ALCOHOLISM CLINICAL & EXPERIMENTAL RESEARCH

Disrupted Fear and Sadness Recognition in Binge Drinking: A Combined Group and Individual Approach

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Background: Binge drinking is a harmful pattern of alcohol consumption, associated with cognitive and cerebral impairments. Indeed, various cognitive processes have been identified as disrupted in binge drinking, ranging from perceptive to executive functions, but emotional processes have conversely been little investigated. Particularly, it is unclear to what extent binge drinkers (BD) present difficulties to recognize and categorize the emotions expressed by other individuals. Such an exploration would, however, offer a more comprehensive view of the deficits associated with alcohol-related disorders and potentially involved in the maintenance of this harmful habit.

Methods: Fifty-two BD and 42 control participants performed an emotional task assessing the ability to recognize 6 basic emotions (i.e., anger, contempt, disgust, fear, happiness, and sadness). Accuracy score and detection threshold were collected for each emotion. To explore the extent of emotion recognition difficulties, 2 analyses were conducted: (i) classical repeated measures analyses of variance, to compare groups' performance, and (ii) multiple single-case analyses (i.e., Crawford's *t*-tests), to determine the percentage of BD presenting genuine emotion recognition deficits. Correlations were also performed between alcohol consumption characteristics and emotional recognition scores.

Results: BD presented reduced performance for the recognition of fear and sadness. Multiple single cases highlighted that these deficits respectively concerned 21.15 and 15.38% of the binge drinking sample, and the relation between binge drinking and reduced sadness detection was supported by correlational analyses.

Conclusions: These findings show that binge drinking is associated with a disrupted processing of emotional stimuli. By identifying heterogeneity in the impairments presented by BD, the present results also underline the usefulness of a combined group and individual approach.

Key Words: Emotion, Facial Expression, Alcohol, Analysis of Variance, Multiple Single Cases.

BINGE DRINKING IS a harmful alcohol consumption pattern, widespread among adolescents and young adults. It has been defined as the repeated alternation between alcohol intoxications (i.e., at least 4 [women] or 5 [men] alcohol doses in 2 hours; NIAAA, 2004) and abstinence periods (Courtney and Polich, 2009). Binge drinking has been related to various negative consequences (e.g., physical injuries, sexual assaults; White and Hingson, 2014), but, beyond these short-term issues, a growing interest has been raised regarding the consequences identified at longer term. Especially, it has been proposed that the specific succession of drunkenness and abstinence episodes characterizing this drinking pattern would lead to cognitive and emotional impairments (Stephens and Duka, 2008).

First, the cognitive deficits presented by binge drinkers (BD) have been widely described in the 2 last decades, studies mostly indexing impairments for executive and memory abilities (see Carbia et al., 2018, for a review). The systematic review of Carbia and colleagues (2018) also emphasized the absence of consistent findings in this research field (e.g., some studies highlighting massive impairments, others claiming for more subtle changes or even an absence of difficulty). To target this issue, some studies have attempted to specify the processes underlying the possible impairments (e.g., Bø et al., 2016) while others have emphasized the importance to explore the heterogeneous profiles of BD (Gierski et al., 2017; Lannoy et al., 2017a), which suggests a large interindividual variation of impairments.

Second, compared to cognitive abilities, the investigation of emotional impairments in binge drinking has only emerged quite recently. However, it is now established that emotional impairments play a pivotal role in the

