; *n* = 8); [g]Liechti *et al.* 2001 (*n* = 74); [h]Liester *et al.* 1992 (*n* = 20); [i]Pereira de Almeida & Silva 2003 (*n* = 52); [j]Siliquini *et al.* 2001 (*n* = 145); [k]Solowij *et al.* 1992 (*n* = 100); [l]Topp *et al.* 1998 (*n* = 329); [n]van de Wijngaart *et al.* 1998 (*n* = 876); [o]Verheyden *et al.* 2003 (*n* = 428); [p]Williamson *et al.* 1997 (*n* = 82); [r]Zervogiannis *et al.* 2003 (*n* = 50).

by more than two studies. Even though sexual arousal/increased sensual awareness (Downing 1986; Zemishlany *et al.* 2001), improved sex (Zemishlany *et al.* 2001) and enhanced lubrication in women (Zemishlany *et al.* 2001) were reported by at least 80% of participants in one or more studies, these proportions represented relatively few participants (i.e. maximum of 35 participants). The experience of yet another sexual effect—inhibited arousal and/or climax (Topp *et al.* 1999a)—was reported by less than a majority (45%) of Topp *et al.*'s (1999a) sample, but 96 of their participants reported experiencing this effect. There were nine relatively rare sexual ASEs recorded by no more than one investigator and, with two exceptions (lowered inhibitions and inhibited arousal/climax), reported by fewer than two dozen participants. Approximately half of these apparently infrequent effects were desirable (e.g. positive effect on erection, more intense orgasm) and approximately half were undesirable (e.g. negative effect on erection, makes sex worse).

Sensory perception

We recorded 11 different types of sensory–perceptual ASEs associated with ecstasy. Four of the 11 sensory–perceptual effects were recorded by three or more investigations: visual effects/changes in visual perception (k = 6; prevalence = 14–85%), sound hallucinations/altered sound perception (k = 3; prevalence = 13–100%), enhanced sense of touch/tactile illusion (k = 3; prevalence = 3–95%) and hallucinations, not otherwise specified (k = 3; prevalence = 2–60%).

There were two additional sensory–perceptual effects that, although reported by fewer than three investigations and by fewer than 50 people in each study, were experienced by at least 80% of participants in each of the noted investigations: altered time perception (Liester *et al.* 1992) and feeling more aware/heightened perceptions (Zervogiannis *et al.* 2003). This latter effect—heightened awareness/perceptions—was also reported by over 100 people in Verheyden *et al.*'s (2003) investigation, although this number represents only a little over one-quarter of their sample. Finally, we recorded five relatively rare sensory–perceptual effects recorded by only one investigation, all of which were experienced by 30 or fewer participants.

Sleep

We recorded five different types of sleep effects associated with ecstasy. Sleeplessness was the only effect recorded by more than one investigation (k = 7; prevalence = 9–85%). The remaining four sleep effects were recorded by only one investigation each and, except for difficulty

arising from bed the next day (Verheyden *et al.* 2003), three of these ASEs were experienced by three or fewer participants.

Appetite

There were only two, apparently contradictory, appetite-related ASEs—decreased appetite and increased appetite. The former was reported by nine investigations (prevalence = 14–100%), compared to only two recording increased appetite following consumption of ecstasy (prevalence = 3–4%).

Combined and miscellaneous effects

We recorded 17 different effects that, because they combined two of the aforementioned categories of effects (e.g. somatic and emotion), or did not conform to one of the aforementioned categories, are listed separately in Table 4. Talkative(ness) was the only effect in this category recorded by more than one investigation (Davison & Parrott 1997; Zervogiannis *et al.* 2003). There were other combined or miscellaneous effects that we decided not to record in Table 4 because of the low proportion and/or notably few participants ($n < 10$) who experienced these often idiosyncratic effects.

Factors affecting ecstasy experience

Several of the studies reporting prevalence rates examined the relationship between ASEs and factors such as gender, age, dose and ecstasy use history. For example, although they did not report the prevalence of ASEs by gender, Topp *et al.* (1999b) reported that females experienced a greater number of negative physical and psychological effects than did males, and van de Wijngaart *et al.* (1999) reported that females were more frequently ill during or shortly after parties/raves where they had consumed ecstasy. With regard to age of the user, Topp *et al.* (1999b) reported that younger users experienced more negative physical effects, but Verheyden *et al.* (2003) reported that age did not seem to be related to ASEs.

