Psychopharmacology (2017) 234:41–51
DOI 10.1007/s00213-016-4431-6

ORIGINAL INVESTIGATION

# Alcohol acutely enhances decoding of positive emotions and emotional concern for positive stimuli and facilitates the viewing of sexual images

**Patrick C. Dolder[1] · Friederike Holze[1] · Evangelia Liakoni[1] · Samuel Harder[1] · Yasmin Schmid[1] · Matthias E. Liechti[2]**

Received: 9 June 2016 / Accepted: 5 September 2016 / Published online: 19 September 2016


**Abstract**
*Rationale* Social cognition influences social interactions. Alcohol reportedly facilitates social interactions. However, the acute effects of alcohol on social cognition are relatively poorly studied.
*Methods* We investigated the effects of alcoholic or non-alcoholic beer on emotion recognition, empathy, and sexual arousal using the dynamic face emotion recognition task (FERT), Multifaceted Empathy Test (MET), and Sexual Arousal Task (SAT) in a double-blind, random-order, cross-over study in 60 healthy social drinkers. We also assessed subjective effects using visual analog scales (VASs), blood alcohol concentrations, and plasma oxytocin levels.
*Results* Alcohol increased VAS ratings of stimulated, happy, talkative, open, and want to be with others. The subjective effects of alcohol were greater in participants with higher trait inhibitedness. Alcohol facilitated the recognition of happy faces on the FERT and enhanced emotional empathy for positive stimuli on the MET, particularly in participants with low trait empathy. Pictures of explicit sexual content were rated as less pleasant than neutral pictures after non-alcoholic beer but not after alcoholic beer. Explicit sexual pictures were rated as more pleasant after alcoholic beer compared with non-alcoholic beer, particularly in women. Alcohol did not alter the levels of circulating oxytocin.
*Conclusions* Alcohol biased emotion recognition toward better decoding of positive emotions and increased emotional concern for positive stimuli. No support was found for a modulatory role of oxytocin. Alcohol also facilitated the viewing of sexual images, consistent with disinhibition, but it did not actually enhance sexual arousal. These effects of alcohol on social cognition likely enhance sociability.
*Trial registration* www.clinicaltrials.gov/ct2/show/NCT02318823

**Keywords** Alcohol · Emotion recognition · Empathy · Oxytocin · Sexual arousal

✉ Matthias E. Liechti
matthias.liechti@usb.ch

[1] Division of Clinical Pharmacology and Toxicology, Department of Biomedicine and Department of Clinical Research, University Hospital Basel and University of Basel, Basel, Switzerland

[2] Division of Clinical Pharmacology and Toxicology, University Hospital Basel, Hebelstrasse 2, 4031 Basel, CH, Switzerland

## Introduction

Few studies have evaluated the acute effects of alcohol on aspects of social cognition that potentially contribute to its use as a social enhancer. Alcohol acutely induces subjective relaxation, positive mood, and disinhibition, but acute alcohol may also alter affect recognition and the processing of other social stimuli. Indeed, face emotion recognition can be experimentally influenced by acute alcohol administration. Specifically, alcohol (0.2–0.4 g/kg) was shown to impair the recognition of sad but not happy or angry facial expressions in social drinkers (Attwood and Munafo 2014; Attwood et al. 2009b; Craig et al. 2009). Better discrimination of happy faces at a low dose (0.14 g/kg) compared with a high dose (0.56 g/kg) of alcohol was also reported (Kano et al. 2003). These findings indicate that low doses of alcohol may bias affect recognition toward the better recognition of positive vs. negative emotional stimuli. However, another study found no effects of a high dose of alcohol (0.8 g/kg; Kamboj et al. 2013). Others also reported no effects of alcohol on recognition of happy or sad faces (Felisberti and Terry 2015), but

better recognition of disgust and contempt (Felisberti and Terry 2015), and impaired recognition of anger (Borrill et al. 1987) and reduced perceived threat of angy faces (Stevens et al. 2008). Because of the rather limited and inconsistent data, we tested the effects of alcoholic beer drinking (0.3 and 0.25 g/kg in men and women, respectively) in a Face Emotion Recognition Task (FERT).

Empathy refers to the capacity to recognize, feel, and share what another person is experiencing. Empathy includes cognitive and emotional aspects (Blair 2005). Alcohol-dependent patients show lower self-reported empathy (cognitive and emotional aspects) in the Empathy Quotient questionnaire (Lawrence et al. 2004) compared with controls (Martinotti et al. 2009). However, no data are available on the acute effects of alcohol on empathy. Psychoactive substances with prosocial effects (Hysek et al. 2014) similar to alcohol but a different pharmacology, such as 3,4-methylenedioxymethamphetamine (MDMA; ecstasy), were shown to enhance both empathic concern in particular for positive stimuli (Hysek et al. 2014; Schmid et al. 2014) and prosociality (Hysek et al. 2014) in laboratory studies. Similarly, we hypothesized that alcoholic beer would acutely enhance emotional empathy in an experimental empathy test without impairing cognitive empathy at a low-moderate alcohol dose. The participants also self-rated their trait empathy, which was expected to positively correlate with state emotional empathy on the Multifaceted Empathy Test (MET; Hysek et al. 2014).

Alcohol is thought to alter cognitive processes by decreasing attention to inhibitory cues, such that behavior becomes more guided by immediate salient stimuli (Steele and Josephs 1990). Alcohol consumption has also been implicated in sexual disinhibition and sexual risk taking (George and Stoner 2000; Hesse and Tutenges 2008). Alcohol prolonged the viewing of erotic pictures (Lang 1985) and also produced an approach bias toward erotic stimuli compared with placebo (Simons et al. 2015). However, unclear is whether alcohol actually enhances sexual arousal and desire or produces disinhibition (Prause et al. 2011), and we are unaware of studies that evaluated whether alcohol acutely enhances subjective sexual arousal by sexual/erotic visual stimuli. Therefore, we examined the effects of alcoholic beer in a Sexual Arousal Task (SAT) that was previously shown to be sensitive to the effects of a psychostimulant (Schmid et al. 2015b).

The neurobiological mechanisms by which the social cognitive effects of alcohol might be mediated are largely unexplored. A possible mediator is oxytocin, which is a key regulator of emotional and social behaviors (Heinrichs et al. 2009). Although evidence suggests that chronic alcohol administration affects oxytocinergic function in the brain (Silva et al. 2002), only two very small studies tested the acute effects of alcohol on circulating oxytocin (Bershad et al. 2015; Mennella and Pepino 2006) and the findings were inconclusive. Oxytocin has been shown to facilitate the recognition of positive facial expressions (Di Simplicio et al. 2009; Marsh et al. 2010) and enhance emotional empathy (Hurlemann et al. 2010). Oxytocin also enhanced the recognition of positive sex-related words compared with placebo (Unkelbach et al. 2008). Because of the similarities in the socio-cognitive effects of alcohol and oxytocin (Mitchell et al. 2015), we hypothesized that alcoholic beer would increase circulating oxytocin levels.

The primary aim of the present study was to evaluate the effects of alcoholic beer on aspects of social cognition, including face emotion recognition, empathy, and sexual arousal using non-alcoholic beer as a placebo control. Additionally, subjective effects and blood alcohol concentrations (BACs) were measured. The study hypotheses were that alcohol would produce positive and prosocial subjective effects, improve the decoding of positive emotions, impair the decoding of negative emotions, enhance emotional empathy and sexual arousal by visual stimuli, and increase plasma levels of oxytocin.