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development and maintenance of severe alcohol use disorders (SAUDs; e.g., Kornreich, 2002; Rupp et al., 2017). It has also been proposed that binge drinking could represent a first step toward SAUDs (Bonomo et al., 2004) and that BD would be characterized by qualitatively similar impairments than patients with SAUDs (Stephens and Duka, 2008). Emotional impairments in binge drinking could thus contribute to maladaptive alcohol use (e.g., Wills et al., 2016); it thus appears central to characterize these early emotional difficulties in binge drinking. To our knowledge, 7 studies have explored the processing of emotional stimuli in binge drinking and only 2 have focused on behavioral performance. A first study explored the emotional cross-modal integration (i.e., multisensorial decoding of emotions) and showed an absence of behavioral difference between BD and matched control participants (CP; Lannoy et al., 2017b). A second study, using a more complex and sensitive task, indicated a globally poorer performance in BD for the decoding of emotional states (Lannoy et al., 2018a). This study assessed the recognition of 6 emotional categories (anger, contempt, disgust, fear, happiness, and sadness) but did not allow highlighting differential impairments across emotion categories in binge drinking. This null result could be explained by a lack of statistical power due to a small sample size (23 BD and 23 controls; Lannoy et al., 2018a) but also potentially by an important heterogeneity regarding emotional performance in BD. At the electrophysiological level, the components associated with the processing of emotional prosody (Maurage et al., 2009), emotional cross-modal integration (Lannoy et al., 2018b), and affective pictures (Connell et al., 2015) were found to be disrupted in binge drinking. The affective modulation of event-related theta oscillations was also reduced in BD during the processing of emotional pictures (Huang et al., 2018). Finally, at the neuroimaging level, results showed that young BD had reduced performance in emotional prosody categorization, related to brain modifications potentially indexing a compensatory activity in cerebral areas usually not involved in emotional processing (Maurage et al., 2013). These preliminary findings thus call for an in-depth exploration of emotional processes in binge drinking. Particularly, research with patients presenting SAUDs highlighted differential findings across emotions and mainly showed deficits for the processing of negative stimuli (D'Hondt et al., 2014). However, in binge drinking, no study explored the variation of the deficit across emotions. Preliminary studies suggested a specific difficulty for the processing of negative stimuli (Connell et al., 2015; Lannoy et al., 2018b; Maurage et al., 2013), while others underlined impairments for both positive and negative valences (Huang et al., 2018; Maurage et al., 2009).

As a whole, the current binge drinking literature suggests that emotional impairments might vary across emotions, but this variation should be further understood, notably because the pattern of emotional deficits might be predictive of specific outcomes (e.g., disrupted processing of anger is related to interpersonal conflicts, while poorer understanding of others' internal states, such as impaired sadness processing, is related to reduced social integration; Rupp et al., 2017). Importantly, as previous studies postulated the presence of a wide heterogeneity in binge drinking profiles (Gierski et al., 2017; Lannoy et al., 2017a) but also in the emotional and interpersonal difficulties presented by patients with SAUDs (Maurage et al., 2017), it remains crucial to explore these processes in BD. Indeed, previous binge drinking studies indicated distinct personality and motivational profiles, but it is unclear whether binge drinking may also be characterized by heterogeneous emotional impairments. This research question can be efficiently investigated by combining group and individual approaches.

The current study thus evaluates the processing of emotional stimuli in binge drinking by using a validated facial emotion recognition test (Gaudelus et al., 2015). Compared to previous ones (e.g., Lannoy et al., 2018a), this study investigates the recognition of 6 basic emotions in a larger sample of college students. Moreover, this research presents 2 main originalities as it: (i) explores the differential deficits across emotions and (ii) takes into account the possible heterogeneity by assessing the interindividual variability in BD. For this purpose, analyses at group and individual levels were combined. Indeed, as this task is characterized by a sufficient difficulty level, it appears suitable to detect subtle deficits with single-case analyses (Crawford and Garthwaite, 2006).

MATERIALS AND METHODS

Participants

BD (n = 57) and CP (n = 48) were recruited from 2 universities (Université catholique de Louvain, Belgium; Université de Reims Champagne-Ardenne, France)[1] and selected according to alcohol consumption criteria: BD had to present a binge drinking score higher than 15 (as proposed in previous studies; e.g., Lannoy et al., 2017c) and to drink more than 6 alcohol doses in 1 occasion (a standard alcohol dose contains 10 g of pure ethanol in both Belgium and France) at least once a month, whereas CP had to present a binge drinking score lower than 13 and to have abstained from ever drinking more than 6 alcohol doses in 1 occasion during the last year. The binge drinking score (Townshend and Duka, 2002) was computed through the following formula: [(4 × consumption speed) + number of drunkenness episodes + (0.2 × percentage of drunkenness episodes)]. Complementarily, the consumption of more than 6 alcohol doses (i.e., a typical binge drinking episode) was evaluated thanks to the third item of the Alcohol Use Disorders Identification Test (AUDIT; Gache et al., 2005), a widely used tool to evaluate the dangerousness of alcohol consumption, as proposed in previous studies (e.g., López-Caneda et al., 2013). The AUDIT total score also allowed qualifying the global alcohol use of the participants. Indeed, all selected participants were alcohol consumers in order to compare alcohol use patterns (low consumption vs. binge drinking) rather than to merely measure the effects of alcohol consumption (vs. abstinence). Participants were all French speakers.