Participants in Zervogiannis *et al.* (2003) reported that larger doses were associated with some of the same effects as 'usual' doses (e.g. jaw clenching, nausea, paranoia, panic attacks and vomiting), but also resulted in unique effects (e.g. nystagmus, muddled thought, feeling jittery, a loss of control, panic attacks, unpredictable mood, erratic behavior and memory loss). In addition, Solowij, Hall & Lee (1992) reported that, relative to the ecstasy experience reported following smaller doses, larger doses were associated with more hallucinatory effects, disorientation, loss of control and increased side effects. Effects following consumption of additional tablets after the initial dose had abated were typically less intense and shorter-lasting than those following the first tablet taken; successive doses were also associated with reduced pleasurable effects and increased side effects (Solowij *et al.* 1992). Topp *et al.* (1999b) reported that participants who consumed ecstasy on a continuous basis without sleep for 48 hours or more experienced a greater number of negative physical and psychological effects compared to non-bingers, but they did not list these specific negative effects.

Table 4 Prevalence of reported combined and miscellaneous acute subjective effects across 7 studies.

Combined and miscellaneous acute subjective effects (k)	*Prevalence rates reported*
Talkative; talkativeness or increased communication (2)	68%,[r] 80%[b]
Decreased ability (20%) or desire (70%) to perform mental or physical tasks (1)	20%,[h] 70%[h]
Learned new ways to deal with psychological problems; gained lasting insight into psychological problems (1)	14%,[d] 24%[d]
Sillier, feels like laughing, or sees comical side of things more (1)	75%[f]
Pleasant and enjoyable (1)	75%[k]
Less control of body, thoughts, or feelings (1)	63%[f]
Warmer, fresher, more alive, euphoric, loving feelings (1)	55%[d]
Intoxicated (1)	50%[g]
Speech changes (1)	45%[h]
Boring (with ecstasy not living up to their expectations or not worth the money) (1)	41%[k]
Felt more acceptance of negative experiences or more patient in some way (1)	35%[d]
Predominantly acute bad reactions (such as paranoia, panic, loss of reality, loss of control, anxiety, hallucinations) (1)	28%[k]
Spiritual awareness (1)	26%[r]
Decreased impulsivity (1)	25%[h]
Experienced at least one bad MDMA trip (variety of adverse physical, emotional, and cognitive effects) (1)	25%[b]
Unpleasant (having experienced negative feelings or indulged in undesirable behaviors) (1)	25%[k]
Decreased compulsiveness (1)	20%[h]

[b]Davison & Parrott 1997 ($n = 20$); [d]Greer & Tolbert 1986 ($n = 29$); [f]Harris *et al.* 2002 (1.5 mg/kg; $n = 8$); [g]Liechti *et al.* 2001 ($n = 74$); [h]Liester *et al.* 1992 ($n = 20$); [k]Solowij *et al.* 1992 ($n = 100$); [r]Zervogiannis *et al.* 2003 ($n = 50$).

Although Siliquini *et al.* (2001), Liester *et al.* (1992) and Verheyden *et al.* (2003) found no meaningful relationship between ecstasy use history and ASEs, several other investigations have reported an association between such effects and use history. For example, according to van de Wijngaart *et al.* (1999), participants who reported longer duration of ecstasy use (5 years versus 3 months) experienced health problems less often, were sick at parties less often and went to first aid posts at parties less often than participants who had consumed ecstasy for a shorter duration of time. Solowij *et al.* (1992) reported that 'multiple time users' more frequently experienced activation and insight than those who had used fewer than three times. There were no significant differences between naive and experienced users on subscales measuring positive mood, negative mood and intimacy. Although the two groups also did not differ significantly on subscales measuring physical effects and mental effects, the severity of these effects was correlated positively with total number of doses consumed and frequency of use.

Reported effects from comparison studies

Ten studies reported the relative strength of ASEs. We divided these studies into three categories: (a) laboratory studies (k = 6), in which assessment measures were administered subsequent to MDMA consumption in the laboratory; (b) club studies (k = 2), in which assessment measures were administered subsequent to ecstasy consumption at a nightclub; and (c) retrospective studies (k = 2), in which individuals described their past experience associated with ecstasy. These studies included objective measures of psychomotor performance (Camí *et al.* 2000; Hernández-López *et al.* 2002), cognitive performance (Curran & Travill 1997; Parrott & Lasky 1998) and physiological effects (Liechti *et al.* 2001; Tancer & Johanson 2001, 2003; Harris *et al.* 2002; Hernández-López *et al.* 2002), as well as measures of emotional, somatic, sensory perceptual and cognitive experiences associated with MDMA/ecstasy. Eight of these studies compared the effects of MDMA/ecstasy to placebo or the effects of other substances (e.g. alcohol, amphetamines, mCPP), and two reported the intensity of selected effects of MDMA/ecstasy alone. Because some substances (such as amphetamines) have effects similar to those of MDMA/ecstasy (e.g. euphoria, increased energy), if we recorded only those effects differing significantly from comparable substances, we could fail to capture the broad range of effects associated with ecstasy. Therefore, for the purposes of this review, we identified ASEs (experienced less than 24 hours following ingestion of MDMA/ecstasy) that differed significantly from those effects experienced subsequent to administration of placebo (or prior to taking MDMA/ecstasy).

