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## Emotional processes in binge drinking: a systematic review and perspective

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Table 1. Description and main results of	studies evaluating emotional appra	aisal and identification in binge drinking.
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			Particip	ants	Intervention	Comparator	Experimental design Outcomes				omes	Scoring
Authors (year)	Sample (n)	Age	Gender ratio (% of males)	Inclusion criteria	Binge drinking criteria	Control group/variable	Processes measured	Task/scale	Stimuli	Main results	Limits	
E	motional ide	ntificati	on of intern	nal cues								
Bekman et al. (2013)	39 BD	Range 16-18 Mean 17.74	51%	No recent substance consumption No psychiatric or neurological disorders	Drinking alcohol on more than 100 occasions at lifetime. At least 3 binge drinking episodes (≥ 70 alcohol gr for boys and ≥ 56 gr for girls on one occasion) during the past month At least 1 withdrawal symptom following a recent drinking episode	26 non-BD (no history of binge drinking or alcohol use problems)	Anxiety and depression Mood	6-week research following abstinence: two assessments (start and end) and daily follow- up (3-6 times/day) The Hamilton Rating Scales for Anxiety and Depression State-Trait Anxiety Inventory Self-reported negative affects (down, angry, and stressed)	N/A	Negative affect at early stage of abstinence: BD > non-BD Depression, anxiety: BD > non-BD Correlations between negative affect and maximum number of drinks consumed on one occasion and total number of drinks	No information about affective states prior the onset of alcohol use	82.35
Chen & Feeley (2015)	179 college students	Range 18-29 Mean 19.76	46.9%	N/A	Number of binge drinking episodes in the past 2-week (≥ 70 alcohol gr for boys and ≥ 56 for girls in 2 hours)	Analyses were controlled for ge, gender, ethnicity, and health status	Stress Loneliness	2-week research Perceived Stress Scale UCLA Loneliness Scale	N/A	Students with higher stress depicted increased binge drinking 2 weeks later No associations were found with loneliness	Convenience sample	41.18
Ewing et al. (2010)	45 college students	Range 21-33 Mean 22.8	44.44%	No MRI contraindication, personal or family history of psychopathological disorder, current medical condition, mental retardation, left handedness, or current substance use No alcohol, caffeine, and nicotine use prior scanning	At least 42 alcohol gr (men) or 28 (women) per drinking occasion, 2-5 times per week, for 4 weeks Number of binge drinking episodes (at least 70 gr) in the past month	N/A	Depressive symptoms Anxiety symptoms	AUDIT Beck Depression Inventory Beck Anxiety Inventory fMRI: taste-cue paradigm (alcohol and non-alcohol appetitive cues)	N/A	Depression was positively associated with brain activations (insula, cingulate, ventral tegmentum, striatum, and thalamus) while viewing alcohol cues Anxiety was positively associated with brain activations (striatum, thalamus, insula, and inferior frontal, mid-frontal, and cingulate gyri) while viewing alcohol cues	No control group	76.47

Hartley et al. (2004)	14 BD	Range 18-23 Mean 21.13	64.3%	N/A	$\geq$ 80 alcohol gr on one occasion Binge drinking score $\geq$ 24	13 teetotalers	Trait anxiety and depression Mood	The Hospital Anxiety and Depression Scale Visual analogue rating scales (alertness, well-being, anxiety)	N/A	Trait anxiety and depression: BD < teetotalers NS for mood rating	Comparison with a group of non- drinkers (i.e., it assesses the effect of alcohol consumption but not a specific effect of binge drinking)	88.24
Haynes et al. (2005)	8,580 adults at baseline	18-74	N/A	Absence of mental disorder at baseline	≥ 48 alcohol gr on one occasion at least once a month	Analyses were adjusted for age, gender, socio-demographic and - economic variables, other substance use and mental health	Depression	18-month study Clinical Interview Schedule at baseline (n=2,413 who completed the follow-up have no mental disorder) AUDIT Severity of Alcohol Dependence Questionnaire	N/A	Hazardous drinking, binge drinking, and severe alcohol use disorders were not related to anxiety or depression at follow-up Sub-threshold of anxiety and depression at baseline was related to the onset of severe alcohol use disorders (weak evidence)	No information about the evaluation of depression and anxiety during the 18 months (e.g., recovery)	88.24
