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REVIEW

Acute alcohol effects on facial expressions of emotions in social drinkers: a systematic review

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Background: As known from everyday experience and experimental research, alcohol modulates emotions. Particularly regarding social interaction, the effects of alcohol on the facial expression of emotion might be of relevance. However, these effects have not been systematically studied. We performed a systematic review on acute alcohol effects on social drinkers' facial expressions of induced positive and negative emotions.

Materials and methods: With a predefined algorithm, we searched three electronic databases (PubMed, PsycInfo, and Web of Science) for studies conducted on social drinkers that used acute alcohol administration, emotion induction, and standardized methods to record facial expressions. We excluded those studies that failed common quality standards, and finally selected 13 investigations for this review.

Results: Overall, alcohol exerted effects on facial expressions of emotions in social drinkers. These effects were not generally disinhibiting, but varied depending on the valence of emotion and on social interaction. Being consumed within social groups, alcohol mostly influenced facial expressions of emotions in a socially desirable way, thus underscoring the view of alcohol as social lubricant. However, methodical differences regarding alcohol administration between the studies complicated comparability.

Conclusion: Our review highlighted the relevance of emotional valence and social-context factors for acute alcohol effects on social drinkers' facial expressions of emotions. Future research should investigate how these alcohol effects influence the development of problematic drinking behavior in social drinkers.

Keywords: alcohol, alcohol effects, emotion, encoding, social drinking context, facial action

Introduction

It is both common sense and a corroborated finding of scientific research that alcohol affects emotions.[1–8] In Western countries, where social drinking is common and well accepted, alcohol is expected to facilitate interpersonal communication by promoting positive and attenuating negative emotions. Alcohol is frequently exploited as a social lubricant, and improvement in social interaction is one of the most commonly reported motives for occasional alcohol consumption in social drinkers.[5,9–12] Indeed, moderate alcohol consumption has been found to enhance positive emotions in social drinking contexts.[12,13] However, alcohol intake can also facilitate aggressive behavior, which might be due to negative effects of alcohol on impulse control.[14–18] As such, alcohol has repeatedly been found to modulate behavior associated with both positive and negative emotions according to social context.

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In this review, we focus on expressions of emotions, due to their prominent role in social interaction. Facial expressions of emotions are an essential complement of verbal communication, as they validly reflect the subject's emotional state and thus convey the emotional content of a message.[19–24] Simulated facial expressions of emotions can be distinguished from those of truly experienced emotions, due to subtle differences in patterns of facial activity.[25] Moreover, both encoding (ie, display) and decoding (ie, recognition) of facial expressions of emotions are mostly immediate and automatic processes.[26] Facial expressions thus enable quick information exchange, as often required in emotionally relevant situations.[27,28] With the development of a systematic coding system by Ekman and Friesen that enabled the reliable measurement of facial activity, facial expressions became the most investigated component of nonverbal expressions of emotions.[21,29,30]

In this review, we focus exclusively on social drinkers for two reasons. First, we were interested in the effects of alcohol intake on nonverbal communicative behavior under nonpathological conditions, which seems highly relevant given the frequent consumption of alcohol at social events in Western cultures. Second, findings in patients with alcohol abuse or dependence are difficult to interpret, due to persisting cognitive and motor impairments and emotional difficulties in this group.[31,32] Despite alcohol's ability to modulate expressions of emotions and despite the relevance of facial expressions of emotions for social interaction, we are the first to review alcohol effects on facial expressions of emotions in social drinkers.

Heuristic model of alcohol effects on facial emotion processing

To guide our literature search, we developed an heuristic model of alcohol effects on different stages of facial emotion processing (Figure 1). Our heuristic model posits alcohol effects on the emotional state, encoding of emotional state into facial motor programs, the inhibitory gate for facial expressions, and compliance with social display rules.

Alcohol effects on emotional state

Empirical evidence suggests that the consumption of an alcoholic beverage increases self-reported pleasurable moods, euphoria, and elation.[1,4,5,8] In addition, slightly to moderately drunk individuals show a decrease in self-reported stress and anxiety.[8,33–35] Moreover, alcohol attenuates startle potentiation in response to unpleasant stimuli, possibly by lowering threat appraisal.[2–4,36] Nevertheless, alcohol has also been found to increase self-reported anger states, thus indicating an aggression-facilitating effect of alcohol.[15,37] Giancola found that individual-trait anger mediated the relationship between alcohol intake and aggression.[16]

Alcohol effects on encoding of emotional state into facial motor programs

There is ample evidence that motor abilities deteriorate after alcohol intake.[38–40] With regard to facial expressions, Dethier et al found that long-term alcohol abuse and alcohol addiction impaired performance when deliberately encoding facial expressions of emotions.[31,41] However, alcohol effects on

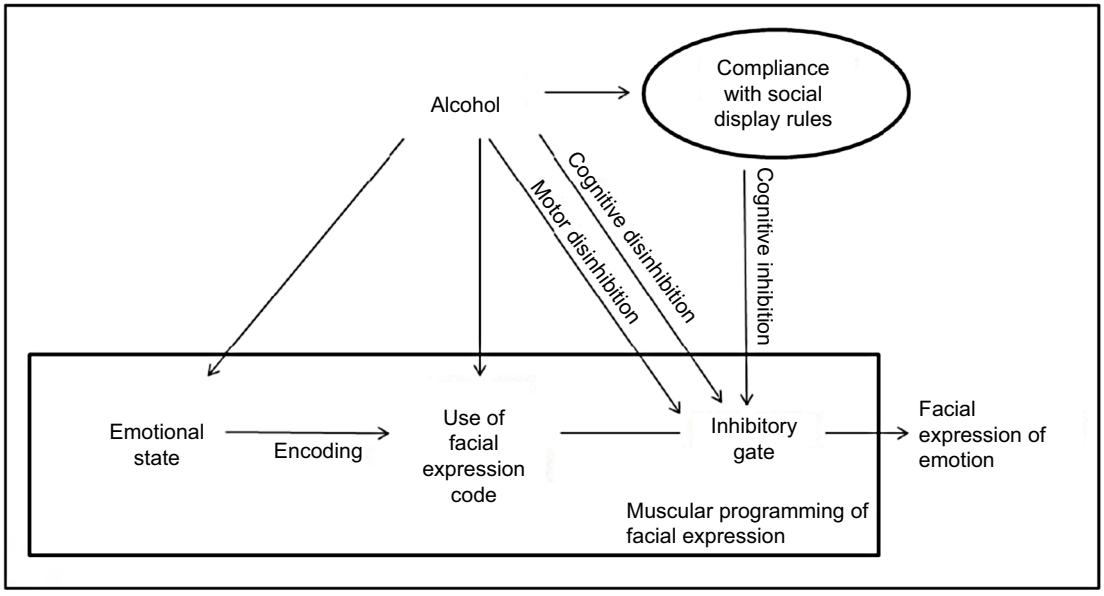

Figure 1 Heuristic model of facial emotion processing.
Notes: Rectangle indicates processes within individuals; ellipse denotes a social influence.

deliberate encoding of facial expressions in social drinkers are (to our knowledge) not yet investigated.