[1]Complementary analyses revealed slight differences between Belgian and French subsamples: (1) Belgian binge drinkers had higher alcohol consumption, and (2) Belgian control participants presented higher depression and state anxiety scores. These differences were not related to emotional performance and did not impact the main results of this study.

They reported no past or present severe alcohol or other substances use (except for tobacco) and no neurological or psychiatric disorders. The second edition of the Beck Depression Inventory (BDI-II; Beck et al., 1996) was used to ensure the absence of clinically significant depressive symptoms (i.e., participants presenting a score higher than 12 did not take part in the experiment) and further compare groups. The State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983) was also used and allowed to confirm that groups did not differ regarding anxiety symptoms. The study was conducted according to the Declaration of Helsinki and approved by: (i) the Psychological Science Research Institute of the Université catholique de Louvain for the Belgian site and (ii) the national regulatory authority (*Comité de Protection des Personnes*; CPP, Dijon) for the French site.

Stimuli and Task

Participants had to perform the facial emotion recognition test validated by Gaudelus and colleagues (2015). This task assessed emotion decoding from 6 emotional categories, namely anger, contempt, disgust, fear, happiness, and sadness. Each emotional face was morphed (from neutral to full-blown emotion) to evaluate both the accuracy score (percentage of correct responses for all stimuli depicting an emotion) and the detection threshold (minimal intensity at which an emotion was constantly detected). In the current research, we used the same design than the one validated by Gaudelus and colleagues (2015) and previously used in binge drinking (See Lannoy et al., 2018a, for more details) to offer reliable comparisons across previous and present studies. The task therefore presented 6 different faces (3 women and 3 men), stimuli being presented in full-screen size and accompanied by a 6-label list (right side) reminding the 6 potential responses.

Data Reduction and Distribution Normality

The detection of outliers regarding emotional recognition performance was conducted. A first general exploration identified participants presenting a general percentage of emotion recognition (i.e., mean score for all emotions) lower than 50%, leading to the exclusion of 1 BD and 1 CP. A second exploration was then conducted in each group and for the 6 emotional categories to identify outliers (i.e., participants with a score lower than 3 standard deviations from the group mean). Four BD were excluded from the analyses, 3 exhibiting aberrant scores for happiness recognition (scores below 55.55%) and 1 for disgust recognition (score of 33.33%). Then, 5 CP were also excluded due to their low scores for disgust recognition (scores below 44.44%). The final sample comprised 94 participants (39 women) aged between 18 and 27 years old ($M = 21.07$, $SD = 2.11$), encompassing 52 BD (18 females) and 42 CP (21 females).

Subsequent explorations were conducted to check the distribution of the emotion recognition data (i.e., main variable of interest), as normality is a required condition to perform the statistical analyses chosen. Normality was assessed using skewness and kurtosis, coefficients that underlined an absence of normality with a left asymmetrical distribution. Before the multivariate analysis, variables were thus square-root-transformed. The distribution of the transformed variables was normal.