Concurrent laboratory studies

Using a double-blind within-subjects design, Hernández-López *et al.* (2002) studied the effects of MDMA (100 mg with and without ethanol) in nine male volunteers who had used ecstasy on at least five occasions. Participants reported experiencing a significant difference from placebo on scales measuring euphoria, dysphoria-and-somatic symptoms and amphetamine-related effects. Drug consumption also resulted in (drug) liking, (feeling) stimulated, (feeling) high, content(ment), different/changed/unreal body feelings and various sensory–perceptual effects. Ingestion of MDMA was associated primarily with desirable effects, which were experienced with more intensity than were undesirable effects. ASEs usually peaked between 45 and 90 minutes after MDMA consumption and lasted from 4.5 to 9 hours (duration was defined by measuring the time elapsed between peak drug experience and return to basal values).

Liechti *et al.* (2001) analyzed data from three double-blind, placebo-controlled within-subject studies, in which a total of 74 subjects (54 males) were administered 70–150 mg of MDMA. MDMA ingestion was followed by reports of anxiety, improved mood, depression, physical/emotional fatigue, positive cognitive changes, thought disorder, and changes in perception and sociability. In one of the few investigations that assessed gender differences, Liechti *et al.* (2001) found that females seemed to experience presumably undesirable effects (e.g. thought disorder, anxiety, depressed mood and perceptual changes) with greater intensity than males who, on the other hand, reported being more active and feeling more energetic subsequent to being given MDMA. ASEs began 30–60 minutes subsequent to consumption and reached their maximum at 75–120 minutes (Liechti *et al.* 2001). The mean duration of these effects was 3.5 hours.

Harris *et al.* (2002) evaluated ASEs using a sample of eight Caucasian participants, five of whom were males. Using a within-subjects design, participants were given placebo, 0.5 mg/kg MDMA and 1.5 mg/kg MDMA, and were then asked to describe their experience both before and several times following ingestion. The smaller dose was associated with euphoria, relaxation and tension, but produced no significant change on any of the visual analog scales assessing changes in mood and cognition. Only three of the eight volunteers felt that the 0.5 mg/kg dose was worth paying for. The higher dose led to reports of drug liking, intoxication, insightfulness, confidence, euphoria, relaxation, cognitive improvement and autonomic arousal. They also endorsed undesirable experiences, including cognitive impairment, tension, bad drug effects and 'effects associated with LSD' (i.e. labile and contradictory emotions and perceptions). This study not

only confirmed a dose–response relationship and the experience of both desirable and undesirable effects, but also revealed that undesirable effects were experienced with less intensity than positive effects. ASEs reached their maximum at 2 hours subsequent to ingestion of MDMA (mean range 1.5–4 hours); although duration of each subjective effect was not specified, several experiences lasted approximately 8 hours.

Camí *et al*. (2000) evaluated ASEs using a sample of eight young males who were administered 75 mg and 125 mg of MDMA. What few effects were experienced subsequent to the smaller dose of MDMA reflected amphetamine-related effects, dysphoria-and-somatic symptoms, and different, changed or unreal body feelings. At the higher dose, participants not only experienced most of the effects reported at the smaller dose, but also reported feeling high, feeling drunk, liking the drug, euphoria, stimulation, confusion, and changes in shapes, lights and hearing. Subjective effects reached their maximum between 90 minutes and 2 hours, and lasted from 2.5 to 8.5 hours (duration defined by measuring the time elapsed between peak drug experience and return to basal values).