Alcohol effects on inhibitory gate for facial expressions

It is assumed that before the motor expression of an affective state can be executed, the particular motor program has to pass an inhibitory gate specific for facial expressions. Alcohol effects on this inhibitory process seem likely, as disinhibiting alcohol effects on both a motor-inhibitory task performance and a cognitive-inhibitory task performance were reported by Rose and Duka.[42] Moreover, an event-related brain-potential study found that after alcohol intake, individuals have to activate more cognitive resources to regulate and inhibit behavioral responses in both early and later stages of inhibitory control.[43]

Alcohol effects on compliance with social display rules

Social display rules include informal norms about when, where, and how emotions should be expressed, and are thought to moderate social nonverbal behavior, including facial expressions.[44,45] Previous findings have suggested that alcohol might affect compliance with social display rules. First, as alcohol has been found to impair cognitive processes and inhibition, it possibly counteracts the inhibitory effect of social display rules.[42,43] There is evidence that alcohol triggers increased nonverbal behavior that might usually be inhibited by social display rules in social drinking contexts.[46] Second, alcohol consumption might reduce the perceived necessity to comply with social display rules. Indeed, slightly to moderately drunk individuals are commonly expected to show disinhibited nonverbal (emotional) behavior that is often not in accordance with social norms.[17,42,43,47]

In conclusion, we assume that alcohol exerts influence on facial expressions of emotions via different pathways. Based on these pathways, we developed our search algorithm for identifying relevant studies. Moreover, in our search for literature, we applied a broad working definition of emotions that is widely accepted, in spite of the variety of theoretical views and concepts.[48] Accordingly, emotions are defined as temporary specific mental states of happiness, sadness, anger, anxiety, jealousy, pride, surprise, compassion, shame, guilt, envy, disappointment, relief, and mental states sufficiently similar to the emotions just mentioned.[48] We limited our search to laboratory studies, as these provide higher controllability than field studies and enable the detection of potential underlying mechanisms of action. Furthermore, we selected investigations that studied evoked emotional expressions using well-defined experimental methods. Previous research has shown that both affective responses to alcohol and the display of facial expressions depend on the method "prompting the [emotional] response, and how strong its impact is on motives or emotions".[8,22] Moreover, we examined how sample characteristics as well as personality variables influence alcohol effects on facial expressions of emotions. Due to previously reported effects of sex, drinking history, and alcohol expectancy (ie, individual beliefs about how emotions, mood, and behaviors are affected by alcohol) on general subjective alcohol effects, we also assumed these variables to influence the effect of alcohol on facial expressions of emotions.[7,33,49–52]

Based on the aforementioned considerations, we developed the following hypothesis. We assumed that alcohol facilitates facial expressions of anger under aggressive provocation conditions, but also enhances facial expressions of positive emotions in innocuous drinking contexts. Additionally, we considered the role of sex, drinking history, and alcohol expectancy with regard to alcohol effects on facial expressions of emotions.

Materials and methods

The researchers prepared this review in compliance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines for systematic reviews and meta-analysis.[53]

Search algorithm

We used the PRISMA flow diagram to present the selection of suitable publications (Figure 2).[53] First, we scanned our selected online databases with a predefined search algorithm. Having removed duplicates, we reviewed the titles and abstracts of the retrieved results and extracted relevant publications that met our predetermined criteria as regards content and methodology. The detailed selection process is further described in the following paragraphs.

We searched for relevant empirical studies in the electronic databases PsycInfo, PubMed, and Web of Science (database selection was done according to similar systematic reviews dealing with alcohol effects on emotional parameters)[54–56] within the overall time span covered by each database (from 1887, 1900, and 1926, respectively) until May 2017 in English and German languages. Considering our heuristic model of facial emotion processing (Figure 1), we applied the keywords "facial emotion encoding OR facial emotion inhibition OR nonverbal social behavior OR facial expression