Statistical Analyses

Analyses were conducted with IBM SPSS Statistics 25 (group analyses) and with the Singlims program for single-case analyses (Crawford and Howell, 1998). Statistical analyses were conducted in 2 steps and compared emotional recognition in BD and CP. First, group analyses were performed and targeted both accuracy score and detection threshold through repeated measures analyses of variance (ANOVAs). Before the ANOVAs, preliminary Student's *t*-tests were performed to ensure the correct group matching regarding age, gender, depression, and anxiety. Then, analyses were conducted with Group (BD, CP) as between-subjects factors and Emotion (anger, contempt, disgust, fear, happiness, and sadness; square-root-transformed variables) as within-subjects factor. Post hoc *t*-tests were performed to investigate significant main effects or interactions. The significance level was set at 5%. To further understand the relationship between the ability to recognize emotional facial expressions and alcohol consumption pattern, correlations were performed between emotion recognition and the binge drinking score. Eventually, although none of the participants presented clinical depression or anxiety, correlations were computed to discard the potential effects of subclinical depressive and anxiety symptoms on emotion recognition. Second, multiple single-case analyses were conducted on emotion recognition performance. In the same vein than preliminary tests for group analyses, the reliability of the control group had to be supported for single-case analyses. Indeed, to perform reliable comparisons, all the subjects in the control group had to be correctly matched with each BD individually (age, gender, and education level). All the participants selected were young adult university students; BD and CP were therefore comparable on age and education level. However, in order to compare each male BD with a group of males and each female BD with a group of females, control groups for individual analyses were defined according to gender ($n = 21$ men and $n = 21$ women). Two questions were tested at the individual level. First, we evaluated the percentage of BD who present significant impairments. For this purpose, Crawford analyses (i.e., $t = [(\text{mean patient} - \text{mean group})/\text{SD group} \sqrt{((N \text{ group} + 1)/N \text{ group})}]$) were performed (Crawford and Garthwaite, 2005; Crawford et al., 2003) and the significance level was investigated according to 1-tailed *p*-value. Second, based on the results of multiple single-case analyses, we wanted to investigate which participants exhibited significant deficits according to the guidelines proposed by Gaudelus and colleagues (2015).

RESULTS

Sample Description

Groups did not differ for age [$t(92) = 0.38$, $p = 0.706$], gender [$\chi^2(1, N = 94) = 2.27$, $p = 0.132$], depression [BDI-II: $t(92) = 0.28$, $p = 0.783$], and anxiety [STAI-state: $t(91) = 0.04$, $p = 0.969$, and STAI-trait: $t(91) = 0.59$, $p = 0.554$] (see Table 1).

Group Analyses

Descriptive results are shown in Table 2.

Accuracy Score. A main[2] Emotion effect, $F(5, 460) = 118.81$, $p < 0.001$, was found, showing better recognition for happiness than sadness [$t(93) = 7.43$, $p < 0.001$], anger [$t(93) = 9.64$, $p < 0.001$], disgust [$t(93) = 16.74$, $p < 0.001$], and contempt [$t(93) = 16.10$, $p < 0.001$]; for fear than sadness [$t(93) = 6.08$, $p < 0.001$], anger [$t(93) = 8.44$,

[2]When gender was added as a between factor in this analysis, no Gender × Emotion, $F(5, 450) = 1.70$, $p = 0.133$, Group × Gender, $F(1, 90) = 0.14$, $p = 0.708$, or Group × Gender × Emotion, $F(5, 450) = 0.73$, $p = 0.582$, was found. Only a main effect of Gender, $F(1, 90) = 12.91$, $p = 0.001$, showed better emotion recognition in women than men.

Table 1. Demographic and Psychological Measures for BD and CP: Mean (SD)

Variable	BD (n = 52)	CP (n = 42)
Age[a]	21.00 (2.11)	21.17 (2.13)
Gender ratio (female/male)[a]	18/34	21/21
BDI-II[a]	3.99 (3.56)	4.20 (3.88)
State Anxiety Inventory (STAI-A)[a]	29.31 (6.90)	29.38 (9.51)
Trait Anxiety Inventory (STAI-B)[a]	36.55 (8.11)	37.64 (9.66)
AUDIT[b]	16.36 (5.05)	3.07 (2.21)
Binge drinking score[b]	42.23 (22.16)	5.51 (3.37)
Total alcohol units per week[b]	26.23 (16.36)	1.42 (1.90)
Consumption speed (units per hour)[b]	3.23 (0.94)	0.91 (0.53)

[a]Non significant.
[b]$p < 0.001$.