Tancer & Johanson (2001) evaluated ASEs in a sample of 15 young adults who received placebo and a single dose of MDMA (75 mg, 110 mg or 145 mg/70 kg). Visual inspection of the data indicated that there was no clear relationship between the magnitude of the subjective response and the dose of MDMA. The drug produced presumably positive effects, including significant euphoria, elation, stimulation, intoxication ('high'), sociability ('friendliness') and amphetamine-like effects. MDMA also produced presumably negative effects including dysphoria-and-somatic symptoms, anxiety and confusion. Finally, MDMA produced what the authors called 'hallucinogenic effects', including changes in perception, changes in emotion, alterations in thought processes or content, and interoceptive, visceral and cutaneous/tactile effects. Most of the subjective effects described by participants in this study reached their maximum 2 hours subsequent to ingestion and returned to baseline levels 4 hours later. In a follow-up study to their 2001 investigation, Tancer & Johanson (2003) again found many of the same positive and negative effects over the same time-course when they compared a 2 mg/kg dose of MDMA to placebo. In addition, on a measure designed to assess the drug's reinforcement value, participants viewed the 2 mg/kg dose of MDMA as more desirable than placebo.

Concurrent club studies

Parrott & Lasky (1998) conducted a longitudinal study in which they examined ASEs reported by 15 novice users (one to nine previous occasions) and 15 regular users (10 or more previous occasions) before, during and after attending a nightclub. Fifteen additional individuals who also regularly visited nightclubs, but who reported never having consumed ecstasy (but had consumed various other substances), served as a comparison group. Some of the ecstasy users also reported having used cannabis, cocaine, amphetamine and/or alcohol at the nightclub. Although Parrott & Lasky (1998) did not conduct statistical analyses to evaluate the impact of use history on ecstasy experience, our inspection of their results indicates that the ecstasy experiences of novice and regular users were similar. All effects reported by ecstasy users are described below, regardless of whether the strength of these effects differed significantly from that of the comparison group, because they had consumed a variety of illicit substances besides ecstasy. Regular users of ecstasy reported feeling good-tempered, interested, abnormal, calm, steady, well-co-ordinated, sober, and energetic with *much* intensity; they reportedly felt quick-witted, clear-headed, and drowsy with *moderate* intensity; and they reportedly felt depressed, ill, unsociable, unpleasant and sad with relatively *little* intensity.

Curran & Travill (1997) also recruited participants in a club setting and compared the subjective experience of 12 individuals who had reported using ecstasy to that of 12 individuals who reported having drunk an average of 10.8 units of alcohol but not having taken ecstasy (or any other psychoactive drugs apart from caffeine and/or nicotine). We reviewed effects reported by the 12 ecstasy users on both the day of and the day following consumption because they met our definition of acute effects, having been experienced within 24 hours of ingestion. Participants reported feeling energetic, amicable, tranquil, relaxed, gregarious, clear-headed, excited, proficient and quick-witted with greater intensity on the night ecstasy was ingested relative to the following day/afternoon. Participants also reported presumably undesirable effects, including sweating, dry mouth, blurred vision, difficulty breathing and nausea with greater intensity the evening of ingestion. Effects experienced more intensely the following day included primarily undesirable effects, including restlessness, impaired concentration, lack of energy, physical tiredness, feeble(ness), headache, irritability, agitation, depression, anxiety, feeling drowsy and feeling clumsy. Presumably positive effects experienced with greater intensity the day following ingestion were feeling content, dreamy, happy and interested.

Retrospective studies

Parrott & Stuart (1997) recruited 21 young recreational polydrug users to describe their past experiences of ecstasy. There were no reported negative effects following ecstasy use, nor did participants report that ecstasy had a significant impact on items measuring clear-headed(ness)/confusion, but they did report feeling

energetic, elated, agreeable and confident. The authors did not specify either the time at which these effects reached their maximum or the duration of these effects.

Davison & Parrott (1997) also conducted a retrospective study in which 20 young adults (11 males) were asked to describe their past experiences with ecstasy. Participants reported feeling significantly more energetic, elated, agreeable and confused after taking MDMA. Similar to Parrott & Stuart (1997), the authors did not specify either the time at which these effects reached their maximum or the duration of these effects.

DISCUSSION

During the 1990s, ecstasy use increased globally, despite being associated with increased likelihood of engaging in unhealthy behaviors while intoxicated and increased likelihood of neuropsychological and psychiatric complications. Multiple factors are motivating use of this drug, including, among others, the desirable effects of acute intoxication that recreational users attribute to ecstasy. Therefore, we conducted a review of 24 investigations reporting frequency data and/or intensity of acute subjective effects experienced either while intoxicated or within 24 hours of consumption.