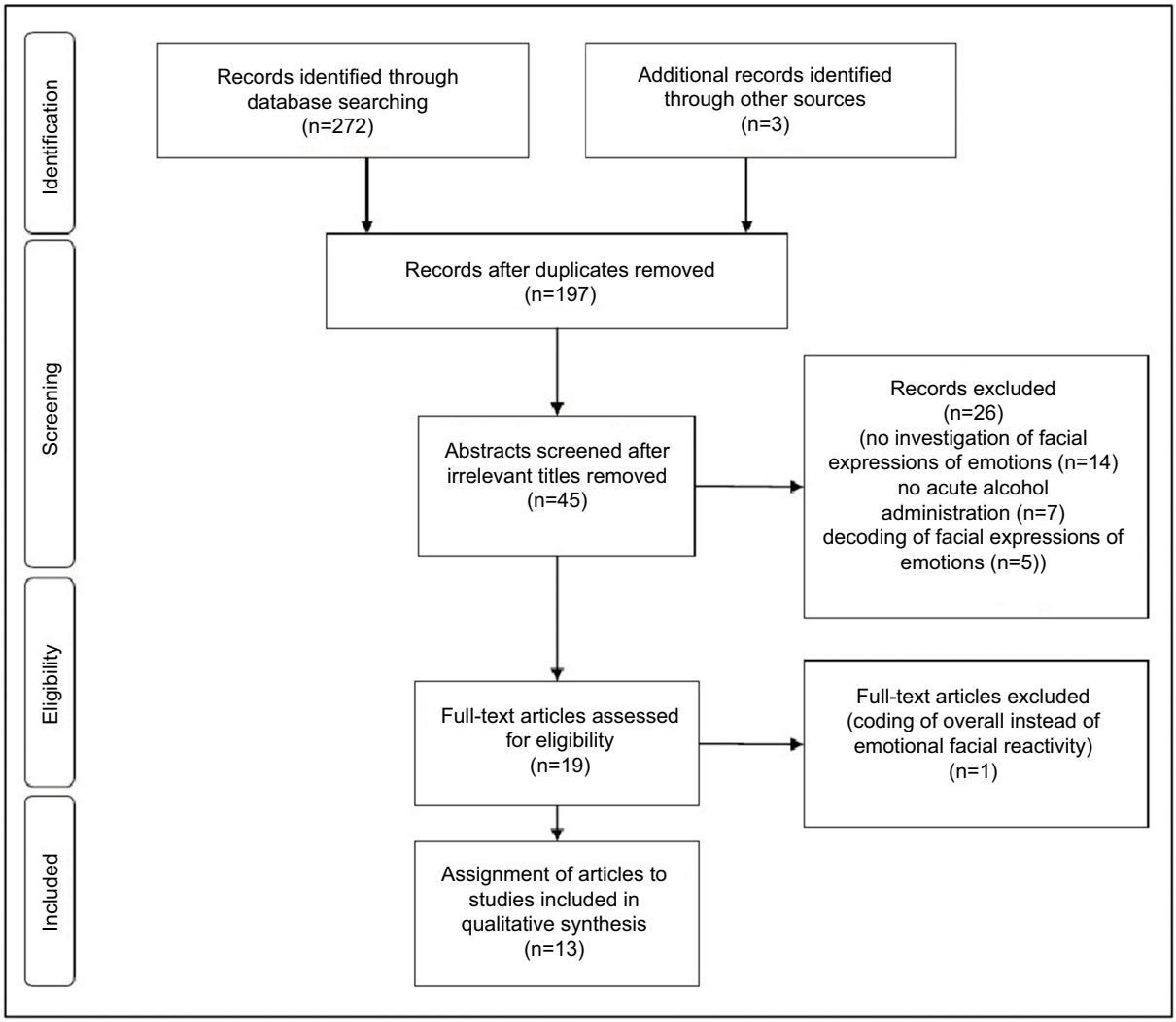

Figure 2 Process of study selection according to PRISMA flow diagram.[53]
Abbreviation: PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

of emotion" to our search. Additionally, we searched for studies that used objective measurements of facial expressions of emotions. Objective measurements do not only minimize the risk of observer-decoding bias within one investigation but also increase comparability between several investigations on alcohol effects on facial expressions of emotions. Facial actions can be assessed most objectively via electromyography (EMG) or via established psychometrical coding systems. We added the keywords "facial action coding OR facial electromyography" to our search algorithm. Finally, we combined ("AND") these keywords with "alcohol OR ethanol", and retrieved 383 articles published in English and one published in German. A brief glance at these search results revealed the inclusion of articles describing certain well-examined topics associated with alcohol effects on facial expressions that were, however, irrelevant for our review. Those articles focused on alcohol effects on facial emotion recognition, the influence of prenatal alcohol consumption on infants' facial expressions, and effects of pathological alcohol consumption. To exclude this literature, we narrowed our search algorithm using the "NOT" function ("NOT recognition NOT prenatal NOT pathologic"). This resulted in a total of 272 articles published in English that potentially suited the scope of our review. Moreover, we included three additional records previously identified through scanning reference lists.

Having excluded duplicates, the next step was conducted by two independent researchers in order to assure objectivity. This step consisted of the screening of both titles and abstracts of the obtained publications and the exclusion of those that appeared irrelevant for our review. In cases of disagreement, the researchers discussed their positions until they reached consensus. Deeper analysis of the remaining studies (n=19) was done with regard to eight exclusion criteria we applied to our review. The empirical studies 1) had to be published in a

peer-reviewed journal and 2) conducted on social drinkers in 3) laboratory settings. We included only investigations that used 4) systematic observations and recordings of 5) facial expressions of positive and negative emotions 6) induced by experimental methods. As observational studies can always imply the risk of the aforementioned observer bias, we only included studies with observer data that were either based 7) on established psychometrical coding systems for facial expressions (facial action coding system, maximally discriminative facial movement coding system) or 8) on self-developed systematic coding rules with detailed observer instructions.[29,57] According to this selection procedure and exclusion criteria, we identified 18 relevant publications with data derived from 13 primary studies (see Table 1 for the detailed assignment of publications to primary studies).

Results and discussion

In this section, we firstly review general characteristics, ie, sample characteristics, experimental control methods, and alcohol-administration characteristics, of the selected primary studies. Secondly, we describe and discuss acute alcohol effects on facial expressions of positive and negative emotions, whereby we used two perspectives. For the first perspective, we classified alcohol effects according to the valence of emotion expressed by the face. For the second perspective, we grouped these effects according to the level of social interaction implied in the study design. Thereby, we describe the methods to evoke and measure facial expression in more detail. As this systematized presentation of the data under these perspectives already goes beyond the mere presentation of results, we decided to combine results and discussion for better readability.

General characteristics of studies reviewed

From the primary studies selected, we retrieved information about general design, namely sample characteristics and experimental control methods (Table 1) and characteristics of alcohol administration (Table 2). We describe each of these study features first, and then discuss their effects on the relationship between alcohol and facial expressions of emotions (Tables 1–4).

Sample characteristics

Sample sizes in the 13 primary studies included in our review were 27–720 participants. Except for one study, which was conducted with panic-disorder patients, all samples consisted of healthy participants.[58] In all but one investigation, participants were younger than 35 years. While eight of the studies were conducted with participants of both sexes, the others investigated either exclusively males (n=3) or used all-female samples (n=2; see Table 1 for descriptive sample characteristics). Participants' drinking habits (Table 1) were assessed via self-report (eg, by psychometric questionnaires [n=4]) in all but one study. This study did not include any information about this topic,[59] whereas two other studies provided very detailed reports of the subjects' drinking behavior.[60,61]

Experimental control methods

As shown in Table 1, we listed the control methods "placebo control", "baseline control", "blinding", and "randomization", which helped us to evaluate the methodical quality of the reviewed studies. Weaver et al considered only "randomization".[59] Both control conditions and randomization were provided in two double-blind investigations and six single-blind investigations.[58,60–68] The majority of studies used baseline control (n=10). Physiological measures during the testing, eg, recording of autonomous activation via heart/pulse rate or blood pressure, were considered rarely.[62,63]

The term "beverage group" describes the alcoholic or nonalcoholic beverage administered in a group of participants. Independently of this, drinkers can be either blinded or unblinded about the alcohol content of their beverages in a specific beverage group. While allocation to a specific beverage group was utilized as a between-subject factor (ie, each subject was allocated to one specific drinking group) in all investigations, only one study additionally compared the effect of different alcoholic and nonalcoholic drinks within subjects (beverage group as within-subject factor). There, subjects underwent two test sessions and were allocated to each drinking group once.[60] In most of the studies (n=10), participants were blinded to the content of their beverage. The assessment of alcohol expectancy (eg, via self-report) was neglected throughout. Figure 3 overviews the study protocols with regard to beverage groups and blinding.