## Material and methods

### Experimental design

We used a double-blind, cross-over design in 60 participants who each drank alcoholic and non-alcoholic beer in two separate sessions. The washout period between the two sessions was at least 24 h, and the order of the sessions was counterbalanced. The study was conducted in accordance with the Declaration of Helsinki and approved by the local Ethics Committee. The study was registered at ClinicalTrials.gov (NCT02318823). All of the participants provided written informed consent before participating in the study and were paid for their participation.

### Participants

Sixty healthy European/Caucasian participants (30 men, 30 women; mean age, 25 ± 4 years; range, 18–43 years) were recruited from the University of Basel. All of the participants were self-reported heterosexuals. The inclusion criterion was age of 18–50 years. The exclusion criteria were pregnancy, chronic or acute medical condition, current or previous personal history of psychotic or major affective disorder, alcohol use disorder (indicated by >15 points on the Alcohol Use Disorder Identification Test [AUDIT]; Rumpf et al. 2002), alcohol intolerance/hypersensitivity, history of alcohol abuse in first-degree relatives, lifetime prevalence of illicit drug use of more than 15 times (with the exception of past cannabis use), the use of any illicit substances (including cannabis) within the last week or during the study period (determined by urine tests conducted during screening and before the test

sessions), and the use of medications that might interfere with alcohol (i.e., antidepressants and sedatives). On average, participants consumed (mean ± SD) 4.5 ± 4 (range 0–20) drinks/week (males 6.0 ± 3, range 0–20; females 3.0 ± 2, range 1–8). The AUDIT scores were 5.8 ± 2.8 (range, 1–14) in the total sample, 6.7 ± 2.8 (2–14) in male, and 4.8 ± 2.5 (range, 1–12) in female participants. The participants were requested to abstain from any alcohol consumption the evening before the study session and abstain from illicit psychoactive drugs and excessive alcohol consumption during the study. Additionally, the participants were not allowed to eat or drink coffee within 3 h prior to the study session. Smokers were told to maintain their usual smoking habits during the study but not smoke during the actual sessions.

### Personality trait measures

Two personality trait measures were assessed during the screening interview. First, the inhibitedness scale (score range: 0–12) of the revised Freiburger Personality Inventory (FPI-R) was used as a trait measure of social inhibition (Fahrenberg et al. 1984) that was expected to be reduced by the administration of alcohol (Steele and Josephs 1990). Second, the validated German version of the Interpersonal Reactivity Index (IRI, empathic concern scale, score range 0–16; Davis 1983) was used to assess trait emotional empathy (Hysek et al. 2014).

### Study procedures

The experimental sessions each lasted 3 h and took place in a quiet hospital research ward with no more than two research participants present per session. An intravenous catheter was inserted for blood sampling, and baseline subjective effect measurements were performed. The participants were then asked to drink beer (alcoholic or non-alcoholic) over 15 min, and tests were performed starting 30 min after the start of beer intake when maximal effects were expected (Bershad et al. 2015). We used a low-to-moderate dose of alcohol that sought to achieve a BAC of 0.4 g/L, which was associated with alterations in emotion recognition in some previous studies but not expected to result in nonspecific performance deficits (Attwood et al. 2009a). The amount of alcohol was estimated for each participant based on sex and body weight according to the formula presented by Fisher et al. (Fisher et al. 1987): Target BAC = 0.4 g/L = $G \times 100 \times 0.8/(W \times F)$, where $G$ is the grams of alcohol, $W$ is the body weight (in kilograms), and $F$ is the conversion factor for the calculation of total body water (0.583 and 0.485 in male and female participants, respectively). Consistent with previous studies, this resulted in lower g/kg doses in women (0.24 g/kg) than in men (0.29 g/kg; Felisberti and Terry 2015). Body weights were (mean ± SD) 70 ± 14 kg (range, 45–117 kg) in all of the participants, 78 ± 13 kg (range, 60–117 kg) in men, and 61 ± 7 kg (range, 45–86 kg) in women. Beer intake was (mean ± SD) 497 ± 133 ml (range, 288–900 ml) in all of the participants, 600 ± 100 ml (range, 462–900 ml) in men, and 392 ± 51 ml (range, 288–550 ml) in women, corresponding to alcohol intake of 23 ± 4 g and 15 ± 2 g in men and women, respectively. The participants received the same amount of non-alcoholic beer as calculated for alcoholic beer. Beer was served in one 1-L glass that was covered with aluminum foil at a temperature of 4 °C. The alcoholic beer brand was Feldschlösschen original (4.8 vol%, Rheinfelden, Switzerland), sold as glass bottles. The non-alcoholic beer brand was Feldschlösschen alcohol-free (0.45 vol%), sold as glass bottles.

### Blood alcohol concentrations

Blood samples for measurements of BACs were collected in fluoride tubes at baseline and 30, 70, and 95 min after beer administration. Serum alcohol concentrations were measured using an enzymatic method (Cobas, Roche Diagnostics, Mannheim, Germany). The limit of quantification was 0.1 g/L. Concentrations <0.1 g/L were set to 0.

### Subjective effects

Visual analog scales (VASs; Attwood et al. 2009a; Bershad et al. 2015; Hysek et al. 2012) were used to assess the subjective effects of alcohol, including feeling "any effect," "stimulated," "happy," "talkative," "open," "be with others," and "be alone," before and 30, 70, and 95 min after beer administration. The VASs were presented as 100 mm horizontal lines that were marked "not at all" on the left and "extremely" on the right. The VASs for "happy," "talkative," "open," "want to be with others," and "want to be alone" were bidirectional (± 50 mm; Hysek et al. 2012).

### Face emotion recognition task

Facial affect recognition was tested using a dynamic FERT (Domes et al. 2008), which was previously shown to be sensitive to psychoactive substances (Hysek et al. 2014). The FERT was performed 30 min after beer administration and lasted 15 min. Pictures of the six basic emotions (i.e., fear, sadness, disgust, happiness, anger, and surprise) were chosen from the NimStim set of facial expressions (Tottenham et al. 2009) and morphed in 1 % steps of intensity from 0 % (neutral) to 100 % of a specific emotion using Winmorph 2.0. Three female and three male faces were chosen, resulting in 36 sets of faces (6 emotions × 6 faces) with 100 pictures each. Each picture was presented for 80 ms, beginning with 0 % intensity and increasing to 100 % intensity in 1 % steps. The participants were instructed to press a stop button as soon

as they recognized a specific emotion. After pressing the stop button, the picture disappeared, and the participants had to indicate the correct emotion out of six emotions. The 36 trials in one block were presented in a randomized order and presented twice, resulting in 72 trials. As dependent variables, the emotional intensity at which the trial was stopped for correct answers was recorded. The emotion recognition accuracy was then assessed, defined as the percentage of correctly identified emotions (Domes et al. 2008).