Howland et al. (2010)	193 college students	Range 21-24 Mean 21.47		No alcohol problems or other substance use, no medical condition No night shifts work, no regnancy, no travel across two or more time zones in the prior month	At least one binge drinking episode (≥ 70 alcohol gr for boys or ≥ 56 for girls) in the past month <u>Alcohol administration</u> : 1.068 g/kg for boys and 0.915 g/kg for girls with cans of beer in one-hour interval. Non-alcoholic beer as placebo condition.	Analyses were controlled for gender and session Alcohol administration versus placebo	Mood	2-week research (alcohol versus placebo) and assessment following beverage administration (morning and afternoon) Profile of Mood States	N/A	Mood was affected the morning after alcohol consumption (BAC of 12%)	Not reported	82.35
Mngoma et al. (2020)	355 youth	Range 14-24 Mean 18.6	100%	N/A	No specific binge drinking criteria	N/A	Anxiety Depression	Brief Symptom Inventory Rosenberg Self-Esteem Scale Social Provisions Scale Substance use	N/A	Suicidal thoughts were associated with depression, anxiety, worthlessness, and binge drinking	No inclusion of women	47.06
Mushquash et al. (2013)	191 women	Mean 19.9	N/A	N/A	Dichotomic alcohol measure: 0: no more than 56 gr in 2 hours 1: more than 56 gr in 2 hours at least once in the past week	N/A Use of structural equation modeling	Depression Mood	4-week research Depression Adjective Checklist Center for Epidemiological Studies Depression Scale	N/A	Depressive symptoms predicted binge drinking over one week but binge drinking did not predict depression.	No inclusion of men	64.71

								Profile of Mood States				
Nourse et al. (2017)	201 college students	Mean 21.1	25.4%	N/A	AUDIT score ≥ 7	N/A	Anxiety Depression	Generalized Anxiety Questionnaire Patient Health Questionnaire AUDIT	N/A	No association between hazardous drinking and depression or anxiety	No inclusion of men Small convenience sample	64.71
Pape & Norström (2016)	2,171 youth people	Range 13-17 Time 1 Mean 14.9	43%	N/A	Frequency of alcohol use and intoxication feelings in the past 12 months	Separate analyses according to age (to consider developmental trajectories) and gender	Anxiety Depression Loneliness (as a control measure at the longitudinal level)	13-year research, 4 assessment times The Hopkins Symptom Check List The Depressive Mood Inventory UCLA Loneliness Scale	N/A	Emotional distress was not associated with binge drinking in early adolescence From adolescence to adulthood (mean age: 16.4 yo to 21.8 yo) and in late adulthood (mean age: from 21.8 yo to 28.3 yo), depression, but not anxiety, was positively associated with binge drinking	Subjectivity related to the binge drinking measure	94.12
Pedersen (2013)	248 college students	Range 18-29 Mean 20.83	37.09%	N/A	Number of binge drinking episodes (≥ 70 alcohol gr for boys or ≥ 56 for girls) in the past month	Separate analyses for men and women. Analyses controlled for class level and employment status	Depressive mood Stress	Behavioral Risk Factor Surveillance System (BRFSS) School stress scale	N/A	In men, binge drinking was positively related to depression In women, the relation between binge drinking and depression was explained by class level (first university year), employment status (higher number of work hours) and school-related stress	Single-item measure of depression	47.01
Rose & Grunsell (2008)	10 BD	Range 18-25 Mean 21.5	50%	No psychiatric or substance use disorder, no current medication No alcohol drinking, caffeine, or fat meal before the experiment	<ul> <li>≥ 80 alcohol gr per week</li> <li>Binge drinking score ≥ 24</li> <li><u>Alcohol administration</u>:</li> <li>0.6 g/kg for boys and 0.5 g/kg for girls with lemonade in a 500 ml solution drank in a 30-minute period. In the control condition, 500 ml of lemonade with drops of ethanol (≤ 5 ml)</li> </ul>	10 non-BD (binge drinking score ≤ 16) Alcohol administration versus placebo	Mood	Visual Analog Scale (alert, content, relaxed, stimulated, lightheaded, and irritable), completed (1) before alcohol drinking and (2) 30 minutes after drinking alcohol	N/A	Ratings of "stimulated" decreased between baseline and post-preload: (1) placebo condition, BD < non-BD (2) alcohol condition, BD > non-BD Ratings of "lightheaded" following alcohol preload, BD < non-BD	Not reported	58.82
Ruiz et al. (2020)	1505 participants	Range 18-30	25%	N/A	Number of binge drinking episodes ( $\geq$ 70 alcohol gr for	Analyses were controlled for the total volume of alcohol consumed and sex	Emotional distress	AUDIT	N/A	Psychological distress: Early drinkers > Late drinkers	Not reported	76.47