Alcohol administration

We screened the studies with regard to the alcohol administered, the period of drink consumption (ie, the time subjects had to finish their drinks), and the time interval between drink consumption and the recording of facial expressions. Moreover, we extracted information on the assessment of breath-alcohol concentration (BAC) via spirometry. Alcohol-administration characteristics are reviewed in Table 2.

In all studies alcohol was administered orally, the dose was adjusted to the subjects' body weight, and (if reported)

Table 1 General design of studies reviewed

Experimental manipulation									
Reference(s)	**Samples**	**Sex (female)**	**Age, years (mean ± SD/range)**	**Drinking behavior and other characteristics**	**Design**	**Placebo control[c]**	**Baseline control[d]**	**Blinding[e]**	**Randomization[f]**
93	138	Mixed (65%)	21–28	Social drinkers (self-report)	Within-subject Between-subject	Yes	No	Single	Yes
71, 72, 85, 92[a]	720	Mixed (50%)	21–28	Social drinkers (self-report)	Within-subject Between-subject	Yes	No	Single	Yes
60	49	Mixed (55%)	23.9±2.6 19–32	Social drinkers (TPQ)	Within-subject Between-subject	Yes	Yes	Single	Yes
64	54	Male	21–35	Social drinkers (self-report)	Within-subject Between-subject	Yes	Yes	Single	Yes
58	27	Mixed (70%)	30.3±7.3 21–48	Panic disorder, social drinkers (self-report)	Between-subject	Yes	Yes	Double	Yes
69	42	Female	23.3±2	Social drinkers (self-report)	Between-subject	No	Yes	No	Yes
65, 66[a]	136	Male	20.78±2.1 18–30	Social drinkers (B-MAST)	Within-subject Between-subject	Yes	Yes	Single	Pseudo
67, 68[a]	61	Female	22.9±3 19–30	Students, social drinkers (self-report)	Between-subject	Yes	Yes	Double	Yes
70	88	Mixed (50%)	24.36±4.2	Dating couples, social drinkers (self-report)	Within-subject Between-subject	No	Yes	No	Yes
62	42	Mixed (not specified)	21–28	Social drinkers[b]	Between-subject	Yes	Yes	Single	Yes
63	169	Mixed (50%)	21–28	Social drinkers[b] (ADS)	Between-subject	Yes	Yes	Single	Yes
61	138	Mixed (50%)	21–35	Smokers, social drinkers (self-report)	Within-subject Between-subject	Yes	Yes	Single	Yes
59	63	Male	>21	Students	Within-subject Between-subject	No	No	Not reported	Yes

Notes: [a]Publications derive from one experimental investigation and count as one experiment; [b]Cahalan drinking history inventory; [c]administration of both alcoholic and nonalcoholic drinks within one investigation; [d]repeated assessment of values prior to and after drink consumption, which also allows for the control of potential confounding variables (eg, alcohol or food intake prior to the day of testing); [e]participant or experimenter or both not made aware of whether alcohol or placebo administered; [f]random allocation to specific drinking group.

Abbreviations: TPQ, Tridimensional Personality Questionnaire; B-MAST, Brief Michigan Alcoholism Screening Test; ADS, Alcohol Dependence Scale.

Table 2 Characteristics of oral alcohol administration in studies reviewed

Reference(s)	Period of drink consumption	Dose of alcohol	Time between consumption end and recording facial expression	BAC assessment		Mean BAC, mg/dL (SD)
				Predrink	Postdrink[a]	
93	36 minutes	0.82 g/kg (males) 0.74 g/kg (females)	0–3 minutes, 13–36 minutes	Yes	0, 40 minutes	Overall: 74 0 minutes postdrink: 63 (16) 40 minutes postdrink: 73 (17)
71, 72, 85, 92	36 minutes	0.82 g/kg (males) 0.74 g/kg (females)	0–3 minutes, 13–36 minutes	Yes	0, 40 minutes	Overall: 74 0 minutes postdrink: 68 (15) 40 minutes postdrink: 76 (14)
60	15 minutes	0.5 g/kg	20 minutes	Yes	After task completion, not specified	21
64	30 minutes	0.82 g/kg	During drink administration	Yes	40, 90 minutes	40 minutes postdrink: 63 (11) 90 minutes postdrink: 83 (17)
58	20 minutes	Not reported	20 minutes	No	Postdrink, not specified	74–79
65, 66	20 minutes	0.99 g/kg	10 minutes	Yes	10 minutes; after task completion	Pretask: 111 (12) Posttask: 123 (12)
69	20 minutes	2.3 mL/kg (high) 0.77 mL/kg (low)	During drink administration	No	90 minutes	High dose: 105 (17) Low dose: 15 (9)
67, 68	5 minutes	0.39 g/kg (high) 0.22 g/kg (low)	30 minutes	No	Not assessed	–
70	30 minutes	2.3 g/kg	10 minutes	Yes	5 minutes	80
62	30 minutes	0.67 g/kg	Not specified	Yes	During drink administration; 5 minutes; prior to and after instruction (not specified)	Prior to instruction: 62 After instruction: 59
63	30 minutes	0.82 g/kg (males) 0.74 g/kg (females)	18 minutes	Yes	10, 11, 23, 50 minutes	10 minutes postdrink: 83 (18) 11 minutes postdrink: 85 (17) 23 minutes postdrink: 91 (16) 50 minutes postdrink: 92 (15)
61	30 minutes	0.82 g/kg (males) 0.74 g/kg (females)	3 minutes	Yes	30, 47 minutes	30 minutes postdrink: 87 (16) 47 minutes postdrink: 90 (15)
59	3 minutes	1.9 g/kg (high) 0.9 g/kg (low)	12 minutes	No	Not assessed	–

Notes: [a]Postdrink BAC specified in minutes after drink completion or in relation to a given task.
Abbreviation: BAC, breath-alcohol concentration.