### Multifaceted empathy test

The MET is a reliable and valid task that assesses the cognitive and emotional aspects of empathy (Dziobek et al. 2008; Hurlemann et al. 2010; Hysek et al. 2014). The MET has been shown to be sensitive to acute challenge with oxytocin (Hurlemann et al. 2010) and MDMA (Hysek et al. 2014; Schmid et al. 2014). The MET was performed 50 min after beer administration and lasted 15 min. The computer-assisted test consisted of 40 photographs that showed people in emotionally charged situations. To assess cognitive empathy, the participants were required to infer the mental state of the subject in each scene and indicate the correct mental state from a list of four responses. Cognitive empathy was defined as the percentage of correct responses relative to total responses. To measure emotional empathy, the participants were asked to rate how much they were feeling for an individual in each scene (i.e., explicit emotional empathy or concern) and how much they were aroused by each scene (i.e., implicit emotional empathy) on a 1–9 point scale. The three aspects of empathy were each tested with 20 stimuli with positive valence and 20 stimuli with negative valence. Explicit emotional empathy was the primary predefined outcome measure because it is most robustly altered in acute pharmacological challenge studies (Dolder et al. 2016; Hurlemann et al. 2010; Hysek et al. 2014; Schmid et al. 2014).

### Sexual arousal task

The SAT included 16 color photographs that were taken from the International Affective Picture System (Lang et al. 2008), as previously described (Schmid et al. 2015b). The SAT was performed 85 min after alcohol administration and lasted 10 min. Eight neutral and eight erotic or sexual pictures were presented. Neutral pictures showed landscapes, objects, or people without sexual signals. Erotic pictures included four implicit sexual scenes (i.e., no primary or secondary sexual organs were shown explicitly, but the people in the photographs were shown in stimulating poses showing some skin) and four explicit sexual scenes (i.e., clearly pornographic poses or scenes). In the neutral, implicit, and explicit conditions, two pictures with a single person and two pictures with couples were shown, respectively. Thus, we had four pictures of neutral objects (two pictures) and landscapes (two pictures), four pictures of neutral people (two pictures of a single person and two pictures of couples), four pictures of implicit sexual scenes (two pictures of a single person and two pictures of couples), and four pictures of explicit erotic scenes (two pictures of a single person and two pictures of couples). Additionally, male and female versions of the test were applied. Female participants were shown only males in the single person condition, and male participants were shown only females in the single person condition. Because men and women were tested on different tasks, the scores could not be compared directly. The participants were asked to rate each picture on five dimensions. The dimensions included "pleasant," "arousing/exciting," "attractive," "likeable," and "erotic." The original Self-Assessment Manikin was used for the affective dimensions valence ("pleasant") and arousal ("arousing/exciting"; Bradley and Lang 1994), resulting in a 9-point rating scale. Ratings for "attractive," "likeable," and "erotic" were made on a 9-point scale, marked "not at all" on the left and "very" on the right. Ratings of all neutral, implicit sexual, and explicit sexual pictures were averaged for each dimension.

### Oxytocin

The plasma levels of oxytocin were measured at baseline and 30, 70, and 95 min after beer administration and analyzed as described previously (Neumann et al. 2013).

### Data analysis

The statistical analysis was performed using Statistica 12 software (StatSoft, Tulsa, OK, USA). Measures were individually analyzed using *t* tests with alcohol (alcoholic vs. non-alcoholic beer) as the within-subjects factor. Analysis of variance (ANOVA) was used to analyze VAS ratings and oxytocin plasma levels with alcohol and time (0, 30, 70, and 95 min) as within-subjects factors. For the MET, valence (positive and negative stimuli), and for the SAT, sexual content (neutral, implicit, and explicit) was added as an additional within-subjects factor in the ANOVA. Tukey's post hoc tests were performed based on significant main effects or interactions in the ANOVAs. Additionally, sex differences were assessed by adding sex as between-subjects factor for each descriptor in the ANOVAs. Associations between measures were tested using Spearman rank correlations. Values of $p < 0.05$ (two-tailed) were considered statistically significant.

## Results

### Blood alcohol concentration

After the administration of non-alcoholic beer and before the administration of alcoholic beer, all of the measured BACs

were below the lower limit of quantification (0.1 g/L). After the administration of alcoholic beer, the maximal BAC was (mean ± SD) 0.38 ± 0.1 g/L (range, 0.20–0.63 g/L; Fig. 1). The maximal BACs were 0.41 ± 0.1 and 0.35 ± 0.1 g/L in men and women, respectively ($T_{1,58}$ = 2.61, $p$ < 0.05).

### Subjective effects

The subjective effects of alcoholic and non-alcoholic beer are shown in Fig. 1. The ANOVAs revealed significant alcohol × time interactions on all of the VASs ($F_{3,183}$ = 4.45–46.21, all $p$ < 0.01), indicating that alcoholic beer significantly altered subjective effects over time compared with non-alcoholic beer. Significant increases in ratings were observed for most of the subjective effects between 30 and 95 min and thus during the time interval when the social cognitive tests were performed. Adding sex to the ANOVA yielded a significant sex × alcohol × time interaction for "any effect" ($F_{3,174}$ = 4.00, $p$ < 0.01), indicating a greater overall effect of alcoholic beer compared with non-alcoholic beer in women compared with men. Other ratings of subjective effects did not differ between sexes. Trait inhibitedness ratings (mean ± SD = 4.5 ± 2.2, range 1–10) correlated with maximal responses to alcoholic beer for "any effect" ($R_s$ = 0.40, $p$ < 0.01), "open" ($R_s$ = 0.42, $p$ < 0.001), "talkative," "high," and "happy" (all $R_s$ = 0.30, $p$ < 0.05). Inhibitedness was near-significantly higher in women (5.0 ± 2.1) compared with men (3.9 ± 2.2; $F_{1,58}$ = 3.80, $p$ = 0.056). The effect of inhibitedness on the response to alcohol was consistently observed in female and male participants.

### Facial affect recognition task

Alcoholic beer facilitated the recognition of happy faces, reflected by shorter recognition times (lower % stopping thresholds; $T_{1,58}$ = 2.73, $p$ < 0.01) after the administration of alcoholic beer compared with non-alcoholic beer (Fig. 2). No differences were found in the recognition times for emotions other than happy (Fig. 2). The accuracy of emotion decoding was unaltered by alcoholic vs. non-alcoholic beer for any of the emotions.