Table 2. Accuracy Score (Percentage of Correct Answers) and Detection Threshold for BD and CP for Each Emotion in the Facial Emotion Recognition Test: Mean (SD)

Experimental variable	BD (n = 52)	CP (n = 42)
Accuracy score		
Anger	73.93 (12.22)	70.63 (17.84)
Contempt	47.22 (17.72)	44.71 (20.16)
Disgust	61.32 (9.20)	60.32 (11.01)
Fear	**85.25 (12.59)**	**89.68 (8.64)**
Happiness	92.09 (10.85)	88.36 (13.43)
Sadness	**71.15 (17.08)**	**78.31 (14.30)**
Total	71.83 (6.05)	72.00 (7.09)
Detection threshold		
Anger	47.12 (15.76)	53.69 (19.66)
Contempt	68.75 (11.79)	66.10 (13.53)
Disgust	55.19 (8.85)	56.90 (10.82)
Fear	36.15 (13.05)	33.57 (11.70)
Happiness	29.71 (10.07)	32.74 (12.06)
Sadness	**50.77 (15.86)**	**43.33 (13.91)**
Total	47.95 (5.31)	47.63 (6.36)

Significant group differences are highlighted in bold.

$p < 0.001$], disgust [$t(93) = 17.14$, $p < 0.001$], and contempt [$t(93) = 15.41$, $p < 0.001$]; for sadness than disgust [$t(93) = 6.31$, $p < 0.001$] and contempt [$t(93) = 10.02$, $p < 0.001$]; and for disgust than contempt [$t(93) = 6.59$, $p < 0.001$]. In summary, happiness and fear did not significantly differ and were better recognized than sadness, anger, disgust, and contempt, respectively. This main effect was qualified by a Group × Emotion interaction, $F(5, 460) = 2.36$, $p = 0.039$. Post hoc comparisons showed that BD exhibited poorer sadness [$t(91) = 2.19$, $p = 0.026$] and fear [$t(88) = 2.06$, $p = 0.041$] recognition, but no group differences emerged for other emotional contents (all $t \leq 1.49$, all $p \geq 0.140$). There was no main Group effect, $F(1, 92) = 0.05$, $p = 0.819$.

Detection Threshold. A main Emotion effect, $F(5, 455) = 99.44$, $p < 0.001$, was observed, showing that happiness was associated with lower detection thresholds than fear [$t(93) = 2.45$, $p = 0.016$], sadness [$t(93) = 8.61$, $p < 0.001$], anger [$t(93) = 9.02$, $p < 0.001$], disgust [$t(93) = 16.30$, $p < 0.001$], and contempt [$t(93) = 21.09$, $p < 0.001$]; fear was associated with lower thresholds than sadness [$t(93) = 6.29$, $p < 0.001$], anger [$t(93) = 7.95$, $p < 0.001$], disgust [$t(93) = 13.58$, $p < 0.001$], and contempt [$t(93) = 19.36$, $p < 0.001$]; sadness was associated with lower detection thresholds than disgust [$t(93) = 4.85$, $p < 0.001$] and contempt [$t(93) = 9.55$, $p < 0.001$]; anger was associated with lower thresholds than disgust [$t(93) = 3.30$, $p = 0.001$] and contempt [$t(93) = 7.64$, $p < 0.001$]; and disgust was associated with lower detection thresholds than contempt [$t(93) = 7.33$, $p < 0.001$]. In summary, detection thresholds were lower for happiness than for fear, sadness, anger, disgust, and contempt, without significant differences between sadness and anger. The main Emotion effect was also qualified by a Group × Emotion interaction, $F(5, 455) = 2.74$, $p = 0.019$. Post hoc comparisons showed that BD needed higher detection thresholds for sadness [$t(92) = 2.33$, $p = 0.022$] and no group differences were found for other emotional states (all $t \leq 1.61$, all $p \geq 0.110$). There was no main effect of Group, $F(1, 92) = 0.07$, $p = 0.792$.

Correlational Analyses

Correlations between binge drinking score and emotional recognition were performed among the whole sample and showed a negative association between binge drinking score and sadness recognition ($r = -0.23$, $p = 0.018$). Surprisingly, a positive relation was also found with happiness recognition ($r = 0.24$, $p = 0.020$). No other relationships were observed (all $r \leq 0.12$, all $p \geq 0.256$).

