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Drug effects on responses to emotional facial expressions: recent findings

Melissa A. Miller, **Anya K. Bershad**, and **Harriet de Wit**

Department of Psychiatry and Behavioral Neuroscience, University of Chicago, Chicago, Illinois, USA

Abstract

Many psychoactive drugs increase social behavior and enhance social interactions, which may, in turn, increase their attractiveness to users. Although the psychological mechanisms by which drugs affect social behavior are not fully understood, there is some evidence that drugs alter the perception of emotions in others. Drugs can affect the ability to detect, attend to, and respond to emotional facial expressions, which in turn may influence their use in social settings. Either increased reactivity to positive expressions or decreased response to negative expressions may facilitate social interaction. This article reviews evidence that psychoactive drugs alter the processing of emotional facial expressions using subjective, behavioral, and physiological measures. The findings lay the groundwork for better understanding how drugs alter social processing and social behavior more generally.

Keywords

alcohol; cannabinoids; drug effects; emotion; facial expression; human; nicotine; opioids; stimulants

Introduction

For reasons that are not fully understood, most recreational drug use takes place in social settings, in the presence of other people (Single and Wortley, 1993; Halkitis *et al.*, 2005; Rodgers *et al.*, 2006; Acosta *et al.*, 2008). The presence of others appears to facilitate drug use, and drugs, in turn, can enhance social interactions. Both laboratory-based and naturalistic studies support the idea that social contexts facilitate both drug use (i.e. initiation, maintenance, and relapse) and the quality and magnitude of direct drug effects (Carlin *et al.*, 1972; Kelly *et al.*, 1994; Doty and de Wit, 1995; Kirkpatrick and de Wit, 2013). Conversely, many abused drugs also enhance social interactions by increasing the desire to socialize, social bonding, verbal behavior, and the perception of attractiveness in others (Sayette *et al.*, 2012).

Correspondence to Harriet deWit, PhD, Department of Psychiatry and Behavioral Neuroscience, 3841 South Maryland Ave MC 3077, Chicago, IL 60637, USA hdew@uchicago.edu.

Conflicts of interest

There are no conflicts of interest.

The ability to recognize and respond to the emotional states of others is a critical component of daily social interaction. Facial expressions are potent social cues that signal how others are feeling and thus guide appropriate social responses. Early investigations concerning facial processing examined basic facial recognition and identification of emotion. Initial work by Ekman (1972) and Izard (1971, 1977) indicated that humans identify basic emotions that are universally recognized across cultures: surprise, fear, anger, sadness, disgust, and happiness. Since then, studies on facial processing have expanded our understanding of how differences and biases in the perception of these emotions are directly correlated with mood and behavior. Even modest difficulties with emotional perception can influence mood states and underlie several psychiatric conditions such as depression, anxiety, and schizophrenia (Feinberg *et al.*, 1986). The direction of this relation is not always clear: mood states can also influence the perception of emotional expressions (Bouhuys *et al.*, 1995). Beyond emotional states, difficulties in facial processing contribute significantly to interpersonal problems (Carton *et al.*, 1999; Bourke *et al.*, 2010), including social anxiety and rejection from peers (Edwards *et al.*, 1984; Philippot and Feldman, 1990; Feldman *et al.*, 1991).

Clinical studies suggest that behavioral therapy and psychotropic drugs, such as antidepressants and anxiolytics, can positively affect the processing of social cues both in individuals with mood disorders (Harmer *et al.*, 2009; Tranter *et al.*, 2009) and in healthy adults (Harmer *et al.*, 2003, 2004). Indeed, it has been suggested that changes in perception of affective stimuli precede and even predict improvements in mood and social functioning. Recreational drugs of abuse also alter the processing of facial expressions in ways that may make the drugs more attractive to users. Here, we examine the evidence that drugs of abuse alter the interpretation of emotions in others and speculate how these effects might influence social behavior and further consumption of the drug. We review studies examining emotional processing in response to five drugs of abuse: alcohol, nicotine, cannabinoids, stimulants, and opiates. For each drug type, we review evidence of acute effects of the drug on behavioral, psychophysiological, and neural responses to emotional faces, and then briefly discuss indirect evidence that chronic use of these drugs affects emotional processing, by comparing nonusers with long-term drug users.