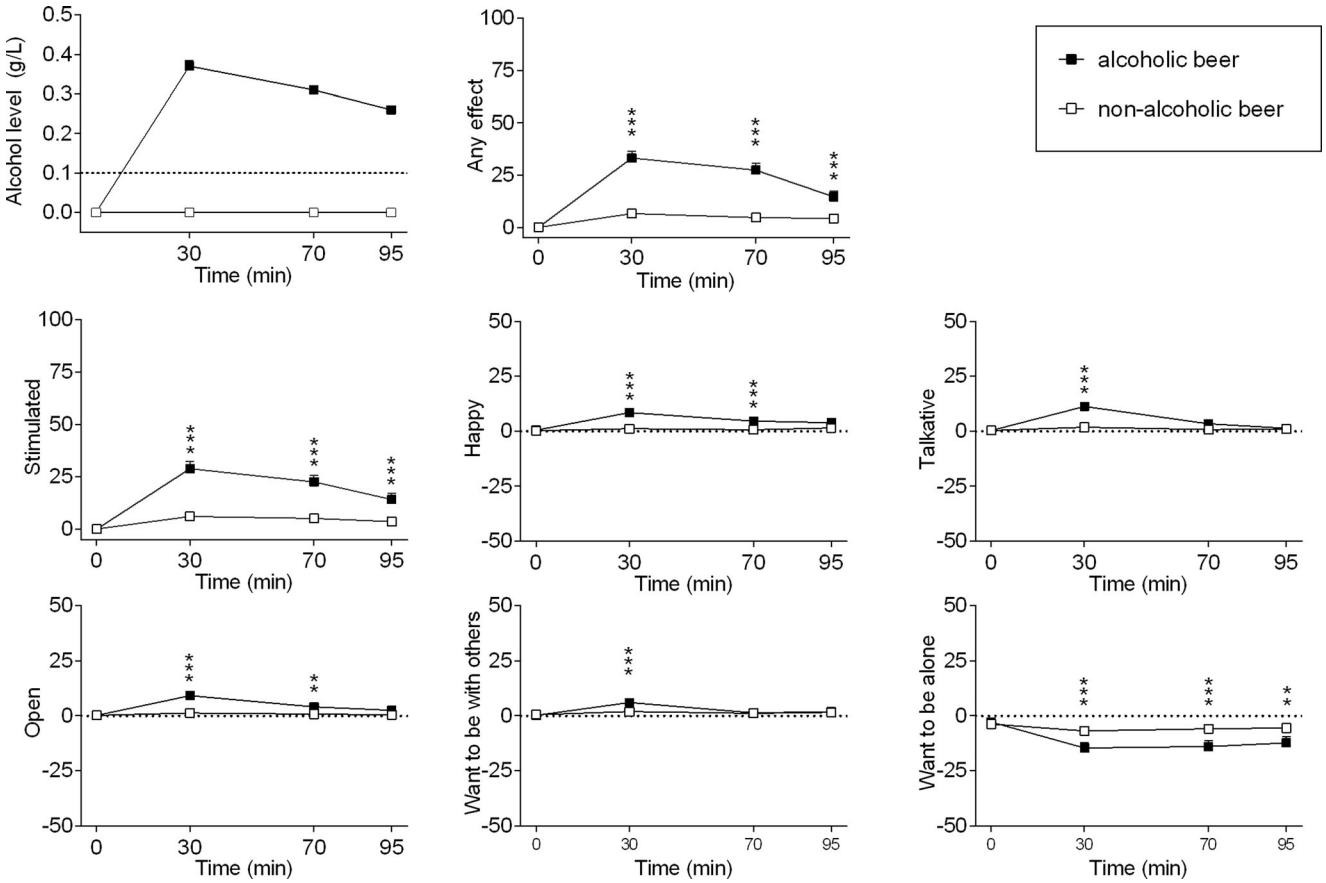


**Fig. 1** Blood alcohol concentrations and subjective effects after administration of alcoholic and non-alcoholic beer. Alcoholic but not non-alcoholic beer increased blood alcohol concentrations above the lower limit of quantification (0.1 g/L, indicated by a dashed line). Concentrations <0.1 g/L were set to 0. Alcoholic beer increased subjective effect ratings on all visual analog scales compared with non-alcoholic beer. **$p$ < 0.01; ***$p$ < 0.001; significant differences between alcoholic and non-alcoholic beer for corresponding time-points (Tukey post hoc tests based on significant alcohol × time interactions in the analyses of variance). The data are expressed as mean ± SEM in 60 participants

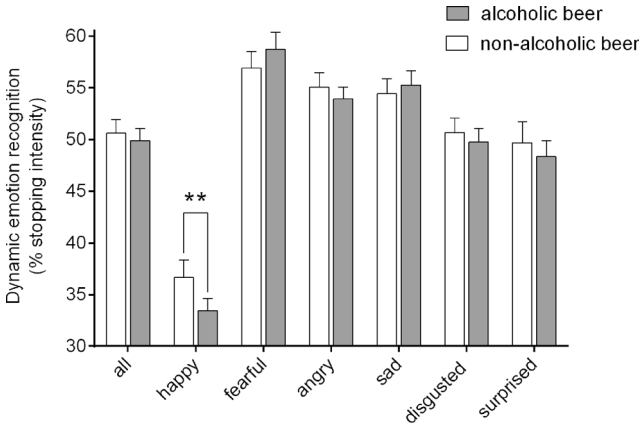


**Fig. 2** Effects of alcoholic and non-alcoholic beer on facial affect recognition. In the dynamic Facial Emotion Recognition Task, happy faces were recognized at a lower intensity and faster after alcoholic beer compared with non-alcoholic beer (**$p < 0.01$). The data are expressed as the mean ± SEM in 60 participants

### Multifaceted empathy task

ANOVA on explicit emotional empathy ratings showed no significant drug main effect ($F_{1,59} = 2.26$, $p = 0.14$), a significant main effect of valence ($F_{1,59} = 4.73$, $p = 0.03$), and a near-significant drug × valence interaction ($F_{1,59} = 3.77$, $p = 0.06$). Alcohol increased explicit emotional empathy ratings for positive stimuli (Tukey test $p = 0.02$ or uncorrected $T_{1,59} = 2.26$, $p < 0.05$) but not for all stimuli or negative stimuli (Fig. 3). Self-rated IRI trait empathic concern scores were (mean ± SD) 10.1 ± 2.1 (range, 6–15) in all participants, 9.4 ± 1.9 in male and 10.7 ± 2.1 in female participants. Greater trait empathy was associated with greater explicit emotional empathy ratings on the MET after non-alcoholic and alcoholic beer administration ($R_s = 0.46$, $p < 0.001$, and $R_s = 0.36$, $p < 0.01$, respectively). Lower trait empathy was associated with greater alcohol-induced increases in emotional empathy on the MET ($R_s = 0.26$, $p < 0.05$). Alcohol did not significantly affect indirect emotional empathy ($F_{1,59} = 0.31$, $p = 0.58$) or cognitive empathy ($F_{1,59} = 1.51$, $p = 0.22$).

### Sexual arousal task

The effects of beer on SAT scores are shown in Table 1 and Fig. 4. Data from one subject were missing for the SAT because of technical problems. Significant main effects of sexual content (neutral, implicit, and explicit) were found for all ratings (all $F_{2,116} > 50$, $p < 0.001$). The participants rated implicit sexual content significantly higher than neutral content on all