Hundreds of sometimes idiosyncratic effects have been reported following ecstasy consumption, but only a subset of the ASEs have been reported across multiple investigations. Twelve of the most common ASEs across the 18 prevalence investigations were somatic, each recorded in five or more investigations: nausea and/or vomiting, bruxism/teeth problems, headache, body temperature changes, accelerated heart/heartbeat, muscle aches or tightness, fatigue or mental fatigue, dizziness and/or vertigo, dry mouth/thirst, increased energy, sweating/sweaty palms and numbness/tingling. Another six common effects were emotional: anxiety or nervousness, depression, tenderness/closeness, fear and/or paranoia, euphoria or improved mood, and feeling peaceful/calm. Only one sexual ASE (sexual arousal/increased sensual awareness), one cognitive ASE (confused thought), one sensory–perceptual ASE (visual effects/changes in visual perception), one sleep-related ASE [sleepless(ness)] and one appetite-related ASE (decreased appetite) were reported across five or more investigations.

Similar to the studies reporting prevalence rates of specific ASEs, participants in both laboratory and *in situ* studies reported many of the same emotional, sensory–perceptual and cognitive ASEs following ingestion of MDMA. Furthermore, the comparison investigations demonstrated that desirable ASEs appeared to be experienced more often and with more intensity relative to undesirable ASEs. A greater number of presumably negative effects were experienced with greater intensity the day following MDMA consumption. ASEs typically began 30–60 minutes subsequent to consumption, reached their maximum 75–120 minutes after consumption/onset and lasted 2–12 hours.

In those few studies that examined dose effects, participants associated larger doses with a more intense and longer-lasting MDMA/ecstasy experience and smaller doses with fewer negative effects. Although women reported more undesirable ASEs (e.g. physical illness, depressed mood, anxiety, thought disorder and perceptual changes) with greater intensity relative to males, gender effects were studied in only three studies. To the degree that gender is associated with either the reaction to MDMA/ecstasy or the report of one's experiences, the prevalence of some specific effects may reflect the recruitment of more men than women as participants. Two studies examined the association of age and ASEs, and only one found any relationship (being younger was associated with experiencing more physical effects, all of which we judged to be undesirable). Although six of the 24 reviewed studies evaluated the association between history of ecstasy use and the prevalence of specific experiences, the results did not reveal a consistent relationship between these variables. We could not calculate prevalence of effects by either gender or ecstasy history because almost all studies reported results collapsing across gender and ecstasy-use histories, and many did not report the latter.

Several other factors may also influence the report of prevalence, intensity and duration of MDMA/ecstasy. For example, deficits in memory and attention associated with chronic ecstasy use (Montoya *et al*. 2002) may impact the report of ASEs in retrospective studies. Participants with histories of prolonged use may have difficulty completing longer or more detailed surveys, may complete them less carefully and may have difficulty recalling effects associated with their ecstasy experiences. Furthermore, appraisal of the ecstasy experience may be biased by outcome expectancies (Engels & ter Bogt 2004) or as a result of participants having altered their attitudes regarding ecstasy to justify the expense or experience of ecstasy consumption.

It is also important to consider the content and format of assessment method on the range of effects recorded in the studies reviewed. If questions regarding the experience of MDMA/ecstasy are restricted to emotional, cognitive and somatic effects, then some sensory–perceptual, sexual, sleep-related and appetite-related effects experienced by participants will not be captured by the researchers' assessment measures.

Also, if one elicits descriptions about the MDMA/ecstasy experience using open-ended questions versus checklists of effects, participants may fail to recall or report some of their experiences associated with use.

Consequently, researchers may capture only those effects most salient to participants (e.g. intense positive or negative effects versus moderate positive or negative effects). On the other hand, relative to checklists of effects, open-ended questions are more likely to capture unique experiences attributed to MDMA/ecstasy consumption (e.g. telepathic abilities). Therefore, it is not surprising that some of the effects obtained through open-ended questions were recorded with less frequency than those effects obtained through checklists of effects. Furthermore, a checklist of effects may inflate artificially the apparent significance of a particular experience if an effect which is experienced only mildly or transiently is recorded as experienced with the same frequency as an effect that is experienced with greater intensity or for a longer duration.

Recruitment strategy and inclusion criteria also have the potential to impact prevalence of ASEs. For example, individuals who experience primarily negative effects subsequent to ecstasy or polydrug use may be less likely to attend clubs and raves where subjects have often been recruited. In addition, the location where one consumes ecstasy may influence the effects attributed to the drug. Furthermore, if individuals who experience primarily negative effects reduce or stop taking ecstasy, they will be less likely to meet criteria for participation in studies that require multiple previous experiences with ecstasy and/or recent consumption of ecstasy use for inclusion.