Drug effects on facial processing

Alcohol

Alcohol is typically initially used and regularly consumed in the presence of others (Wechsler *et al.*, 1995; Cashin *et al.*, 1998; Kairouz and Greenfield, 2007). Peers strongly influence the initiation of drinking (Simons-Morton *et al.*, 2001), and social drinkers consume greater amounts when they are in the presence of others (Doty and de Wit, 1995). Many people claim to drink to lower inhibitions and increase their sociability (Smith *et al.*, 1993), and there is evidence that alcohol increases the attractiveness of social settings and interactions, as well as the perceptions of others. Here, we review evidence that alcohol enhances social interactions by altering the way drinkers perceive others. We review behavioral and imaging studies of the acute effects of alcohol on the perception and recognition of facial cues. In addition, we discuss findings suggesting that prolonged, heavy

consumption impairs emotional processing and discuss the social implications of these effects.

Effects of acute administration—Alcohol is often considered a 'social lubricant', and it may have this effect by increasing the positive perceptions of contextual stimuli, including other people. This phenomenon is based on both anecdotal reports ('rose colored glasses', 'beer goggles') and controlled studies indicating that alcohol increases the attractiveness of others. In one quasiexperimental study, intoxicated drinkers in a bar were asked to rate the attractiveness of faces of strangers, and higher blood alcohol concentrations were related to higher ratings of attractiveness only for opposite-sex faces (Jones *et al.*, 2003). This suggests that the effect may be related to increases in sexual interest or arousal. In contrast, controlled studies indicate that moderate doses (0.4 g/kg) of alcohol increase drinkers' ratings of attractiveness of faces of strangers regardless of their sex, indicating that the effect may be independent of sexual attraction (Parker *et al.*, 2008; Attwood *et al.*, 2012). Thus, the use of alcohol in social settings such as bars may facilitate both sexual and nonsexual social interactions, mediated in part by alcohol-induced alterations in the perception of others.

Another way in which alcohol may enhance social interactions is by positively biasing the way drinkers perceive emotions in others. Several studies have addressed the effects of alcohol on the ability to identify facial expressions varying in emotional intensity. In three studies, moderate doses of alcohol (0.4 g/kg) disrupted the processing of sad expressions (Craig *et al.*, 2008; Attwood *et al.*, 2009a; Kamboj *et al.*, 2013). Similarly, using the same dose of alcohol, Kamboj *et al.* (2013) showed that participants frequently misidentified sad faces as neutral. Interestingly, the effects on emotion processing in each of these studies were unrelated to alcohol-induced changes in mood or alcohol expectancies. In contrast, two other studies failed to find an effect of alcohol on emotion recognition compared with placebo (Kano *et al.*, 2003; Walter *et al.*, 2011). Thus, there is some evidence that alcohol disrupts the recognition of sadness, which may have the effect of facilitating positive social interactions.

Some work has also examined the effect of alcohol on social processing in individuals with social phobias. Individuals with social anxiety or impaired social function are at a greater risk for alcohol-related problems (Himle and Hill, 1991; Lépine and Pélissolo, 1998), perhaps because alcohol alleviates their social anxieties (Burke and Stephens, 1999; Randall *et al.*, 2001). Using a dot probe task, Stevens *et al.* (2009) examined the effects of alcohol on attentional biases to facial expressions in adults with social phobia compared with healthy controls. Before alcohol administration, individuals with social phobia displayed a greater attentional bias to angry faces compared with controls, and a moderate dose of alcohol significantly reduced this bias in the clinical group, without affecting controls. Thus, the ability of alcohol to reduce attention to negative emotions may be especially pronounced in individuals with pre-existing negative biases in social processing.