Table 3 Facial expressions of positive emotions: evocation, coding, and acute alcohol effects

Emotion induced by	Reference	Facial coding method	Facial expressions registered	Main findings on alcohol effects on facial expressions	Additional findings
Couple conflict	70	Rating scale	Smile	Within level: decreasing alcohol effect on smiles Between level: no alcohol effect on smiles at initial 30 seconds, but decreasing alcohol effect on smiles after 3 minutes	—
Humorous cartoons	67	FACS	2, 6, 12	No main alcohol effect on facial expressions of exhilaration smiles	Self-reported elation increased in high (vs low) alcohol dose; alcohol dose × extraversion interaction
	68	FACS	2, 6, 12	No main alcohol effect on facial expressions of exhilaration smiles	No correlation between rated funniness and facial expressions of exhilaration smiles in beverage group (vs correlation in sober group)
	59	Rating scale	Smile frequency or duration	No main alcohol effect on smile frequency or duration	Type of humor × beverage-group interaction effect on smile frequency; no effect for level of intoxication on rated funniness; no correlation between rated funniness and smile frequency or duration in beverage group (vs correlation in sober group)
Self-disclosing speech	62	MAX	Smile	No alcohol effect on smiles	No sex effects, no time × beverage-group interaction effect
	63	FACS	12, 6+12, +1, 2, 25, 26	No alcohol effect on facial expressions of positive emotions	No beverage group × parental history of alcoholism interaction
Smoking cue exposure	61	FACS	12, 6+12, +1, 2, 25, 26	Heightening alcohol effect on facial expressions of positive emotions during smoking-cue exposure	Marginally significant sex effect on facial expressions of positive emotions during smoking-cue exposure (women > men); time × beverage-group interaction during smoking-cue exposure
Social interaction	64	FACS	6+12	Heightening main alcohol effect at individual and group levels (individual and simultaneous Duchenne smiles)	Self-reported social bonding increased in beverage group; time × beverage-group interaction on simultaneous smiles
	93	FACS	6+12	No main alcohol effect on smiles	Time × beverage-group interaction
	71	FACS	6+12	Heightening alcohol effect on smile contagion and smile duration No alcohol effect on non-Duchenne smiles	Group sex composition × beverage group interaction effect à elimination of sex differences under alcohol; Duchenne smile contagion correlated with drinking pattern
	85	FACS	6+12	Heightening main alcohol effect on individual and group level (individual and simultaneous Duchenne smiles)	No extraversion × beverage-group interaction on smiles
	92	FACS	6+12	Heightening main alcohol effect on individual and group level (individual and simultaneous Duchenne smiles)	Correlation of present and past smiles decreased in alcohol group
	69	BOSIM	Smile	No alcohol effect on smiles	No alcohol effect on self-reported enthusiasm
	72	FACS	6+12	Heightening main alcohol effect on individual and group level (individual and simultaneous Duchenne smiles)	Main effect for gender on the display of facial expressions (women > men); Heightening alcohol effect on self-reported social bonding

Abbreviations: FACS, facial action coding system; MAX, maximally discriminative facial movement coding system; BOSIM, bar-observation social interaction measure.

ranged from 0.22 g/kg to 2.3 g/kg body weight. Only three studies administered a dose higher than 1 g/kg body weight.[59,69,70] Kushner et al administered variable alcohol doses to achieve a targeted BAC.[58] Two (low vs high) alcohol doses were compared for their effects on facial expressions of emotions in three studies included in our review.

Manipulation checks were accomplished by assessing subjective intoxication ratings (n=11) or postdrink breath alcohol measures (n=11). Predrink BACs were assessed in most studies (n=10). Repeated measurement of postdrink BACs to track blood-alcohol levels over time was included in seven studies. Facial expressions were recorded within different time frames (0–36 minutes) after drink completion. One study failed to report the time frame of recording.[62]

Information on the period of drink consumption was provided by all studies but one. However, there was considerable heterogeneity regarding this period: 3–36 minutes. In order to increase comparability between studies with regard to alcohol-administration characteristics, we related the dose of alcohol (g/kg) to the time allowed for drink consumption (minutes). As such, the highest doses of alcohol related to the time for drink consumption were found in Weaver et al:[59] 0.63 g/kg per minute (high dose) and 0.3 g/kg per minute (low dose). This was followed by doses of 0.04–0.12 g/kg per minute in four studies included in our review.[65–70] In the remaining studies (n=7) the ratio was from 0.02–0.03 g/kg per minute.

Effects of general study characteristics on relationship between alcohol and facial expressions of emotions

Regarding sample characteristics, sex effects on facial expressions of emotions after alcohol intake were analyzed in four studies (Tables 3 and 4), and yielded inconsistent results.[60–62,71,72] Two studies reported no effects of sex, whereas the others indicated a higher occurrence of facial expressions of positive (Table 3) and negative (Table 4) emotions in women independently of alcohol intake.

These findings suggest that alcohol does not diminish preexisting sex differences in facial expressions of emotions, which are commonly reported: Men are not only found to be generally less expressive than women but also to show different expressions, eg, more facial expressions interpreted as signs of pride and power, more facial expressions of anger, and fewer smiles compared to women.[73–78] In one of the reviewed studies, alcohol led to disappearance of sex differences in smile contagion, an effect that consists in the spread of smiling within a social group.[71] Sober all-male groups showed less smile contagion than sober mixed-sex groups; these differences vanished after alcohol consumption. This effect was not driven by the sex of the smile initiator, but by the sex of the person who received the smile.

Modulatory effects on facial expressions after alcohol intake by drinking pattern and drinking history were sparsely analyzed in the studies included in our review (n=2). In both studies, the authors found no significant differences in facial expressions under acute intoxication between light- and heavy-drinking groups. In one of these studies, there was only a trend toward heightened musculus corrugator activity (which indicates negative affect) in heavy drinkers (Table 4).[60] Previous research has found that light drinkers report increased sedation but also more aversive alcohol effects than moderate/heavy drinkers.[8,49] Therefore, it seems that differences in subjective alcohol effects between light and heavy drinkers are not necessarily reflected in different facial expressions of emotion. With regard to experimental control methods, participant blindness is crucial in order to minimize the impact of alcohol expectancy.[9,17,18,47,50] Alcohol expectancy was not studied in our review, but has previously been found to influence (light vs heavy) drinking behavior.[51,79,80]

With regard to alcohol-administration characteristics, none of the reviewed studies considered different effects that may occur during the ascending and descending limb of the BAC curve. However, this might be of relevance, as previous research has indicated that similar alcohol concentrations produce positive and stimulating effects on the ascending limb, but depressant effects on the descending limb.[52,81–83] An EMG study by Pishkin et al demonstrated such differences between the ascending and descending limbs with regard to overall facial activity.[84] Compared to sober individuals, intoxicated participants showed more facial activity on the ascending limb after failure (negative emotion) and more activity on the descending limb after success (positive emotion). This finding suggests that pharmacokinetic properties determine alcohol effects on the facial expression of emotion.