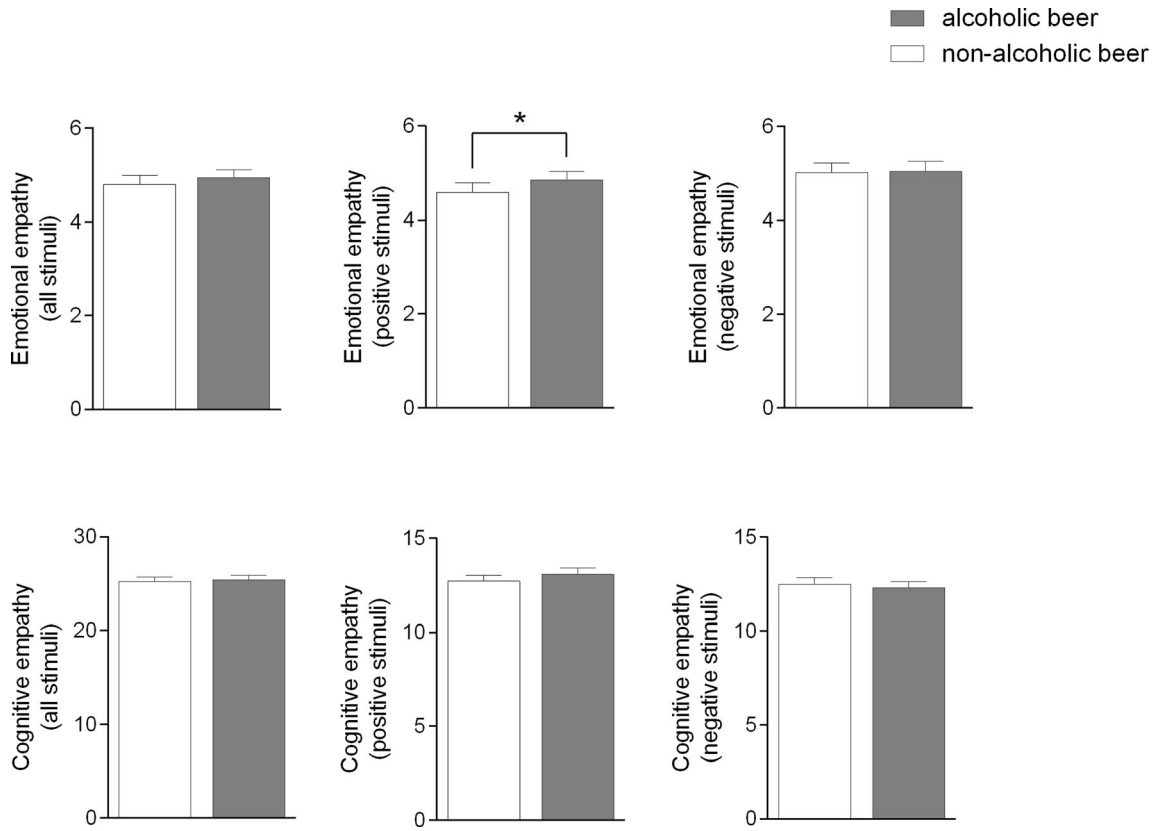


**Fig. 3** Effects of alcoholic and non-alcoholic beer on empathy. Alcoholic beer increased emotional empathy (i.e., empathic concern or feeling with someone) for positive stimuli but not for negative or all stimuli. *$p < 0.05$, compared with non-alcoholic beer. Alcoholic beer did not alter cognitive empathy (i.e., correct identification of emotionally charged situations) compared with non-alcoholic beer. The data are expressed as the mean ± SEM in 60 participants

**Table 1** Effects of alcoholic and non-alcoholic beer in the sexual arousal task

| | Non-alcoholic beer | | | Alcoholic beer | | |
|---|---|---|---|---|---|---|
| | Neutral | Implicit sexual | Explicit sexual | Neutral | Implicit sexual | Explicit sexual |
| Pleasant | 5.8 ± 0.1 | 6.4 ± 0.1# | 4.5 ± 0.2### | 5.8 ± 0.1 | 6.4 ± 0.1## | 5.6 ± 0.2*** |
| Arousing/ exciting | 3.8 ± 0.1 | 5.4 ± 0.2### | 4.2 ± 0.2# | 3.9 ± 0.1 | 5.4 ± 0.2### | 4.3 ± 0.2# |
| Attractive | 4.4 ± 0.1 | 6.4 ± 0.1### | 4.5 ± 0.2 | 4.4 ± 0.1 | 6.2 ± 0.1### | 4.6 ± 0.2 |
| Likeable | 4.2 ± 0.1 | 6.1 ± 0.1### | 4.4 ± 0.2 | 4.1 ± 0.1 | 5.9 ± 0.1### | 4.5 ± 0.2 |
| Erotic | 3.5 ± 0.1 | 5.8 ± 0.2### | 4.2 ± 0.2### | 3.7 ± 0.1 | 5.7 ± 0.2### | 4.1 ± 0.2 |

Values are mean ± SEM in 59 subjects. Tukey post hoc tests ***$p < 0.001$ compared with non-alcoholic beer; #$p < 0.05$, ##$p < 0.01$, ###$p < 0.001$ compared with the respective neutral stimuli (same drug condition)

dimensions (Table 1) and regardless of whether they had non-alcoholic or alcoholic beer. Explicit sexual content was rated as more exciting and more erotic but less pleasant than neutral content after non-alcoholic beer administration. After alcoholic beer administration, explicit sexual content was also rated as more exciting than neutral content. A significant alcohol × content interaction was found for ratings of "pleasant" ($F_{2,116} = 16.54$, $p < 0.001$), and the participants rated explicit sexual content as more pleasant after alcoholic beer administration than after non-alcoholic beer administration. This effect was more pronounced in women than in men, reflected by a significant alcohol × sex interaction for pleasant ratings ($F_{1,57} = 4.62$, $p = 0.04$).

### Oxytocin

Plasma oxytocin levels did not differ between alcoholic and non-alcoholic beer (Fig. 5, alcohol × time interaction: $F_{3,177} = 2.07$, $p = 0.11$). Oxytocin levels did not differ between sexes and sex did not moderate the effects of alcohol. The maximal plasma concentrations of oxytocin were (mean ± SD) 7.5 ± 3.8 pg/ml and 7.7 ± 4.2 pg/ml after alcoholic and non-alcoholic beer administration, respectively ($T_{1,58} = 0.37$, $p = 0.7$). Plasma oxytocin levels did not correlate with the subjective effects of alcohol or FERT, MET, or SAT measures.

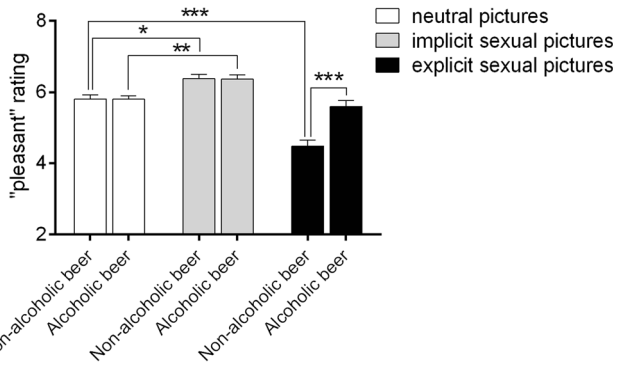


**Fig. 4** Effects of alcoholic and non-alcoholic beer on the Sexual Arousal Task. Erotic pictures with sexually implicit content were rated as more "pleasant" than neutral pictures after both non-alcoholic and alcoholic beer. Pornographic pictures with explicit sexual content were rated as less pleasant after non-alcoholic beer. However, these explicit sexual pictures were rated as more pleasant after alcoholic beer compared with non-alcoholic beer. The data are expressed as the mean ± SEM in 59 participants. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$, significant differences

## Discussion

The present study assessed the acute effects of a low-to-moderate dose of alcoholic beer on aspects of social cognition. As expected (Bershad et al. 2015), alcoholic beer produced positive subjective effects, including stimulation and happy and prosocial effects, such as increases in being talkative and open and the desire to be with others and not alone. These subjective effects likely contribute to the prosocial effects of alcohol. The subjective overall effects of alcohol were greater in women than in men, despite lower BACs in women than in men. Similarly, gender differences in the effects of alcohol with greater subjective intoxication and impairments in attention at comparable exposure levels in women than in men have previously been reported (Mills and Bisgrove 1983; Mumenthaler et al. 1999). Additionally, we found that the increases in the subjective effects of alcohol were associated with greater personality trait inhibitedness. Social phobia, high trait social anxiety, and shyness have been associated with an increase in alcohol use (Meade Eggleston et al.