Another 'social' effect of alcohol is its tendency to increase aggressive and violent behavior, an effect that may also be mediated by changes in the perception of emotions in others – that is, alcohol-induced misidentification of emotions (i.e. misidentifying a neutral expression for anger) could increase interpersonal conflict and aggression. To date, there is no strong

evidence for this. Typically, alcohol-induced aggression is observed with high doses of alcohol, probably higher than the doses used in most laboratory studies (Ito *et al.*, 1996). Alcohol doses of 0.56 and 0.8 g/kg failed to affect detection of angry faces (Kano *et al.*, 2003; Kamboj *et al.*, 2013), but these doses are still lower than those used in natural settings (Monahan and Lanutti, 2000). The possibility that alcohol-induced aggression results from misattributions of emotions in others remains to be studied.

Taken together, these studies suggest that moderate doses of alcohol increase perceptions of facial attractiveness and reduce sensitivity to negative emotions, independent of the drug's effects on mood. These effects may facilitate positive social interactions and thus increase the likelihood of continued drinking. Alcohol-induced decrease in detection of negative emotions may be especially pronounced in individuals with high levels of social anxiety. It remains to be determined whether the effects of alcohol on aggression are also influenced by changes in social perceptions.

Effects of chronic use—Whereas acute use of alcohol appears to facilitate social behavior, long-term, heavy use of the drug impairs social functioning. Some of the interpersonal problems related to excessive consumption, including violence, aggression, and damaged social/familial relationships (Nixon *et al.*, 1992; Duberstein *et al.*, 1993; Kornreich *et al.*, 2002), may be related to impaired or distorted perceptions of emotions in others. Alcoholics show deficits in social processing (Philippot *et al.*, 1999; Kornreich *et al.*, 2001a, 2002; Foisy *et al.*, 2007) that persist even after long periods of abstinence (Kornreich *et al.*, 2001b). They are less able to recognize negative emotions such as anger and disgust compared with healthy controls (Townshend and Duka, 2003), they tend to misidentify expressions such as anger (Philippot *et al.*, 1999; Frigerio *et al.*, 2002), and they show less brain activation in response to expressions of negative emotion compared with controls (Salloum *et al.*, 2007). However, alcoholics also overestimate the intensity of facial expressions (Philippot *et al.*, 1999; Frigerio *et al.*, 2002; Townshend and Duka, 2003). These combined impairments, including misclassifications and exaggerated perceptions of emotional intensity, may contribute to interpersonal difficulties characteristic to alcohol use disorders. Indeed, Kornreich *et al.* (2002) observed a direct relationship between alcoholics' deficits in emotion recognition and self-reported interpersonal problems. However, without detailed longitudinal studies, we cannot determine whether these deficits in social perception precede the development of a drinking problem, or whether they result from years of alcohol use.

Cigarette smoking and nicotine

Social factors influence cigarette smoking at several stages, including at initiation when use begins with peers, at maintenance when social settings increase smoking (e.g. 'social smokers', who smoke only in social situations, Moran *et al.*, 2004), and during quit attempts, when social factors increase relapse (Cengelli *et al.*, 2012). Some of these effects may be attributable to the direct effects of nicotine on perception of social stimuli. Interestingly, in laboratory animals, nicotine also increases the rewarding properties of environmental stimuli, including food, other drugs, and conditioned incentive stimuli that have been paired with rewards (Popke *et al.*, 2000; Clark *et al.*, 2001; Bechtholt and Mark, 2002; Donny *et al.*,

2011). Thus, it is possible that nicotine enhances the value of other, nonpharmacological stimuli, and that perception of emotions in humans is another instance of this more general effect. That is, nicotine may enhance the value of social cues, including the value of faces of strangers.