Another important consideration is the potential for misattribution of various experiences to MDMA/ecstasy. With the exception of the six laboratory studies (Camí *et al.* 2000; Liechti *et al.* 2001; Tancer & Johanson 2001, 2003; Harris *et al.* 2002; Hernández-López *et al.* 2002) and two additional *in situ* studies (Downing 1986; Greer & Tolbert 1986) in which MDMA was given to participants, the contents of the ecstasy pills participants reported ingesting is unknown. Therefore, it is possible that the effects apparently associated with ecstasy are in fact the result of taking another substance (e.g. caffeine, amphetamine, LSD, ketamine) or the combination of MDMA and another substance in the same tablet.

Furthermore, ecstasy users often report consuming additional substances (e.g. cannabis, cocaine, alcohol, amphetamines), either during the time of assessment or when they typically use ecstasy, to enhance the ecstasy experience or to assist in 'coming down' from ecstasy (Curran 2000). This, too, makes it difficult to determine whether the reported effects were the result of MDMA, an unrelated substance, or a combination of substances (which may or may not include MDMA). It is also possible that some of the effects attributed to ecstasy use, such as difficulty getting out of bed the next day, might better be attributed to the activities (e.g. dancing, staying awake through the night) associated with ecstasy use rather than to the ecstasy itself. Nonetheless, the overall experience of MDMA/ecstasy users in the retrospective studies and concurrent club studies seemed to be similar to that demonstrated in the controlled laboratory studies.

These limitations notwithstanding, given the two dozen studies we examined—representing thousands of ecstasy users, across a diversity of countries and cultures, employing a variety of methodological approaches and assessment tools—this review provides clinicians and researchers with a comprehensive summary of desirable and undesirable ASEs that may motivate and restrain ecstasy use. This summary also may assist public health efforts to reduce biomedical harms (e.g. fainting, dehydration, shortness of breath, bruxism) associated with recreational use of MDMA/ecstasy. Furthermore, educators should acknowledge the positive effects users have attributed to ecstasy, or they may sabotage or discredit prevention efforts, especially when prevention messages are inconsistent with users' own experiences or the experiences of their peers (Zervogiannis *et al.* 2003). In addition to these applied recommendations, we encourage researchers to move beyond recording the prevalence of acute subjective effects to identifying the intensity and duration of such effects as a function of gender, age, polydrug use and ecstasy-use history. As they do so, researchers should continue to attend to ethical issues involved in conducting research in which participants consume MDMA/ecstasy.

References

Akram, G. & Galt, M. (1999) A profile of harm-reduction practices and co-use of illicit and licit drugs amongst users of dance drugs. *Drugs: Education, Prevention and Policy*, **6**, 215–225.

Allaste, A. & Lagerspetz, M. (2002) Recreational drug use in Estonia: the context of club culture. *Contemporary Drug Problems*, **29**, 183–200.

Bellis, M., Hughes, K., Bennett, A. & Thomson, R. (2003) The role of an international nightlife resort in the proliferation of recreational drugs. *Addiction*, **98**, 1713–1721.

Bond, A. & Lader, M. (1974) The use of analogue scales in rating subjective feelings. *British Journal of Medical Psychology*, **47**, 211–218.

Boyd, C., McCabe, S. & d'Arcy, H. (2003) Ecstasy use among college undergraduates: gender, race and sexual identity. *Journal of Substance Abuse Treatment*, **24**, 209–215.

Burgess, C., O'Donohoe, A. & Gill, M. (2000) Agony and ecstasy: a review of MDMA effects and toxicity. *European Psychiatry*, **15**, 287–294.

Camí, J., Farré, M., Mas, M., Roset, P., Poudevida, S., Mas, A. *et al.* (2000) Human pharmacology of 3,4-methylenedioxymethamphetamine ('ecstasy'): psychomotor performance and subjective effects. *Journal of Clinical Psychopharmacology*, **20**, 455–466.

Cohen, R. (1995) Subjective reports on the effects of the MDMA ('ecstasy') experience in humans. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, **197**, 1137–1145.

Çorapçioglu A. & Ogel, K. (2004) Factors associated with ecstasy use in Turkish students. *Addiction*, **99**, 67–76.

Curran, V. (2000) Is MDMA ('ecstasy') neurotoxic in humans? An overview of evidence and of methodological problems in research. *Neuropsychobiology*, **42**, 34–41.

Curran, H. & Travill, R. (1997) Mood and cognitive effects of +-3,4-methylenedioxymethamphetamine (MDMA, 'ecstasy'): week-end 'high' followed by mid-week low. *Addiction*, **92**, 821–831.