Regarding the potential influence of depressive and anxious symptoms, results showed no significant relationship between BDI-II score and percentage of correct recognition for all emotional categories (all $r \leq 0.10$, all $p \geq 0.365$). This lack of association was also observed for trait (all $r \leq 0.08$, all $p \geq 0.455$) and state (all $r \leq -0.21$, all $p \geq 0.056$) anxiety.

Individual Analyses on Accuracy Score

Percentage of Individuals Presenting Impairments. Compared to a control group, no BD presented impairments for the recognition of anger; 5.77% had difficulties to detect contempt; none presented impairments for the recognition of disgust; and 21.15% had difficulties to detect fear, 3.85% to detect happiness, and 15.38% to detect sadness (Fig. 1).

Presence of Significant Deficit Compared to Task Norms. In the validation study of the facial emotion recognition test, Gaudelus and colleagues (2015) showed that scores below than 61.58 indicated clinical impairments. Accordingly, among the participants identified as impaired in single-case analyses, 9 (out of eleven) presented a clinical deficit for fear recognition (scores ≤55.55), and all presented a clinical deficit for sadness recognition (all scores ≤55.55).

DISCUSSION

The processing of emotional stimuli has been identified as a key factor in the persistence of alcohol-related disorders,

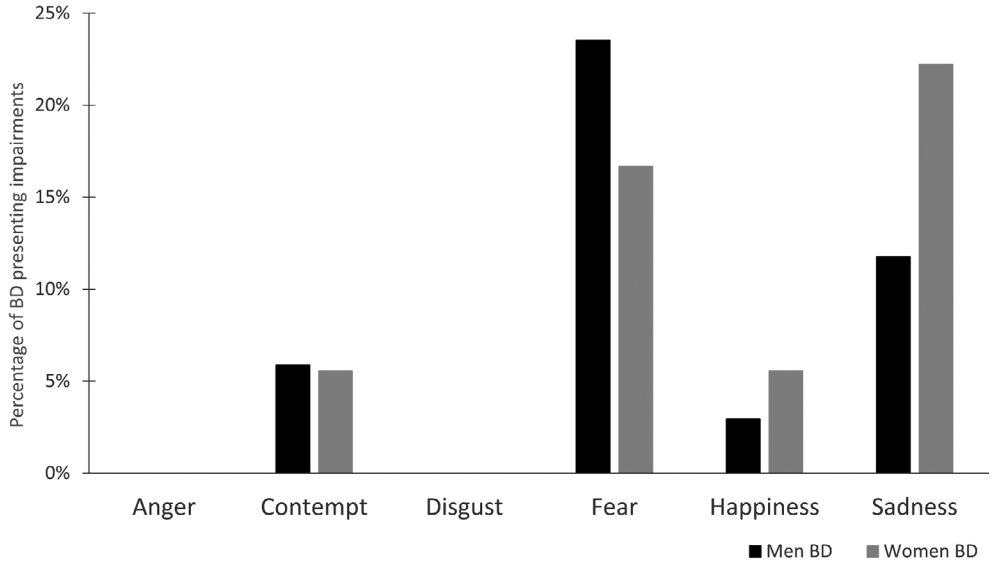

Fig. 1. Percentage of BD presenting impairments for emotional recognition. This figure depicts results from the single-case analyses (Crawford's *t*-tests), separately for men (in **black**) and women (in **gray**) and according to the emotional content (anger, contempt, disgust, fear, happiness, and sadness).

and preliminary studies in binge drinking have supported the importance of these processes. Nevertheless, previous studies presented 2 main limitations, as: (i) they did not explore the differential deficits across emotions; (ii) they did not measure the interindividual variability across BD. The current study evaluated the ability to recognize basic emotional contents in binge drinking. For this purpose, we selected participants with an intense and frequent binge drinking pattern (as reported in Table 1 and compared to previous studies; e.g., Cohen-Gilbert et al., 2017; Connell et al., 2015) and contrasted them to a control group.