Effects of acute administration—Two studies investigated the effects of nicotine on ratings of facial attractiveness. In one study, nondependent smokers who smoked a nicotinized cigarette rated facial stimuli as significantly more attractive compared with those who smoked a denicotinized cigarette (Attwood *et al.*, 2009a, 2009b). Moreover, this effect was not related to the sex of the participant or the images, indicating a global increase in the inherent value of faces, probably unrelated to sexual attraction. Another study examined the effects of alcohol and nicotine, alone and together, on facial attractiveness ratings (Attwood *et al.*, 2012). Both drugs increased the ratings of attractiveness, and the combination produced higher ratings of attractiveness than either drug alone. The effects of nicotine on ratings of attractiveness were unrelated to the subjective or mood effects of the drug, suggesting that this reflects a distinct cognitive process.

These initial findings suggest that nicotine enhances the value of social cues just as it enhances other rewarding stimuli in laboratory animals. Thus, the drug may enhance the influence of peers and social context on smoking behavior, thereby escalating further use. Although the two studies reviewed here examined the rating of attractiveness of faces, little is known about whether nicotine specifically alters processing of positive or negative emotional facial expressions, which may be a fruitful direction for future research.

Effects of chronic use—To our knowledge, no studies have examined the longterm effects of smoking on social processing. A recent study reported that nondependent smokers exhibited impaired recognition of happy and sad faces compared with adults who had never smoked (Meyers *et al.*, 2015), suggesting that a history of smoking might contribute to changes in emotional recognition. It remains to be determined whether chronic exposure to nicotine and nicotine dependence affect appraisal and processing of social cues.

Cannabinoids

Like alcohol and cigarettes, cannabis is commonly used in social contexts. Some cannabis users report feelings of closeness, empathy, and interpersonal warmth under the effects of the drug (Tart, 1971), and some report taking the drug to alleviate social stress and anxiety (Reilly *et al.*, 1998; Ogborne *et al.*, 2000; Buckner *et al.*, 2006; Bonn-Miller *et al.*, 2007). Further, the two primary constituents of *Cannabis sativa*, Δ^9-tetrahydrocannabinol (THC) and cannabidiol (CBD), appear to alter core emotional processes including anxiety (Sethi *et al.*, 1986; Wachtel *et al.*, 2002; De Souza Crippa *et al.*, 2004). Thus, THC or CBD may facilitate social behavior, perhaps by reducing the effect of socially threatening stimuli. There is evidence that both acute and long-term cannabis use specifically alter processing of threatening facial stimuli.

Effects of acute administration—One recent study examined the effects of oral THC (7.5 and 15 mg) on identification of emotional facial stimuli in healthy young adults (Ballard

et al., 2012). The higher dose impaired recognition of anger, whereas both doses impaired recognition of fear and neither dose affected the recognition of happy or sad faces. These findings suggest that THC specifically disrupts processing of threatening stimuli. Because psychoactive drugs often have direct effects on mood states, the question arises whether the effects on face recognition can be accounted for by the drug's effects on mood. In this study, 15 mg THC increased self-reported ratings of anxiety, but this mood effect did not account for the effects of the drug on the recognition of threatening stimuli.

Several studies have examined the effects of THC on brain activation induced by emotional faces (Phan *et al.*, 2008; Fusar-Poli *et al.*, 2009; Bhattacharyya *et al.*, 2010). Social signals of threat are known to increase amygdalar activity (Morris *et al.*, 1996; Whalen *et al.*, 1998). Using functional MRI, Phan *et al.* (2008) reported that a relatively low dose of THC (7.5 mg oral) reduced amygdalar activity in response to angry and fearful faces, without affecting responses to other emotions. However, a higher dose (10 mg) did not produce this effect in two other studies (Fusar-Poli *et al.*, 2009; Bhattacharyya *et al.*, 2010). These differences across doses may be related to the mood-altering effects of THC. In the study by Fusar-Poli *et al.* (2009), THC (10 mg) increased subjective ratings of anxiety and skin conductance, consistent with other evidence that high doses increase anxiety and even induce paranoia (Berrendero and Maldonado, 2002; Manzanares *et al.*, 2004; Viveros *et al.*, 2005).