Davison, D. & Parrott, A. (1997) Ecstasy (MDMA) in recreational users: self-reported psychological and physiological effects. *Human Psychopharmacology: Clinical and Experiment*, **12**, 221–226.

Dittrich, A. (1998) The standardized psychometric assessment of altered states of consciousness (ASCs) in humans. *Pharmacopsychiatry*, **31**, 80–84.

Downing, J. (1986) The psychological and physiological effects of MDMA on normal volunteers. *Journal of Psychoactive Drugs*, **18**, 335–340.

Engels, R. C. M. E. & ter Bogt, T. (2004) Outcome expectancies and ecstasy use in visitors of rave parties in the Netherlands. *European Addiction Research*, **10**, 156–162.

Gold, M. S., Tabrah, H. & Frost-Pineda, K. (2001) Psychopharmacology of MDMA (ecstasy). *Psychiatric Annals*, **31**, 675–681.

Greer, G. & Tolbert, R. (1986) Subjective reports of the effects of MDMA in a clinical setting. *Journal of Psychoactive Drugs*, **18**, 319–327.

Gross, S., Barrett, S., Shestowsky, J. & Pihl, R. (2002) Ecstasy and drug consumption patterns: a Canadian rave population study. *Canadian Journal of Psychiatry*, **47**, 546–551.

Haertzen, C., Hill, H. & Belleville, R. (1963) Development of the Addiction Research Center Inventory (ARCI): selection of items that are sensitive to the effects of various drugs. *Psychopharmacologia*, **4**, 155–166.

Harris, D., Baggott, M., Mendelson, J. & Jones, R. (2002) Subjective and hormonal effects of 3,4-methylenedioxymethamphetamine (MDMA) in humans. *Psychopharmacology*, **162**, 396–405.

Hernández-López, C., Farré, M., Roset, P., Menoyo, E., Pizarro, N., Ortuño, J. *et al.* (2002) 3,4-Methylenedioxymethamphetamine (ecstasy) and alcohol interactions in humans: psychomotor performance, subjective effects, and pharmacokinetics. *Journal of Pharmacology and Experimental Therapeutics*, **300**, 236–244.

Janke, W. & Debus, G. (1978) *Die Eigenschaftswörterliste (EWL-K)—Ein Verfahren Zur Erfassung der Befindlichkeit*, 1st edn *[The Adjective List: a Procedure Determine Existential Orientation]* Göttingen: Hogrefe.

Katz, M., Waskow, I. & Olsson, J. (1968) Characterizing the psychological state produced by LSD. *Journal of Abnormal Psychology*, **73**, 1–14.

Kay, S., Fiszbein, A. & Opler, L. (1987) The positive and negative syndrome scale (PANSS) for schizophrenia. *Schizophrenia Bulletin*, **13**, 261–276.

Lenton, S., Boys, A. & Norcross, K. (1997) Raves, drugs and experience: drug use by a sample of people who attend raves in Western Australia. *Addiction*, **92**, 1327–1337.

Liechti, M., Gamma, A. & Vollenweider, F. (2001) Gender differences in the subjective effects of MDMA. *Psychopharmacology*, **154**, 161–168.

Liester, M., Grob, C., Bravo, G. & Walsh, R. (1992) Phenomenology and sequelae of 3,4-methylenedioxymethamphetamine use. *Journal of Nervous and Mental Disease*, **180**, 345–352.

Lorr, M. & McNair, D. (1980) *Profile of Mood States: Bipolar Form.* San Diego, CA: Educational and Industrial Testing Service.

Lua, A., Lin, H., Tseng, Y., Hu, A. & Yeh, P. (2003) Profiles of urine samples from participants at rave party in Taiwan: prevalence of ketamine and MDMA abuse. *Forensic Science International*, **136**, 47–51.

Montoya, A., Sorrentino, R., Lukas, S. & Price, B. (2002) Long-term neuropsychiatric consequences of 'ecstasy' (MDMA): a review. *Harvard Review of Psychiatry*, **10**, 212–220.

Morgan, M. (2000) Ecstasy (MDMA): a review of its possible persistent psychological effects. *Psychopharmacology*, **152**, 230–248.

Parrott, A. C. & Lasky, J. (1998) Ecstasy (MDMA) effects upon mood and cognition: before, during and after a Saturday night dance. *Psychopharmacology*, **139**, 261–268.

Parrott, A. C. & Stuart, M. (1997) Ecstasy (MDMA), amphetamine, and LSD: comparative mood profiles in recreational polydrug users. *Human Psychopharmacology*, **12**, 501–504.