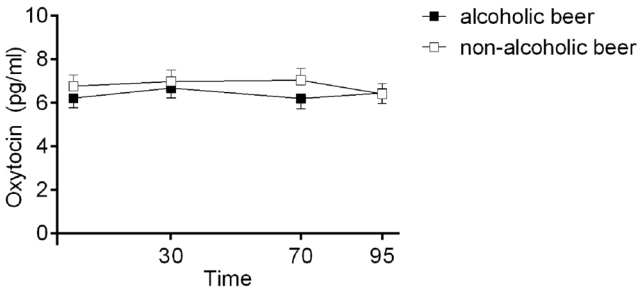


**Fig. 5** Effect of alcoholic and non-alcoholic beer on plasma concentrations of oxytocin. No differences in circulating levels of oxytocin were found between alcoholic and non-alcoholic beer. The data are expressed as the mean ± SEM in 60 participants

2004), and alcohol-assisted extraversion is one strategy that is utilized by shy individuals to deal with their shyness (Young et al. 2015). However, we are unaware of studies that showed greater subjective responses to alcohol in subjects with higher social anxiety.

The main goal of the present study was to assess the effects of alcohol on the processing of emotional-social cognitive stimuli. In contrast to the well-documented deficits in facial emotion recognition in alcohol use disorder (Castellano et al. 2015), few studies have assessed the effects of acute experimental alcohol administration on affect recognition in social drinkers. In the present study, a relatively low amount of alcoholic beer (0.25–0.3 g/kg alcohol) reduced the time to recognize happy faces compared with non-alcoholic beer but did not alter the speed of affect recognition of other basic emotions or recognition accuracy. Happy faces were also better recognized after a low dose of alcohol (0.14 g/kg) in another study (Kano et al. 2003), but we did not replicate the impairments in recognition of sad faces after alcohol (0.4 g/kg) administration that were reported in several other studies (Attwood and Munafo 2014; Craig et al. 2009) or after administration of the prosocial drug MDMA using the same face emotion task (Hysek et al. 2014). Alcohol had no effect on the recognition of disgust in the present study, similar to the effects of low doses of alcohol in other studies, whereas no effects or an increase in the recognition of disgust were reported after high doses of alcohol (0.5–0.8 g/kg; Felisberti and Terry 2015; Kamboj et al. 2013). We found no effects of alcohol on the recognition of anger, in contrast to the impairments that were seen in a previous study that also tested a low dose of alcohol (0.3 g/kg; Borrill et al. 1987). Nevertheless, the data indicate a bias in affect recognition, with facilitated decoding of positive emotional stimuli vs. mostly impaired recognition of negative emotional stimuli, which may contribute to the prosocial effects of alcohol. This positive bias in the effect of alcohol on emotion recognition was only evident at low doses of alcohol (< 0.4 g/kg), whereas higher doses more nonspecifically impaired performance (Kano et al. 2003). Importantly, different emotion recognition tasks were used in all of these studies (Attwood and Munafo 2014), which may explain the discrepancies in the effects of alcohol on negative mood recognition.

In the present study, alcohol facilitated the recognition of positive basic emotions on the FERT and increased emotional empathy for more complex emotional stimuli with positive but not negative emotional valence on the MET. Additionally, participants with lower personality trait empathy exhibited greater increases in emotional empathy in response to alcohol. Empathy includes cognitive and emotional aspects (Blair 2005). Cognitive empathy is defined as the ability to recognize emotional states in others, whereas emotional empathy refers to the emotional response to another person's emotional state (Blair 2005). Identical to alcohol in the present study, MDMA or intranasal oxytocin enhanced emotional empathy for positive stimuli on the MET, without altering cognitive empathy (Hurlemann et al. 2010; Hysek et al. 2014; Schmid et al. 2014). Furthermore, intranasal oxytocin improved the perception of happy faces (Di Simplicio et al. 2009; Marsh et al. 2010) as similarly observed for alcohol in the present study. The great similarity of the effects of intranasal oxytocin and the acute consumption of moderate doses of alcohol has recently been noted (Mitchell et al. 2015). Although similarities are seen in the effects of alcohol, MDMA, and oxytocin on empathy, the neurochemical and neuroendocrine mediators are likely different. Specifically, MDMA mainly induces the transporter-mediated release of serotonin (Hysek et al. 2012) and stimulates oxytocin secretion (Hysek et al. 2014; Ramos et al. 2013), which has been implicated in the prosocial effects of MDMA (Ramos et al. 2013). Additionally, the serotonin receptor agonist LSD (Rickli et al. 2016) stimulated oxytocin secretion (Schmid et al. 2015a), produced prosocial effects, and enhanced emotional empathy in the MET (Dolder et al. 2016). In contrast to MDMA and LSD and our prediction, the present study found that alcohol did not change oxytocin levels in 30 female and 30 male participants at a low dose (0.27 g/kg) as similarly shown for a high dose of alcohol (0.8 g/kg) in seven male subjects (Bershad et al. 2015). Additionally, a slight decrease in circulating oxytocin was previously reported in eight female subjects after 0.4 g/kg alcohol administration (Mennella and Pepino 2006). Furthermore, we found no associations between plasma oxytocin levels and any alcohol-induced emotional or social cognitive effects. Thus, although we did not measure oxytocin in the brain oxytocin seems unlikely to mediate the effects of alcohol on emotion recognition and empathy. Rather, GABA has been suggested to mediate the socio-cognitive effects of both alcohol and oxytocin (Mitchell et al. 2015).

On the SAT, pictures of explicit sexual (pornographic) content were rated as less pleasant than pictures of neutral content after non-alcoholic beer administration but not after alcoholic beer administration. The findings for the non-alcoholic (placebo) condition are consistent with our previous study, in which neutral or implicit sexual (erotic) pictures were rated as more pleasant compared with explicit pornographic pictures (Schmid et al. 2015b). The main finding in the present study was that viewing explicit sexual pornographic pictures was rated as more pleasant after alcoholic beer administration compared with non-alcoholic beer administration, particularly in women. No effect of alcohol was found on the appraisal of implicit sexual content (erotic pictures). Alcohol did not alter ratings of sexual arousal for explicit sexual stimuli. Thus, alcohol reduced the unpleasantness of viewing explicit sexual stimuli rather than enhanced the sexually arousing effects of erotic or pornographic pictures. This finding could be interpreted as alcohol-induced disinhibition of a socially