In conclusion, despite their general relevance for subjective alcohol effects, the variables sex, drinking pattern, drinking history, and alcohol expectancy were (if at all) only sparsely analyzed in the reviewed studies. A such, their modulating effects on alcohol effects on facial expressions of emotions cannot be clarified by our review, and should be a topic in future research.

Alcohol effects on facial expressions of emotions

In order to provide a clearly arranged overview of the findings concerning acute alcohol effects on facial expressions

Table 4 Facial expressions of negative emotions: evocation, coding, and acute alcohol effects

Emotion induced by	Reference	Facial coding method	Registered facial expressions	Main findings on alcohol effects on facial expressions	Additional findings
Humorous cartoons	67	FACS	12 alone, 13, 14	Heightening alcohol effect on facial expressions of non-enjoyment in low dose condition (no differences between high dose and control)	Stimuli were judged more negatively in low-beverage group (vs other groups); correlation between rated negative affect and certain facial expressions of nonenjoyment; no alcohol × extraversion interaction
Panic provocation	58	MAX	Fear/distress score; false smiles (masking reactions)	Decreasing alcohol effect on facial expressions of fear/distress and masking behavior of fear (sum score); decreasing alcohol effect on false smiles	No alcohol effect on facial expressions of fear as single variable
Picture presentation (pleasant, threat, disgust)	60	EMG	Musculus corrugator activity	Heightening alcohol effect on facial expressions of negative emotions	No sex effect; drinking behavior × picture-type interaction trend
Shock-based provocation	66	FACS	4, 5, 23, 24	Heightening alcohol effect on facial expressions of anger	Anger out × beverage group × level of provocation interaction effect; anger control × beverage-group interaction effect
	65	FACS	1, 2, 4, 5, 20	No main alcohol effect on facial expressions of anxiety	Level of provocation × trait anxiety × beverage-group interaction effect
Self-disclosing speech	62	MAX	Gaze aversion; lip compression/ lip biting; furrowed brow	Decreasing alcohol effect on facial expression of shame	Heightened alcohol effect on heart rate; no sex effects
	63	FACS	9, 10, 14, 15, 20, 1+4	No alcohol effect on facial expressions of negative emotions	Order × beverage group interaction effect; no-beverage group × parental history of alcoholism interaction
Smoking-cue exposure	61		9, 10, 14, 15, 20, 1+4	Decreasing alcohol effect on facial expressions of negative emotions during smoking-cue exposure	Marginally significant sex effect on facial expressions of negative emotions during smoking-cue exposure (women > men); time × beverage group interaction
Social interaction	93	FACS	9, 14, 15, 20; 12+14, 15, 23, 24 (smile control)	No alcohol effect on facial expressions of negative emotions; group racial composition × beverage-group interaction effect on smile control à elimination of group racial composition effects under alcohol	–
	69	BOSIM	Frowning	Heightening alcohol effect on frowning	Frowning × child sexual abuse history interaction
	72	FACS	9, 14, 15, 20	Decreasing alcohol effect on AUs 9, 14, 15	Main effect for sex on display of facial expressions (women > men)

Abbreviation: FACS, Facial Action Coding System; MAX, maximally discriminative facial movement coding system; EMG, electromyography; BOSIM, bar-observation social interaction measure; AUs, action units.

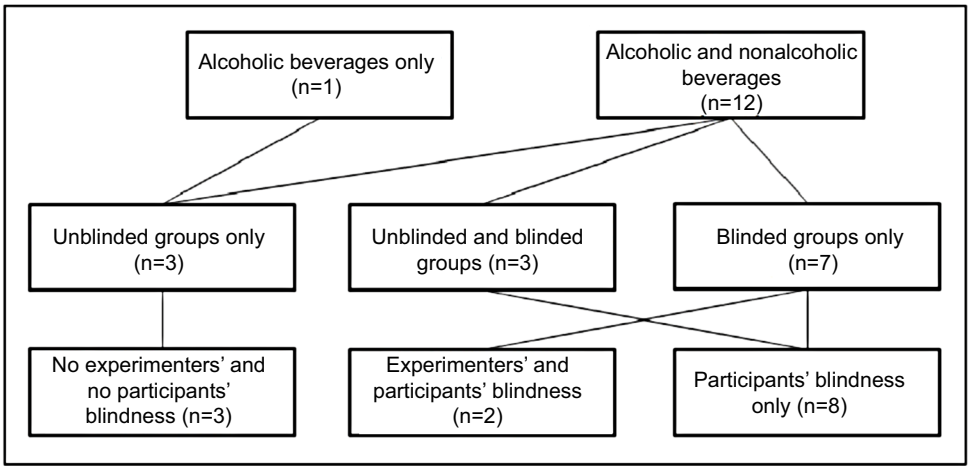

Figure 3 Experimental control methods for different beverage groups according to the study protocols.

of emotions, results were categorized in facial expressions of positive (Table 3) and negative (Table 4) emotions. Both general and dose-dependent alcohol effects are summarized. Thereafter, we review and discuss alcohol effects on facial expressions of emotions dependent on the level of social interaction imposed by the study design. We provide further information about study-design characteristics and particularly refer to the evocation and coding of facial expressions of emotions.

General alcohol effects

With regard to facial expressions of positive emotions, eight studies found no change after alcohol intake, whereas six other studies reported an increase in expressivity. Only one study reported a decrease in facial expressions of positive emotions after drinking.[70] For negative emotions, we identified an almost equal number of studies suggesting unaffected (n=3), increased (n=4), and decreased (n=6) facial expressions during intoxication.