		Mean 23.25			boys or $\geq 56$ for girls on one occasion) in the last 12 months Late drinkers (first alcohol use after 15 yo) and early drinkers (first alcohol use before 14 yo)			Alcohol consequences questionnaire Kessler Scale of psychological distress (anxiety, depression, and non-specific distress) Doherty Scale of Emotional Contagion		Significant relationship between psychological distress and negative consequences of alcohol Psychological distress was not associated with binge drinking but with negative consequences of alcohol		
Scaife & Duka (2009)	30 BD	Range 18-29 Mean 20.6	60%	No use of illicit drug or medication 1 week before the experiment, no alcohol drinking 12 hours before the experiment	Binge drinking score > 31 (median split)	30 non-BD (binge drinking score < 31)	Mood	Profile of Mood States	N/A	No significant difference between BD and controls, only a gender effect showed higher arousal in female	Not reported	82.35
Stickley et al. (2014)	4,045 adolescents	Range 13-15	47.4%	N/A	Drinking more than 70 alcohol gr on one occasion at least once in the past month	Analyses controlled for age, parental education, family structure, and depressive symptoms.	Loneliness	Adapted Center for Epidemiological Studies Depression Scale	N/A	Loneliness was associated with binge drinking in the last month among adolescents in the US	Single-item measure of loneliness	64.71
Strine et al. (2008)	217,379 adults	18 or older	N/A	N/A	<ul> <li>≥ 70 alcohol gr for boys and ≥ 56 for girls on one occasion in the past month</li> <li>Heavy drinking: &gt; 28 gr per day for boys and &gt; 14 for girls</li> </ul>	Analyses were adjusted by sex, age, socio-demographic and - economic status	Anxiety and depression	Patient Health Questionnaire Evaluation of smoking habits, height, weight, physical activity, and alcohol consumption	N/A	Adults who presented current depression or had a lifetime history of depression or anxiety exhibited increased smoking, obesity, physical inactivity, binge, and heavy drinking	No information on the causality link between anxiety/ depression and alcohol use	76.47
Townshend & Duka (2005)	38 BD	Range 18-30 Mean 20.9	60.5%	No psychopathological disorder, neurological disorder, or substance use disorder No use of drug, sleeping tablet, hay fever and alcohol prior the experiment	$\geq$ 48 alcohol gr per week Binge drinking score $\geq$ 24	34 non-BD (binge drinking score ≤16)	Mood	Profile of Mood States	N/A	BD had less positive mood	Self-reported alcohol use	88.24
Venerable & Fairbairn (2020)	60 BD	Range 21–28 Mean 22.5	50%	No medical contraindication for alcohol drinking No severe alcohol use disorders,	Drinking at least 2 times/ week, 56 alcohol gr per occasion Number of binge drinking episodes (≥ 70 alcohol gr for	Comparison between alcohol and placebo sessions	Mood	7-day study, 18-month follow-up Self-report mood, anxiety, and alcohol-related stimulation and sedation	N/A	When controlling for baseline drinking, greater negative mood reduction after alcohol drinking predicted drinking problems at follow-up	Less BD compared to non-BD answered at follow-up	76.47

			extreme body mass index, and no pregnant women	boys or $\geq 56$ for girls on one occasion) in the past 30 days <u>Alcohol administration</u> 0.82 g/kg for boys and 0.74 g/kg for girls (mix of cranberry and vodka) served in three equal parts at 0, 12, and 24 min. In the control condition, isovolumic amount of cranberry juice	of ed I	Transdermal sensors (7 days) Mood scale: positive (upbeat, content, happy, euphoric, energized) and negative (nervous, sad, irritated, lonely, bored) mood after alcohol use Short Inventory of Problems		Greater positive mood after alcohol drinking also predicted drinking problems and binge drinking at follow-up		
Wichaidit et al. (2020)	38,186 students	Age range 12-17 45.5% Mean 15.2	N/A	At least one binge drinking episode (≥ 60 alcohol gr for boys and 50 for girls on one occasion) in the past month Analyses were controlled for socio-demographic and - and psychopathology	se Mood	Substance (tobacco, alcohol, illicit drug) and behaviors (gambling, sexual behaviors, gaming, and social media use) Patient Health Questionnaire	N/A	Depressed mood was significantly associated with alcohol drinking in the past year, the past month, and with past-month binge drinking	No information on the causality	64.71
	Emotional ic	lentification of extended	rnal cues							