On the one hand, analyses conducted at the group level show that BD have reduced abilities to recognize emotional expressions compared to CP. This result is consistent with previous studies (Lannoy et al., 2018a) but specifically emphasizes that BD have lower performance for the processing of facial expressions depicting fear and sadness. First, it has been suggested that amygdala lesions may lead to impaired fear processing (Morris et al., 1998) and this proposal has been supported in SAUDs (e.g., Donadon and Osório, 2017; O'daly et al., 2012; Salloum et al., 2007; Townshend and Duka, 2003). In binge drinking, amygdala dysfunctions have also been observed (Stephens and Duka, 2008; Xiao et al., 2013) and some studies reported impairments in fear processing in preclinical (Stephens et al., 2005) and human (Herman et al., 2018) studies. The current results are thus in line with previous ones (Herman et al., 2018; Stephens et al., 2005) by showing that BD have difficulties to recognize fearful facial expressions. Importantly, the processing of fear is identified as fundamental in the widely known dichotomy between approach and avoidance behaviors (Marsh et al., 2005). Fear indeed allows informing about the presence of threat in the environment and is related to the ability to correctly anticipate dangers and implement protective strategies. Accordingly, disrupted fear detection in others might lead to interpersonal problems and might be involved in excessive alcohol consumption (Donadon and Osório, 2017). Second, this study is the first to underline impairments in the emotional recognition of sadness in binge drinking, and this result is observed in comparison with a control group matched regarding psychopathological variables. In view of the existing literature considering SAUDs, mainly showing that, when controlled for depression, patients did not present difficulties to recognize sadness (e.g., Quaglino et al., 2015), this impairment in BD may appear puzzling. However, it has been shown that the recognition of sadness was associated with decreased brain activations in the anterior cingulate cortex in patients presenting SAUDs (Salloum et al., 2007). The anterior cingulate cortex is related to both emotional and cognitive brain systems (Stevens, 2011). It is involved in affect regulation and performance-monitoring abilities, notably the capacity to adjust (i.e., slow down) after errors (Stevens, 2011), which has also been related to binge drinking (Bø et al., 2016). Interestingly, whereas impaired sadness processing has not been indexed in binge drinking, disrupted activations of the anterior cingulate cortex were reported (see Cservenka and Brumback, 2017, for a review) and decreased activations were observed when negative emotional images were presented during an inhibition task (Cohen-Gilbert et al., 2017). Moreover, the investigation of structural differences showed reduced cortical thickness in the anterior cingulate cortex among BD (compared to light drinkers), and this difference was particularly related to drinking intensity and frequency (Mashhoon et al., 2014). Nevertheless, although some brain modifications have been indexed in binge drinking (e.g., Courtney

and Polich, 2010), no study currently allows supporting that impairments of the anterior cingulate cortex are specifically related to binge drinking or to a poor sadness recognition. This result thus extends the interest to investigate distinct emotional categories in binge drinking and should be further explored in future studies. Eventually, the group difference observed for sadness processing is supported by correlational analyses, showing that higher binge drinking score is related to poor recognition of sad facial expressions in the whole sample. This result also suggests that the difficulty to recognize facial emotional expressions is related to binge drinking intensity.

On the other hand, analyses conducted at the individual level offer further support to the proposal that the deficits observed in BD are mainly related to the processing of fear and sadness facial expressions. However, it also underlines that these difficulties are only generalizable to a subgroup of BD. Actually, the analysis developed by Crawford and Howell (1998) is specifically dedicated to the identification of clinical difficulties in individuals compared to a control group. In the same vein, the facial emotion recognition test used in this study has been validated for clinical use and thus offers cutoff scores for the identification of impairments (Gaudelus et al., 2015). Accordingly, it can be reliably proposed that BD have difficulties to recognize emotional facial expressions of fear and sadness compared to controls, but that only a subsample of BD presents a genuine deficit. Beyond the difficulties identified for the facial expressions of fear and sadness, individual analyses show that some BD present an impaired processing of contempt faces while others present an impaired processing of happiness faces. Importantly, individual analyses strongly support the existence of binge drinking heterogeneity in emotional performance, in line with studies in SAUDs (Maurage et al., 2017). Multiple single-case analyses also allow better considering the impairments in alcohol-related disorders, by taking into account the proportion of BD presenting genuine impairments for the processing of emotional stimuli and, therefore, qualitatively similar deficits compared to patients with SAUDs. Indeed, these findings show that the widely described similarities between binge drinking and SAUDs concern a subgroup of participants. Finally, the comparison with the norms established for the task used leads to the proposal that this subgroup of BD exhibits clinical deficit for emotion recognition. Therefore, it remains crucial to further investigate the presence of deficits in binge drinking and explore whether and how binge drinking may precipitate more chronic alcohol-related disorders.