Dose-dependent alcohol effects

Weaver et al did not find any dose-dependent alcohol effects on facial expressions of negative emotions; other studies reported increased or decreased facial expressions of negative emotions in high- compared to low-intoxication groups.[59,67,69] Moreover, interaction effects between level of intoxication and method of emotion induction on facial expressions of enjoyment occurred. According to this, the higher the alcohol level, the fewer smiles elicited by subtle humor; in contrast, there were no alcohol-dose effects on smiles elicited by blunt humor.[59] Ruch reported interaction effects between the level of intoxication and extraversion on facial expressions of enjoyment:[67] the higher the alcohol level, the fewer smiles displayed by extraverts; there was no alcohol-dose effect on smiles in introverts. In contrary, Fairbairn et al did not find any interaction effects between alcohol level and extraversion on facial expressions of positive emotions.[85]

Overall, these inconsistent findings corroborated the assumption that there are crucial moderating variables with regard to alcohol effects on facial expressions of emotions.[17,86] We have already considered pathways moderating how alcohol exerts influence on facial expressions of emotions (Figure 1). One prominent factor included in our model was social interaction. In general, social interaction comprises communicative behavior between different actors who reciprocally respond to each other, and influence or direct each other.[87] The level of social interaction depends on different factors, eg, the number of interaction partners and the type of interaction (direct vs indirect, face to face vs virtual). The term "social drinkers", which is commonly used for individuals who show a pattern of occasional, nonpathological alcohol consumption, already points to the relevance of social factors for drinking behavior in this group. Moreover, there is evidence that both the emotional response to alcohol (eg, more stimulating alcohol effects in the presence of a drinking partner vs drinking alone) and the display of facial expressions of emotions vary with the social context.[7,8,13,22,88] Therefore, we grouped the studies according to the level of social interaction imposed by the study design into those with low, moderate, and high levels of social interaction. With regard to the communicative function of nonverbal behavior, we assumed alcohol effects on facial expressions of emotions to increase with an increasing level of social interaction.[24]

Alcohol effects on facial expressions of positive and negative emotions considering level of social interaction

We defined low-level social interaction contexts as situations in which participant attention is focused on a specific task that does not include direct social interaction. We assumed a moderate level of social interaction to be present in the studies in which participants were asked to deliver a videotaped speech about what they liked and disliked about their physical appearance. This assumption is based on the fact that participants addressed their speech to an indirect (virtual) but specified interaction partner. In the studies reviewed, the addressee was a group of psychology students. Contexts including face-to-face communication with at least one interaction partner were classified as high-level social interaction.

We found six primary studies that used a low level of social interaction. In four of these studies, the experimenters merely observed the participants during the experimental task, which consisted in the judgment of emotional pictorial stimuli or exposure to smoking cues.[59–61,67,68] In two other studies, the participants underwent a panic provocation or received electric shocks during the absence of the experimenters, who administered the stimuli from a separate room and observed task performance by using video surveillance.[58,65,66]

Alcohol intake did not exert any effect on the facial expression of positive emotions (enjoyment) elicited by humorous stimuli (Table 3).[59,67,68] Moreover, an alteration of alcohol-dose level (high vs low) did not affect facial expressions of exhilaration in these studies. Participants who had consumed alcohol showed more frequent facial expressions of negative emotions in response to humorous stimuli than sober individuals (Table 4).[60,67] Ruch reported increased facial expressions of negative emotions for only a low (vs high) alcohol dose.[67] Glautier et al found heightened EMG musculus corrugator activity, which is considered an indicator of negative affect after alcohol consumption, while watching pleasant, threat-related and disgust-related pictures.[60,89] Therefore, in social drinkers who judged pictorial stimuli in settings with low levels of social interaction, alcohol merely showed increasing effects on facial expressions of negative emotions. It is of note that this effect occurred for both pleasant and unpleasant pictorial stimuli.

Sayette et al investigated the effect of alcohol on facial expressions of emotions that occurred during cigarette craving (12-hour smoking abstinence) in heavy smokers.[61] They found that during exposure to smoking cues (presentation of a lit cigarette), alcohol increased facial expressions of positive emotions (Table 3) and marginally decreased the occurrence of facial expressions of negative emotions; however, this effect declined over time (Table 4).[61] Previous research by Sayette et al suggested that a smoker's facial expression of positive emotions during cigarette craving indicates an increased likelihood of initiating smoking.[90]

In a study by Kushner et al conducted on panic patients, slightly to moderately drunk participants showed decreased facial expressions of fear/distress, as well as less active facial behavior to suppress these signs under panic provocation (Table 4).[58] These findings can be interpreted in the context of previous findings of alcohol attenuating panic symptoms.[2,4]

Regarding healthy participants under provocation by electric shock (Table 4), there is evidence for an alcohol-dependent increase in the facial expression of anger, but no main effect of alcohol on facial expressions of anxiety.[65,66] Alcohol enhanced the relationship between the individual's actual facial expression of emotion and his or her trait anger or trait anxiety under certain levels of provocation (implemented by the intensity of electric shocks). Particularly, under alcohol, trait anger evoked facial expressions of anger under high provocation (ie, high-intensity shocks), and the increase in facial expressions of anxiety occurred only in highly anxious men under low provocation (ie, low-intensity shocks).[65,66] These results were corroborated by other findings highlighting the influence of both aggression-related traits and provocation level on anger expression.[14–18]

In two of the studies reviewed, we found a moderate level of social interaction.[62,63] These studies, in which participants delivered a videotaped self-disclosing speech, reported no alcohol effects on the facial expression of positive emotions (Table 3). Alcohol decreased facial expressions of negative emotions in both studies (Table 4); however, in one of the studies this effect depended on whether the stressor was introduced before or after alcohol administration.[63] Also in the latter study, signs of fear and anger suppression measured by lip compression and lip biting were heightened within slightly to moderately drunk individuals in contrast to their sober counterparts. Alcohol was previously found to modulate signs of negative emotions visible in the face during delivering a speech. Particularly, Stevens et al found decreased facial blushing after alcohol intake and thus highlighted the functional advantage of reduced (facial) signs of nervousness that increased the speakers' self-confidence and reduced social anxiety.[91]

Contexts with high-level social interaction were identified in five studies.[59,61,72,79,80,85,92,93] In general, the process of group formation among unacquainted participants is commonly used in experimental paradigms aimed at investigating social

context effects. Both positive and negative emotional states can equally be evoked by group formation.[7] Moreover, it is possible simultaneously to observe (facial) behavior on individual (reactions of one individual, eg, smiling) and group levels (simultaneous reactions of several individuals, eg, smile contagion) in this context.