Carbia et al. (2020)	180 college students at follow-up	Range 18-20 46.67% Mean 18.01	No personal or family history of severe alcohol use disorder, illicit drug use, neurological or psychiatric disorders	Number of binge drinking episodes ( $\geq$ 60 alcohol gr for boys and $\geq$ 40 gr for girls) in the last 3 months Analyses were controlled for cannabis use, tobacco use, and psychopathology	e Emotional memory	2-year research AUDIT Alcohol Timeline Followback Emotional Verbal Learning Test (assessed at follow-up)	Positive, negative, and neutral words	Boys: no significant effect Girls: BD had an emotional memory bias for negative words, lower recall for positive and neutral words, increased false alarms for negative emotional distractors.	Jo neuropsychological assessment at baseline	76.47
Ehlers et al. (2007)	30 BD 59 BD and drug users	Range 18-25 50% Mean 19.91	No psychiatric disorder	At least one binge drinking episode (> 70 alcohol gr) during adolescence; with or without drug consumption 36 non-BD and non-drug user	s Emotional identification	Facial discrimination task (answer to happy or sad faces and do not answer to neutral) EEG recording: event-related potentials (P3a and P3b)	Happy, neutral, and sad faces	Binge drinking + drug use history: decreased P3a latency during the view of all faces Binge drinking and binge drinking + drug use: decreased P3b amplitude during the view of happy faces	Cross-sectional alcohol use data	70.59
Gowin et al. (2020)	177 BD	Range 22–35 72.31% Mean 27.9	No lifetime history of alcohol abuse or dependence	At least one binge drinking episode ( $\geq$ 70 alcohol g for boys or $\geq$ 56 for girls on one occasion) per week in the last year 309 non-BD	Emotional identification	Penn Emotion Recognition Test (happy, sad, angry, scared or neutral emotional faces) fMRI measures: Emotional task (matching of faces with angry, fearful, or neutral emotional expressions)	Emotional facial expressions of happiness, sadness, anger, and fea compared to neutral ones	Machine learning: Emotion processing did not perform better than chance r The best model to identify BD compared to non-BD included social and language processing	Heterogeneity in the BD sample	88.24

Huang et al. (2018)	32 BD	Range 18-30 Mean 23.3	50%	No history of neurological or neuropsychiatric disorder, visual or auditive problem, learning difficulty, left-handed participant No drug or medication use before the study	At least 5 binge drinking episodes ( $\geq$ 84 alcohol gr for boys or $\geq$ 70 for girls within 2- hour) in the last 6 months	32 non-BD (no more than one nge drinking episode in the last 6 months)	Emotional appraisal	Appraisal of emotional images (9-point Likert scale) EEG recording: event-related theta power at frontal, central, and parietal sides	Emotional scenes: negative, positive, erotic, and neutral stimuli	No behavioral difference in the ratings of emotional images. Modulation of event-related theta power (early and later processing): BD < non-BD	Not reported	76.47
Khan et al. (2018)	147 college students	Range 18-23 Mean 19.92	/	No psychiatric disorder (inclusion of moderate depression), illicit substance use, or significant cognitive deficit	At least one binge drinking episode ( $\geq$ 50 alcohol gr for boys or $\geq$ 40 for girls in two hours) in the past month	Analyses were controlled for gender and drinking quantity	Distress tolerance	The Structured Clinical Interview for DSM-IV The Distress Tolerance Scale Timeline Follow back Brief Young Adult Alcohol Consequences Questionnaire Beck Depression Inventory		Appraisal of distress tolerance predicted alcohol-related problems in BD, when controlling for drinking quantity and sex differences. The relationship between alcohol- related problems and distress tolerance, absorption, and regulation was mediated by drinking to cope.	No information on the causality	70.50
Lannoy et al. (2017)	20 BD	Range 18-23 Mean 19.73	45%	No personal or family history of severe alcohol use disorder, psychological, neurological or medical disorders, medication or drug use, normal visual and auditory abilities	Binge drinking score $\ge 16$	non-BD (binge drinking score $\leq 12$ )	Emotional crossmodal identification	Emotional crossmodal task (identification of emotional stimuli of anger and happiness based on facial and vocal processing)	Emotional facial expression of anger and happiness Emotional bursts of anger and happiness	No significant group difference Non-BD were slower than BD for the recognition of emotional faces	Subjective evaluation of alcohol use (drunkenness)	82.35