CBD, the other important constituent of cannabis, has also been studied in this regard. CBD appears to reduce anxiety and may counteract the anxiogenic effects of THC (Zuardi *et al.*, 1982; Guimaraes *et al.*, 1990; Zuardi *et al.*, 1993; Williamson and Evans, 2000; De Souza Crippa *et al.*, 2004; Moreira *et al.*, 2006). Both Bhattacharyya *et al.* (2010) and Fusar-Poli *et al.* (2009) reported that CBD (600 mg) reduced neural responses to fearful faces, as well as lowered self-reported anxiety and reduced skin conductance. Thus CBD might exert its anxiolytic effects through disruptions in the processing of threatening stimuli occurring at the physiological level.

Together, these findings indicate that both THC and CBD can reduce neural responding to threatening stimuli. Dampened responses to threatening faces may be related to reduced social anxiety and feelings of warmth with others, especially in individuals with high baseline levels of social anxiety. This effect may lead to greater use. Studies on the effect of CBD on behavioral responses or recognition of facial expressions will be important to understand the changes in neural processing of threatening stimuli and the potential role of cannabis as a prosocial drug.

Effects of chronic use—There is limited evidence that long-term use of cannabis affects processing of social stimuli, such as detection of emotional faces. In one study, Platt *et al.* (2010) reported that cannabis users are significantly slower to identify facial expressions and that they require greater perceptual information compared with nonusers. However, the differences were not specific to particular emotional valence (i.e. happiness, sadness, anger). Another study used functional MRI to show that heavy marijuana users exhibited lower amygdalar activity activation during the presentation of angry faces compared with controls (Gruber *et al.*, 2009). It is possible that these lasting changes in the processing of emotions, and in particular threatening emotions, might reinforce the habitual use of marijuana as a

way to reduce social anxiety. The impaired ability to identify or process emotional cues may also adversely affect social functioning. These potential effects remain to be determined.

Opioids

Opioid drugs and the endogenous opioid system are integrally involved in social processing. Early studies in rodents and other mammals have shown that opioid agonists blunt responses to isolation distress (Herman and Panksepp, 1978; Kalin *et al.*, 1988; Stein *et al.*, 2007; Wilson and Junor, 2008) and may serve as a substitute for social reward (Machin and Dunbar, 2011). Opioid receptors are widely expressed in regions of the brain involved in emotion processing, including the bed nucleus of the stria terminalis and the amygdala (Mansour *et al.*, 1995; Simonin *et al.*, 1995; Peckys and Landwehrmeyer, 1999). Opioid users have a high prevalence of social phobia, and many individuals report using the drugs to reduce anxiety and 'fit into' social settings (Becker *et al.*, 2008; McCabe *et al.*, 2009; Rigg and Ibañez, 2010; Barth *et al.*, 2013). Several neuroimaging and behavioral studies have recently extended our understanding of the effects of opioids on responses to emotional faces in both healthy volunteers and drug users.