Altogether, some limitations of the present study have to be acknowledged. First of all, the current sample is exclusively composed of university students, thus limiting potential generalization to other social groups. Moreover, although the diversification of the sample (composed of Belgian and French participants) constitutes a strength of the present study and while it does not influence the results of group and individual analyses, some differences were observed between the Belgian and French subsamples. Future studies should thus extend representativeness of their binge drinker groups and select participants from several countries but also carefully ensure that these samples are correctly matched. Second, alcohol consumption measures were based on retrospective self-reported measures, raising the possibility of recall or estimation errors. Third, to prevent the potential confounding effect of depressive symptoms (Yoon et al., 2016), we decided to exclude participants with high BDI-II scores, which may lead to reduce the sample representativeness. Besides, whereas we ensured the absence of outliers in each group before performing group comparisons, we cannot rule out that the mean scores for the recognition of fear and sadness facial expressions in BD were driven by the subsample of participants presenting genuine deficits. Finally, correlations analyses indicated a positive association between binge drinking and happiness recognition. This result appears surprising but should be further explored as it was not supported, neither by group nor by individual analyses.

Importantly, the current study also has several implications and leads to critical perspectives. Indeed, using multiple single-case analyses, this study is the first to show, beyond the heterogeneity of BD profiles regarding motivational or cognitive factors, the heterogeneity of impairments for the processing of emotional stimuli in binge drinking. Therefore, these results underline the need to combine group and individual analyses (Nickels et al., 2011), notably in emotion research (Leiva et al., 2017), to offer a complete understanding of the deficits associated with binge drinking. In particular, this study is the first to show the existence of differential findings across emotions, as previous research evaluating this question in binge drinking only highlighted a group effect (Lannoy et al., 2018a). In the current approach, combining analyses at group and individual levels, results indeed indicate that BD have specific difficulties for the recognition of fear and sadness facial expressions but also that BD do not present impairments for some emotional categories (i.e., anger and disgust). This is important as anger-processing deficits were identified as a central feature in SAUDs (see Bora and Zorlu, 2017; for a meta-analysis) and as this proposal had obtained preliminary empirical support in binge drinking through identification tasks (i.e., requiring the ability to identify, as quickly as possible, the emotional content presented among 2 categories; Lannoy et al., 2018b; Maurage et al., 2013). The current results thus reinforce the need to largely open this research field in binge drinking, but also call for direct comparisons between BD and SAUDs patients (i.e., to identify the differences and similarities in these 2 consumption patterns) and longitudinal data (e.g., to explore whether the duration or changes in alcohol consumption may be related to differences in the ability to recognize emotions). To go further in this research line, future works should also explore whether alcohol consumption may be related to this heterogeneity of impairments. Indeed, in view of the lack of

studies targeting emotional processing in binge drinking, this research was designed to perform matched comparisons and therefore recruited participants accordingly (e.g., no difference for age, gender, psychopathological symptoms, and selection of specific alcohol consumption patterns with sufficient intensity and frequency), limiting the possibility to compare impaired and nonimpaired BD on these variables. Future studies should thus take into account various binge drinking subpatterns, carefully evaluate the possible presence of SAUDs, and consider the influence of psychopathological symptoms to deepen this question. In line with recent studies (Gierski et al., 2017; Lannoy et al., 2017a), the psychological factors potentially related to this heterogeneity (e.g., personality traits and impulsivity) could also be investigated by cluster analyses. Finally, subsequent studies should more comprehensively explore the difficulties that BD have in processing sadness and fear, and beyond the presentation of facial expressions, by combining behavioral and neuroimaging measures.

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CONFLICTS OF INTEREST

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