unacceptable behavior (viewing pornographic images) and/or sexual disinhibition (Prause et al. 2011; Sumnall et al. 2007). This is different from the effects of the psychostimulant methylphenidate, which primarily enhanced ratings of sexual arousal compared with placebo using the same SAT (Schmid et al. 2015b). Similarly, other psychostimulants, including cocaine and methamphetamine, reportedly increase sexual drive (Rawson et al. 2002). Dopamine has been proposed to mediate the increase in sexual arousal following administration of these stimulant drugs (Schmid et al. 2015b; Volkow et al. 2007). The mechanisms by which alcohol alters sexual arousal are complex and dose-dependent (George and Stoner 2000; Prause et al. 2011). The expectancy of alcohol drinking or actual alcohol drinking increased the time of viewing erotic pictures (George and Stoner 2000; Lang 1985) and approach toward erotic stimuli (Simons et al. 2015), indicating an increase in sexually oriented behavior. Laboratory studies have shown that higher doses of alcohol suppress penile tumescence and vaginal blood volume and increase the latency to orgasm, thus decreasing objective indices of genital arousal and sexual performance (for review, see (George and Stoner 2000; Prause et al. 2011). However, lower doses of alcohol had no such effects or even increased sexual arousal (George and Stoner 2000; Wilson and Niaura 1984). For example, alcohol enhanced penile tumescence in male social drinkers who listened to an erotic audiotape (Wilson and Niaura 1984). Additionally, men who expected to drink alcohol exhibited greater penile tumescence and subjective arousal (Wilson et al. 1985). However, comparable expectancy effects were not seen in women (George and Stoner 2000). Alcohol is used to lower sexual inhibitions and facilitate sexual encounters (Sumnall et al. 2007). Our finding of greater increases in pleasure while viewing pornographic images after alcohol administration in women compared with men could suggest that alcohol increases disinhibition in women with regard to sexual content. Consistent with this possibility, a previous study on sexual risk behavior in women found that women often reported drinking alcohol with the intention of facilitating the initiation of sexual contact (Taylor et al. 1999). In contrast, greater alcohol-induced sexual disinhibition was reported in men than in women (Hesse and Tutenges 2008).

The present study has limitations. We used only a single and low-to-moderate dose of alcohol and provided no dose-response effects. Thus, the findings cannot be extrapolated to higher doses of alcohol. However, our goal was to study the effects of slight intoxication to maintain blinding (George and Stoner 2000) and not lead to nonspecific performance impairments in the computerized tasks. We used beer and not some other form of alcohol administration that is typically used in laboratory studies. The use of beer may produce more alcohol expectancies and associations with the typical setting of social drinking (George and Stoner 2000). As a result, a greater placebo response could be expected. We cannot determine how well the blinding was maintained because the participants were not asked whether they thought they received alcoholic or non-alcoholic beer after the sessions in an attempt to not influence responding in the following session. However, the impression of the investigators was that the blinding was well-maintained using this particular placebo condition. Finally, the effects of alcohol were small and only significant in the MET when we did not adjust for multiple comparisons (uncorrected T-test).

In conclusion, the present study showed that alcohol altered emotion recognition toward the facilitated decoding of positive emotions and increased empathic concern for positively emotionally charged situations. These effects of alcohol on social cognition likely enhance sociability. Although these social cognitive effects are similar to those of oxytocin, our findings do not support the view that oxytocin is a mediator of the effects of alcohol. Alcohol did not enhance sexual arousal but facilitated the viewing of explicit sexual images, which is normally not agreeable and consistent with disinhibition. Altogether, the findings increase our understanding of the way alcohol facilitates social interactions among social drinkers.

**Acknowledgments** The authors acknowledge Michael Arends for editing the manuscript. No financial support was declared.

**Compliance with ethical standards** The study was conducted in accordance with the Declaration of Helsinki and approved by the local Ethics Committee.

**Conflict of interest** The authors declare that they have no conflict of interest.

## References

Attwood AS, Munafo MR (2014) Effects of acute alcohol consumption and processing of emotion in faces: implications for understanding alcohol-related aggression. J Psychopharmacol 28:719–732

Attwood AS, Ataya AF, Benton CP, Penton-Voak IS, Munafo MR (2009a) Effects of alcohol consumption and alcohol expectancy on the categorisation of perceptual cues of emotional expression. Psychopharmacology 204:327–334

Attwood AS, Ohlson C, Benton CP, Penton-Voak IS, Munafo MR (2009b) Effects of acute alcohol consumption on processing of perceptual cues of emotional expression. J Psychopharmacol 23:23–30

Bershad AK, Kirkpatrick MG, Seiden JA, de Wit H (2015) Effects of acute doses of prosocial drugs methamphetamine and alcohol on plasma oxytocin levels. J Clin Psychopharmacol 35:308–312

Blair RJ (2005) Responding to the emotions of others: dissociating forms of empathy through the study of typical and psychiatric populations. Conscious Cogn 14:698–718

Borrill JA, Rosen BK, Summerfield AB (1987) The influence of alcohol on judgement of facial expression of emotion. Br J Med Psychol 60: 71–77

Bradley MM, Lang PJ (1994) Measuring emotion: the self-assessment manikin and the semantic differential. J Behav Ther Exp Psychiatry 25:49–59

Castellano F, Bartoli F, Crocamo C, Gamba G, Tremolada M, Santambrogio J, Clerici M, Carra G (2015) Facial emotion recognition in alcohol and substance use disorders: a meta-analysis. Neurosci Biobehav Rev 59:147–154

Craig LC, Attwood AS, Benton CP, Penton-Voak IS, Munafo MR (2009) Effects of acute alcohol consumption and alcohol expectancy on processing of perceptual cues of emotional expression. J Psychopharmacol 23:258–265

Davis MH (1983) Measuring individual differences in empathy: evidence for a multidimensional approach. J Pers Soc Psychol 44:113–126

Di Simplicio M, Massey-Chase R, Cowen PJ, Harmer CJ (2009) Oxytocin enhances processing of positive versus negative emotional information in healthy male volunteers. J Psychopharmacol 23:241–248

Dolder PC, Schmid Y, Mueller F, Borgwardt S, Liechti ME (2016) LSD acutely impairs fear recognition and enhances emotional empathy and sociality. Neuropsychopharmacology. doi:10.1038/npp.2016.82

Domes G, Czieschnek D, Weidler F, Berger C, Fast K, Herpertz SC (2008) Recognition of facial affect in borderline personality disorder. J Personal Disord 22:135–147

Dziobek I, Rogers K, Fleck S, Bahnemann M, Heekeren HR, Wolf OT, Convit A (2008) Dissociation of cognitive and emotional empathy in adults with Asperger syndrome using the multifaceted empathy test (MET). J Autism Dev Disord 38:464–473

Fahrenberg J, Hampel R, Selg H (1984) Das Freiburger Persönlichkeitsinventar (FPI). Hogrefe, Göttingen

Felisberti F, Terry P (2015) The effects of alcohol on the recognition of facial expressions and microexpressions of emotion: enhanced recognition of disgust and contempt. Hum Psychopharmacol 30:384–392

Fisher HR, Simpson RI, Kapur BM (1987) Calculation of blood alcohol concentration (BAC) by sex, weight, number of drinks and time. Can J Public Health 78:300–304

George WH, Stoner SA (2000) Understanding acute alcohol effects on sexual behavior. Annu Rev Sex Res 11:92–124

Heinrichs M, von Dawans B, Domes G (2009) Oxytocin, vasopressin, and human social behavior. Front Neuroendocrinol 30:548–557

Hesse M, Tutenges S (2008) Gender differences in self-reported drinking-induced disinhibition of sexual behaviors. Am J Addict 17:293–297

Hurlemann R, Patin A, Onur OA, Cohen MX, Baumgartner T, Metzler S, Dziobek I, Gallinat J, Wagner M, Maier W, Kendrick KM (2010) Oxytocin enhances amygdala-dependent, socially reinforced learning and emotional empathy in humans. J Neurosci 30:4999–5007