Effects of acute administration—The acute effects of opioids on responses to emotional faces have been studied in one recent behavioral study and two imaging studies. Ipser *et al.* (2013) showed that the mu-receptor partial agonist, buprenorphine (0.2 mg), reduces the accuracy in recognizing fearful faces in healthy volunteers, without affecting the perception of other emotions. Interestingly, these effects were observed in the absence of any drug effect on mood. Schmidt *et al.* (2013) reported that acute administration of heroin reduced amygdalar responses to fearful faces in heroin addicts, but other emotional expressions were not included in this paradigm. These findings are consistent with other evidence that opioid drugs reduce anxiety and dampen responses to social evaluative threat in humans and potentially social threat in animals (Trezza *et al.*, 2010; Bershad *et al.*, 2015), and with evidence suggesting that activation of the endogenous opioid system is associated with decreased responses to social rejection (Zubieta *et al.*, 2003). In a second imaging study using healthy volunteers, Wardle *et al.* (2014) reported that the mu-receptor agonist, oxycodone (20 mg), decreased right medial orbitofrontal responses to happy faces. This finding seems to contradict other evidence suggesting that mu-receptor agonists dampen responses to negative social stimuli, but as the authors suggest, the result may be attributable to oxycodone's secondary actions on the kappa-opioid receptor, which may influence processing of positive emotional expressions. Overall, opioid analgesics appear to reduce behavioral and neural responses to negative emotional expressions.

There is also limited evidence that opioids are involved in the modulation of other emotions. The endogenous opioid system is involved in social reward in laboratory animals (Vanderschuren *et al.*, 1995; Trezza *et al.*, 2010, 2011), and endorphins are released during positive social encounters, such as social touch (Keverne *et al.*, 1989; Odendaal and Meintjes, 2003). Morphine, a mu-receptor agonist, enhances ratings of facial attractiveness (Chelnokova *et al.*, 2014), which is broadly consistent with preclinical literature suggesting that mu-opioid agonists may enhance pleasure in response to rewarding social stimuli (Guard *et al.*, 2002; Depue and Morrone-Strupinsky, 2005).

Effects of chronic use—Few studies have examined the effects of chronic use of opioids on facial processing. Two studies have shown that opiate users currently maintained on methadone and those recently detoxed are more slower to recognize emotions overall than healthy nondependent individuals (Kornreich *et al.*, 2003; Martin *et al.*, 2006). Like many studies addressing the effects of chronic use on behavioral measures, these results may also be confounded by differences in emotion processing that existed before drug use.

Stimulants

Stimulants are typically used in social contexts, and users frequently report using such drugs to enhance social interactions (Díaz *et al.*, 2005). Stimulants such as methamphetamine and D-amphetamine increase measures of social behavior, such as verbal behavior and choice of social over nonsocial rewards (Higgins *et al.*, 1989; Marrone *et al.*, 2010; Wardle *et al.*, 2012), and in addition affect emotional processing. The effects of stimulants on processing of emotional faces have been discussed below.

Effects of acute administration—The evidence from laboratory studies investigating the influence of stimulants on social behavior is mixed. In animals, stimulants such as amphetamine and cocaine reduce some types of social behavior, including play (Beatty *et al.*, 1982; Achterberg *et al.*, 2014). However, several studies in humans have shown that amphetamine derivatives facilitate social interaction, as they increase verbal behavior, and other measures of sociability (Bedi *et al.*, 2010; Ballard *et al.*, 2012; Wardle *et al.*, 2012), as well as reduce amygdalar responses to faces expressing negative emotions (Rasetti *et al.*, 2010). However, some of the differences between human and nonhuman studies may be a result of cross-species dosing discrepancies (Segal and Kuczenski, 2005). A handful of studies have shown that stimulants such as D-amphetamine, caffeine, and modafinil increase the speed of identification of emotional facial expressions, especially for more complex emotions (Huck *et al.*, 2008; Wardle *et al.*, 2012). These findings may provide insight into the inconsistencies in the literature; acute administration of stimulants such as D-amphetamine may decrease the threshold for identifying emotions, which may manifest itself as enhanced positive or negative emotional reactivity depending on the context.