Pedersen, W. & Skrondal, A. (1999) Ecstasy and new patterns of drug use: a normal population study. *Addiction*, **94**, 1695–1706.

Pereira de Almeida, S. & Silva, M. (2003) Ecstasy (MDMA): effects and patterns of use reported by users in São Paulo. *Revista Brasileira de Psiquiatria*, **25**, 11–17.

Riley, S., James, C., Gregory, D., Dingle, H. & Cadger, M. (2001) Patterns of recreational drug use at dance events in Edinburgh, Scotland. *Addiction*, **96**, 1035–1047.

Sarason, I. G. (1984) Stress, anxiety, and cognitive interference: reactions to tests. *Journal of Personality and Social Psychology*, **46**, 929–938.

Schifano, F., Oyefeso, A., Corkery, J., Cobain, K., Jambert-Gray, R., Martinotti, G. *et al.* (2003) Death rates from ecstasy (MDMA, MDA) and polydrug use in England and Wales 1996–2002. *Human Psychopharmacology: Clinical and Experimental*, **18**, 519–524.

Siliquini, R., Faggiano, F., Geninatti, S., Versino, E., Mitola, B. & Ippolito, R. (2001) Patterns of drug use among young men in Piedmont (Italy). *Drug and Alcohol Dependence*, **64**, 329–335.

Solowij, N., Hall, W. & Lee, N. (1992) Recreational MDMA use in Sydney: a profile of 'ecstasy' users and their experiences with the drug. *British Journal of Addiction*, **87**, 1161–1172.

Strassman, R., Qualls, C., Uhlenhuth, E. & Kellner, R. (1994) Dose–response study of N,N-dimethyltryptamine in humans. *Archives of General Psychiatry*, **51**, 98–108.

Strote, J., Lee, J. & Wechsler, H. (2002) Increasing MDMA use among college students: results of a national survey. *Journal of Adolescent Health*, **30**, 64–72.

Tancer, M. & Johanson, C. (2001) The subjective effects of MDMA and mCPP in moderate users. *Drug and Alcohol Dependence*, **65**, 97–101.

Tancer, M. & Johanson, C. (2003) Reinforcing, subjective, and physiological effects of MDMA in humans: a comparison with d-amphetamine and mCPP. *Drug and Alcohol Dependence*, **72**, 33–44.

Topp, L., Hando, J., Degenhardt, L., Dillon, P., Roche, A. & Solowij, N. (1998) *Ecstasy Use in Australia.* NDARC Monograph no. 39. Australia: University of New South Wales, National Drug and Alcohol Research Centre/University of Queensland, Alcohol and Drug Research and Education Centre.

Topp, L., Hando, J. & Dillon, P. (1999a) Sexual behaviour of ecstasy users in Sydney, Australia. *Culture, Health and Sexuality*, **1**, 147–159.

Topp, L., Hando, J., Dillon, P., Roche, A. & Solowij, N. (1999b) ecstasy use in Australia: patterns of use and associated harm. *Drug and Alcohol Dependence*, **55**, 105–115.

Verheyden, S., Henry, J. & Curran, V. (2003) Acute, sub-acute and long-term subjective consequences of 'ecstasy' (MDMA) consumption in 430 regular users. *Human Psychopharmacology*, **18**, 507–517.

van de Wijngaart, G., Braam, R., de Bruin, D., Fris, M., Maalsté, N. & Verbraeck, H. (1998) *Ecstasy and the Dutch Rave Scene: a Socio-Epidemiological Study on the Nature and Extent of, and the Risks Involved in Using Ecstasy and Other Party Drugs at Dance Events*. Utrecht: Utrecht University, Addiction Research Institute.

van de Wijngaart, G., Braam, R., de Bruin, D., Fris, M., Maalsté, N. & Verbraeck, H. (1999) Ecstasy use at large-scale dance events in the Netherlands. *Journal of Drug Issues*, **29**, 679–702.

Williamson, S., Gossop, M., Powis, B., Griffiths, P., Fountain, J. & Strang, J. (1997) Adverse effects of stimulant drugs in a community sample of drug users. *Drug and Alcohol Dependence*, **44**, 87–94.

Zemishlany, Z., Aizenberg, D. & Weizman, A. (2001) Subjective effects of MDMA ('ecstasy') on human sexual function. *European Psychiatry*, **16**, 127–130.

Zervogiannis, F., Wiechers, E. & Bester, G. (2003) The 'E' in rave: a profile of young ecstasy (MDMA) users. *South African Journal of Psychology*, **33**, 162–169.