Hysek CM, Schmid Y, Simmler LD, Domes G, Heinrichs M, Eisenegger C, Preller KH, Quednow BB, Liechti ME (2014) MDMA enhances emotional empathy and prosocial behavior. Soc Cogn Affect Neurosci 9:1645–1652

Hysek CM, Simmler LD, Nicola V, Vischer N, Donzelli M, Krähenbühl S, Grouzmann E, Hoener MC, Liechti ME (2012) Duloxetine inhibits effects of MDMA ("ecstasy") in vitro and in humans in a randomized placebo-controlled laboratory study. PLoS One 7: e36476

Kamboj SK, Joye A, Bisby JA, Das RK, Platt B, Curran HV (2013) Processing of facial affect in social drinkers: a dose-response study of alcohol using dynamic emotion expressions. Psychopharmacology 227:31–39

Kano M, Gyoba J, Kamachi M, Mochizuki H, Hongo M, Yanai K (2003) Low doses of alcohol have a selective effect on the recognition of happy facial expressions. Hum Psychopharmacol 18:131–139

Lang AR (1985) The social psychology of drinking and human sexuality. J Drug Issues 15:273–289

Lang PJ, Bradley MM, Cuthbert BN (2008) International affective picture system (IAPS): affective ratings of pictures and instruction manual. University of Florida, Gainesville, FL

Lawrence EJ, Shaw P, Baker D, Baron-Cohen S, David AS (2004) Measuring empathy: reliability and validity of the empathy quotient. Psychol Med 34:911–919

Marsh AA, Yu HH, Pine DS, Blair RJ (2010) Oxytocin improves specific recognition of positive facial expressions. Psychopharmacology 209:225–232

Martinotti G, Di Nicola M, Tedeschi D, Cundari S, Janiri L (2009) Empathy ability is impaired in alcohol-dependent patients. Am J Addict 18:157–161

Meade Eggleston A, Woolaway-Bickel K, Schmidt NB (2004) Social anxiety and alcohol use: evaluation of the moderating and mediating effects of alcohol expectancies. J Anxiety Disord 18:33–49

Mennella JA, Pepino MY (2006) Short-term effects of alcohol consumption on the hormonal milieu and mood states in nulliparous women. Alcohol 38:29–36

Mills KC, Bisgrove EZ (1983) Body sway and divided attention performance under the influence of alcohol: dose-response differences between males and females. Alcohol Clin Exp Res 7:393–397

Mitchell IJ, Gillespie SM, Abu-Akel A (2015) Similar effects of intranasal oxytocin administration and acute alcohol consumption on sociocognitions, emotions and behaviour: implications for the mechanisms of action. Neurosci Biobehav Rev 55:98–106

Mumenthaler MS, Taylor JL, O'Hara R, Yesavage JA (1999) Gender differences in moderate drinking effects. Alcohol Res Health 23: 55–64

Neumann ID, Maloumby R, Beiderbeck DI, Lukas M, Landgraf R (2013) Increased brain and plasma oxytocin after nasal and peripheral administration in rats and mice. Psychoneuroendocrinology 38:1985–1993

Prause N, Staley C, Finn P (2011) The effects of acute ethanol consumption on sexual response and sexual risk-taking intent. Arch Sex Behav 40:373–384

Ramos L, Hicks C, Kevin R, Caminer A, Narlawar R, Kassiou M, McGregor IS (2013) Acute prosocial effects of oxytocin and vasopressin when given alone or in combination with 3,4-methylenedioxymethamphetamine in rats: involvement of the $V_{1A}$ receptor. Neuropsychopharmacology 38:2249–2259

Rawson RA, Washton A, Domier CP, Reiber C (2002) Drugs and sexual effects: role of drug type and gender. J Subst Abus Treat 22:103–108

Rickli A, Moning OD, Hoener MC, Liechti ME (2016) Receptor interaction profiles of novel psychoactive tryptamines compared with classic hallucinogens. Eur Neuropsychopharmacol 26:1327–1337

Rumpf HJ, Hapke U, Meyer C, John U (2002) Screening for alcohol use disorders and at-risk drinking in the general population: psychometric performance of three questionnaires. Alc Alcoholism 37:261–268

Schmid Y, Enzler F, Gasser P, Grouzmann E, Preller KH, Vollenweider FX, Brenneisen R, Muller F, Borgwardt S, Liechti ME (2015a) Acute effects of lysergic acid diethylamide in healthy subjects. Biol Psychiatry 78:544–553

Schmid Y, Hysek CM, Preller KH, Bosch OG, Bilderbeck AC, Rogers RD, Quednow BB, Liechti ME (2015b) Effects of methylphenidate and MDMA on appraisal of erotic stimuli and intimate relationships. Eur Neuropsychopharmacol 25:17–25

Schmid Y, Hysek CM, Simmler LD, Crockett MJ, Quednow BB, Liechti ME (2014) Differential effects of MDMA and methylphenidate on social cognition. J Psychopharmacol 28:847–856

Silva SM, Madeira MD, Ruela C, Paula-Barbosa MM (2002) Prolonged alcohol intake leads to irreversible loss of vasopressin and oxytocin neurons in the paraventricular nucleus of the hypothalamus. Brain Res 925:76–88

Simons JS, Maisto SA, Wray TB, Emery NN (2015) Acute effects of intoxication and arousal on approach/avoidance biases toward sexual risk stimuli in heterosexual men. Arch Sex Behav 45:43–51

Steele CM, Josephs RA (1990) Alcohol myopia. Its prized and dangerous effects. Am Psychol 45:921–933

Stevens S, Gerlach AL, Rist F (2008) Effects of alcohol on ratings of emotional facial expressions in social phobics. J Anxiety Disord 22: 940–948

Sumnall HR, Beynon CM, Conchie SM, Riley SC, Cole JC (2007) An investigation of the subjective experiences of sex after alcohol or drug intoxication. J Psychopharmacol 21:525–537

Taylor J, Fulop N, Green J (1999) Drink, illicit drugs and unsafe sex in women. Addiction 94:1209–1218

Tottenham N, Tanaka JW, Leon AC, McCarry T, Nurse M, Hare TA, Marcus DJ, Westerlund A, Casey BJ, Nelson C (2009) The NimStim set of facial expressions: judgments from untrained research participants. Psychiat Res 168:242–249

Unkelbach C, Guastella AJ, Forgas JP (2008) Oxytocin selectively facilitates recognition of positive sex and relationship words. Psychol Sci 19:1092–1094

Volkow ND, Wang GJ, Fowler JS, Telang F, Jayne M, Wong C (2007) Stimulant-induced enhanced sexual desire as a potential contributing factor in HIV transmission. Am J Psychiatry 164:157–160

Wilson GT, Niaura R (1984) Alcohol and the disinhibition of sexual responsiveness. J Stud Alcohol 45:219–224

Wilson GT, Niaura RS, Adler JL (1985) Alcohol, selective attention and sexual arousal in men. J Stud Alcohol 46:107–115

Young CM, DiBello AM, Traylor ZK, Zvolensky MJ, Neighbors C (2015) A longitudinal examination of the associations between shyness, drinking motives, alcohol use, and alcohol-related problems. Alcohol Clin Exp Res 39:1749–1755