The stimulant 3,4-methylenedioxymethamphetamine (MDMA, ‘ecstasy’) is widely recognized as an ‘empathogen’ and is used recreationally to enhance sociability. Evidence from human laboratory studies indicates that MDMA produces several prosocial effects, including increased desire to socialize, heightened feelings of empathy, and enhanced recognition of positive emotions (Ter Bogt and Engels, 2005; Sumnall *et al.*, 2006; Hysek *et al.*, 2012, 2013; Kirkpatrick *et al.*, 2014; Schmid *et al.*, 2014; Wardle and de Wit, 2014). In an effort to understand how MDMA affects social processing, several studies have examined its effects on neural and behavioral responses to faces. Functional neuroimaging has shown that MDMA reduces amygdalar responses to fearful faces (Bedi *et al.*, 2010). Another study using facial electromyography to assess emotional reactivity to facial expressions found that MDMA enhances responses to happy expressions, in addition to slowing recognition of angry expressions (Wardle and de Wit, 2014). This is consistent with other studies showing that MDMA improves the detection of positive, but not negative emotions (Hysek *et al.*, 2012, 2013; Schmid *et al.*, 2014). However, the doses used in these studies all produced

significant subjective reports of euphoria, which makes drug effects on emotion processing difficult to dissociate from effects on mood. Taken together, these studies suggest that acute administration of MDMA acts both to dampen responses to negative emotional expressions and to enhance responses to positive expressions. Such effects may contribute to its reputation as a prosocial drug.

Effects of chronic use—In contrast to the acute effects of psychostimulants on emotion processing, chronic use of drugs such as cocaine and methamphetamine may reduce sensitivity to emotional expressions and dysregulate emotional responses more generally (Kemmis *et al.*, 2007; Kim *et al.*, 2011). Methamphetamine-dependent individuals show alterations in neural responses to emotional faces, such as hyperreactivity in the dorsal anterior cingulate cortex, in addition to reduced activity in the ventrolateral prefrontal cortex (Payer *et al.*, 2008). These individuals also report increased interpersonal sensitivity and hostility. Such changes may underlie disruptions in social behavior that occur during methamphetamine dependence, or may be a result of pre-existing differences in emotion processing in methamphetamine-using populations.

Conclusion

We have reviewed evidence that psychoactive drugs affect emotional processing, both following single doses and after chronic use. The literature reviewed here suggests that drugs may acutely enhance social experiences, but also that prolonged, heavy use can disrupt or negatively bias social processing, thus impairing social functioning. Initial drug effects may facilitate drug taking by enhancing the positive aspects of social stimuli, either lessening threat-related stimuli or enhancing positive stimuli. Among chronic drug users, the deficits in social perception may contribute to the interpersonal problems characteristic of addiction. The directionality of the relationships between social functioning and chronic use is difficult to determine. That is, drug users may have pre-existing social deficits that make them more prone to using drugs to attenuate social anxiety. However, prolonged exposure to the drug may lead to the problems observed in chronic users. More longitudinal work is needed to understand the causality of this relationship.

Most drugs of abuse also produce pleasurable subjective effects (euphoria), which may influence the perception of emotional stimuli, including faces expressing emotions. This raises the question of whether mood effects mediate the changes in perception, or possibly even whether the perceptual changes affect mood states. However, in many of the studies discussed in this review, drug-induced changes in emotional processing were not related to subjective drug effects or changes in mood. This was the case in studies examining alcohol, nicotine, THC, and some opioids. This dissociation suggests that the effects of drugs on responses to social cues are independent of the mood-altering effects of drugs. Whether the effects of drugs on responses to social cues indeed contribute to the reinforcing effects of drugs remains to be determined.

Finally, this review focused on the effects of psychoactive drugs in both healthy adult populations and long-term drug users, with little focus on individual differences that may influence responsiveness to such drug effects. Sex differences, genetic differences, and

differences in personality, psychopathology, and social functioning all influence responses to facial cues (McClure, 2000; Hamann and Canli, 2004). Such individual differences may also contribute to the complexity of the effects of drugs on facial processing reviewed here. An important future direction for work in this area is to identify populations that may be particularly sensitive to these drug effects.

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