Alcohol effects on smile behavior at both individual and group levels were found in three studies using the group-formation paradigm (Table 3).[64,71,72,85,92,93] Fairbairn et al measured fewer smile controls, ie, facial expressions that counteract an occurring smile, under alcohol (Table 4), but no alcohol effects on facial expressions of positive and negative emotions themselves.[93] In another study, alcohol (vs placebo) decreased facial expression of negative emotions (Table 4).[72]

In sum, within the process of group formation, alcohol consumption heightened the frequency of positive facial expressions and smile contagion, and at least partially decreased facial expressions of negative expressions. In a simulated couple-conflict situation, slightly to moderately drunk individuals showed significantly less positive facial expressions relative to their sober counterparts and a decline in expressing positive emotions over time (Table 3).[70] This might indicate that individuals can play their allocated role as conflict partner in a more authentic way after alcohol intake. In other words, slightly to moderately drunk individuals acted more as expected, ie, they performed more socially desirably, considering the given task. Summarizing alcohol effects on facial expressions of emotions in situations with a high level of social interaction, we conclude that moderate dosages of alcohol affect both positive and negative facial expressions in a way that increases desirable social behavior. Moreover, since alcohol also seems to dampen smile-control expressions, a further argument for the function of alcohol as social lubricant is available. In general, mood- and social bond-enhancing alcohol effects can be explained by a "social-attributional" approach, whereby alcohol interferes with the anticipation and elaboration of social rejection.[86] Alternatively, these effects might also be explained by so-called alcohol myopia, which describes a narrowing of perception and cognition by alcohol that temporarily alleviates worries and causes a feeling of relief.[35,92] Further exploratory approaches on how alcohol affects emotions in social drinkers are elaborately discussed in a recent review by Sayette.[7]

Increasing BACs, however, do not seem to enhance these effects, as shown by Parks et al (Tables 3 and 4).[69] In this study, increases in the administered alcohol dose (paralleled by increases in BAC) did not affect facial expressions of positive emotions but increased facial expressions of negative emotions.

Limitations

In the following, we briefly discuss limitations of this review. Moreover, we summarize limitations of the studies reviewed and provide suggestions for future research.

Limitation of this systematic review

In order to review alcohol effects on the facial expression of emotions in social drinkers, we categorized studies according to the level of social interaction imposed by the study design. There are also other factors given by our heuristic model of facial emotion processing (Figure 1) to organize the present review. However, we chose the level of social interaction, because we assumed it to be one of the most important moderating variables in this context and also for the pragmatic reason that all reviewed studies provided information on the level of social interaction, whereas this information would not have been available for the other variables included in our heuristic model.

Limitations of studies reviewed and suggestions for future research

There are also some limitations of the studies reviewed, each highlighting directions for future research. First, alcohol effects on facial expressions of anger and anxiety were assessed only in male participants.[65,66] Due to pronounced sex differences in both facial expressions and aggression, generalization of these effects to female participants is not possible, and future studies should also investigate female samples.[16,73–78,94,95] Second, the studies reviewed considered various emotions that are encoded into specific facial expressions. In order to enhance comparability of the studies, future research should refer to similar concepts of emotions; we propose using a broad working definition of emotion.[48] Moreover, there is to date no experimental investigation dealing with alcohol effects on facial expressions of sadness. However, such effects can be expected due to mood-enhancing and stress-dampening effects of alcohol, and should thus be examined in future research.[7]

Third, the studies included in our review did not compare alcohol effects on facial expressions of emotions that appear on the ascending or descending limb of the BAC curve. However, since the same alcohol concentration often exerts different subjective effects (stimulating vs depressant) on the ascending vs descending limb of the BAC curve, this seems to be an important topic to be considered in future

studies.[52,83] Fourth, in one study, facial muscle activity was measured via EMG using surface electrodes.[60] Despite the high objectivity of this method, the spatial resolution is not good enough to distinguish fully among expressions of different emotions. Indeed, only musculus corrugator and zygomaticus activity are commonly interpreted as measures of negative and positive emotions, respectively. The use of needle electrodes would improve spatial resolution, but may irritate. The application of electrodes always leads to artificial conditions, possibly changing facial expressions. For a comprehensive analysis and interpretation of facial activity, we recommend an additional observer rating to distinguish among different kinds of emotion expressions. Concordance of EMG-recorded facial activity with observer ratings would facilitate the interpretation of certain patterns of EMG facial activity as indicative of the expression of specific emotions.

Fifth, a potential interaction between social context factors and the method used for emotion induction has not yet been studied, but might be considered. For example, emotion induction via picture presentation and anger provocation are confounded with low-level social interaction contexts.[59,60,65–68] Sixth, as already discussed, sex effects, the subjects' drinking history, and alcohol expectancy have been sparsely investigated. Due to their importance for the relationship between alcohol and emotion, however, they should be considered systematically in future investigations. Seventh, no examination of alcohol effects on the facial expression of pain has yet been conducted. There is an established relationship between alcohol consumption and clinical pain: individuals suffering from pain tend to consume more alcohol, and individuals presenting with alcohol abuse often report pain symptoms.[96,97] In addition, pain-dampening effects of alcohol could be proven experimentally.[55,98] Moreover, there is a close relationship between emotion and pain: modulating effects of emotional stimuli on pain perception have been repeatedly reported.[99–103] In sum, due to close mutual relationships among alcohol, emotion, and pain, we would expect to find alcohol effects also on the facial expressions of pain.

Conclusion

Despite the common use of alcohol to modulate emotion, there is still little systematic research on alcohol effects on the facial expression of emotions. As we tried to demonstrate with our heuristic model (Figure 1), alcohol can potentially impact facial expressions of emotion on various stages. To date, our review is the first approach to systematize the available literature on this research topic.

Overall, alcohol exerts effects on facial expressions of emotions in social drinkers. These effects are not generally disinhibiting, but vary depending on the valence of emotion and on social interaction. In moderate- and high-level social interaction, alcohol mostly influences facial expressions in a socially desirable way, thus underscoring the view of alcohol as social lubricant. Important research gaps to be closed by future studies are the investigation of alcohol effects on the facial expressions of sadness and pain, as well as the consideration of potential moderating variables (eg, alcohol expectancy). Future research should also investigate if socially desirable alcohol effects on facial expressions trigger increased drinking and thus might influence the development of problematic drinking behavior in social drinkers.

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Disclosure

The authors report no conflicts of interest in this work.

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