Lannoy et al. (2018a)	17 BD	Range 18-29 Mean 20.52	58.8%	No personal or family history of severe alcohol use disorder, psychological, neurological or medical disorders, medication or drug use, normal visual and auditory abilities	Binge drinking score ≥ 16, dri ≥ 60 alcohol gr per occasion, ≥ ≤ 3 20 gr per hour, 2-4 times per week	17 non-BD (binge inking score between 1 and 12, 30 alcohol gr per occasion, ≤ 3 times per week) 19 teetotalers	Emotional crossmodal identification	Emotional crossmodal task (identification of emotional stimuli of anger and happiness based on facial and vocal processing) EEG recording	Emotional facial expression of anger and happiness Emotional bursts of anger and happiness	No significant behavioral difference N100 latency, anger: BD > non-BD, teetotalers P3b amplitude, congruent happiness: BD > non-BD, teetotalers in Crossmodal integration for anger in incongruent trials Latency: BD > non-BD, teetotalers Amplitude: BD>non-BD, teetotalers	Small sample size	82.35
Lannoy et al. (2018b)	23 BD	Range 18-27 Mean 20.02	47.8%	No personal or family history of severe alcohol use disorder, psychological, neurological or medical disorder, medication or drug use, normal visual abilities	Binge drinking score $\ge 16$ 23	non-BD (binge drinking score $\leq 12$ )	Emotional recognition	Facial emotional recognition test (morphed stimuli)	Facial emotional expressions of anger, contempt, disgust, fear, happiness, and sadness	Overall emotion recognition: BD < non-BD No specific effects of emotion	Small sample size	82.35

Lannoy et al. (2019)	52 BD	Range 18-27 Mean 21.09	65.4%	No personal or family history of severe alcohol use disorder, or psychiatric disorder	At least one binge drinking episode (> 60 alcohol gr) per month Binge drinking score ≥ 16	42 non-BD (no binge drinking episode in the last year, binge drinking score ≤ 12)	Emotional recognition	Facial emotional recognition test (morphed stimuli)	Facial emotional expressions of anger, contempt, disgust, fear, happiness, and sadness	Recognition of fear and sadness: BD < non-BD These deficits concerned 21.15 and 15.38% of the sample, respectively	Possible influence of impaired participants on the group results	88.24
Leganes- Fonteneau et al. (2019)	48 participants	Students Mean 21.2 Youth Mean 15.4	50%	No psychological or neurological disorder, normal visual abilities	High and low BD: median split on the binge drinking score Students, median score = 15.8 Youth, median score = 8.5	Comparison between high and low BD	Emotional identification	Emotional identification (matching of emotional word with emotional face; congruent or incongruent) Emotional perception threshold	Facial emotional expressions of fear, anger, happiness, surprise, sadness, and disgust	Emotion identification, fear: low BD > high BD Emotional perception Sadness: low BD < high BD Happiness: low BD < high BD	Recruitment of two BD groups that did not have the same consumption patterns	70.59
Maurage et al. (2009)	18 BD at time 2	Mean 18.16	38.9%	No positive family history of severe alcohol use disorder, tobacco or drug use, psychiatric, medical or neurological problem, auditory impairment	Baseline: low alcohol use, no binge drinking episode Time 2: distinction between BD (> 200 alcohol gr per week) and controls	18 non-BD (< 30 alcohol gr per week)	Emotional identification	9-month, two assessments: Emotional valence detection task (auditory stimuli, positive or negative valence) EEG recording: event-related potentials (P1, N2, P3)	The word "paper" pronounced with prosody of anger and happiness	After 9 months, P1, N2, P3 latencies: BD > controls	No comparison between emotional cognitive event-related potentials	82.35
Maurage et al. (2013)	12 BD	Range 19-32 Mean 23.8	58.3%	No positive personal or family history of severe alcohol use disorder, medical, psychiatric, or neurological problem, drug or tobacco use, auditory impairment, left-handedness participant	Consumption of more than 50 alcohol gr per occasion, at least 3 times a week; with consumption speed 20 gr per hour	12 non-BD (< 20 alcohol gr per occasion, < 1 per week, < 10 gr per hour)	Emotional identification	Two-alternative forced choice task (morphed stimuli: fear – anger continuum) fMRI recording, whole brain	Auditory stimuli expressing negative affective bursts related to fear and anger	Behavioral categorization: BD < non-BD Bilateral superior temporal gyrus: BD < non-BD Right middle frontal gyrus: BD > non-BD	Small sample size	82.35

*Note*. All alcohol units have been converted in grams of pure ethanol, according to the number of grams per unit in each country. BD = binge drinkers; AUDIT = Alcohol Use Disorders Identification Test; DSM = Diagnostic and Statistical Manuel of mental disorders; fMRI = functional Magnetic Resonance Imaging; EEG = electroencephalogram; yo = years old.