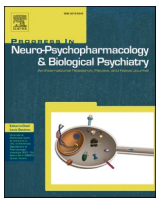
Progress in Neuropsychopharmacology & Biological Psychiatry 136 (2025) 111138



Contents lists available at ScienceDirect

Progress in Neuropsychopharmacology & Biological Psychiatry

journal homepage: www.elsevier.com/locate/pnp



Emotional processing in binge drinking, tobacco use disorder and their comorbidity in youth: A preregistered PRISMA scoping review

Elisa Martini [a], Sorenza Semeraro [a], Séverine Lannoy [b], Pierre Maurage [a,*]

[a] Louvain Experimental Psychopathology research group (LEP), Psychological Science Research Institute, UCLouvain, Louvain-la-Neuve, Belgium
[b] Virginia Institute for Psychiatric and Behavioral Genetics, Virginia Commonwealth University, Richmond, VA, USA

ARTICLE INFO

Keywords:
Alcohol
Tobacco smoking
Emotional appraisal/identification
Emotional response
Emotional regulation

ABSTRACT

Background: Binge drinking (BD) and tobacco use disorder (TUD) are prevalent among youth, with significant social and health implications. However, research into the emotional impairments associated with BD and TUD during adolescence is sparse and lacks integration within a comprehensive model of emotional processes. Moreover, the impact of comorbid BD and TUD on emotional deficits remains largely unexplored. We propose the first review focused on the variation of emotional deficits in BD, TUD, or their comorbidity among adolescents and we systematically explore differences across various emotional abilities.

Methods: Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews guidelines (PRISMA-ScR), we conducted a preregistered review of existing literature on emotional processing impairments in BD and/or TUD among adolescents. From 481 papers initially identified, 7 were included in this review. Additionally, we proposed experimental avenues for future research based on identified shortcomings in current literature.

Results: Our scoping review indicates that emotional deficits are likely prevalent in both BD and TUD populations, affecting emotional appraisal/identification, response, and regulation. However, further investigation is necessary to ascertain the magnitude and scope of these deficits in adolescents and adults, as well as to delineate the distinct or combined influence of BD and TUD on emotional disturbances.

Conclusion: While some emotional deficits are apparent, we contend that examining emotional deficits in BD and TUD separately, as well as together, would offer a more comprehensive understanding of their nature and inform the development of novel treatment strategies.

1. Introduction

Binge drinking (BD) and tobacco use disorder (TUD) are highly prevalent among adolescents (Bierhoff et al., 2019; DeBaker et al., 2020; Gubner et al., 2016) and often co-occur (Grant et al., 2015), increasing health, neurocognitive and social risks (Edkins et al., 2017; Locker et al., 2016; VanderVeen et al., 2013). Such comorbidity between BD and TUD might also be associated with emotional impairments (Carbia et al., 2018; Conti et al., 2019; Lannoy et al., 2019), but these abilities remain poorly investigated. BD is an alcohol consumption pattern characterized by the alternation between acute intoxications (leading to an alcohol blood concentration of 0.08 g/dl or more, NIAAA, 2016) and withdrawal periods (Maurage et al., 2020a). BD, being responsible for around half of alcohol-related deaths (Gubner et al., 2016), is highly prevalent among adolescents and young adults (Lannoy et al., 2021). The psychological (e.g., impulsivity) and interpersonal (e.g., peer pressure) BD risk factors are well-established (Laghi et al., 2018; Locker et al., 2016). The brain modifications occurring during adolescence may also constitute a risk factor (Lannoy and Sullivan, 2021; van Duijvenvoorde et al., 2016), as the maturation imbalance between motivational and control systems favors reward sensitivity and risk-taking behaviors (Carbia et al., 2018; Maurage et al., 2020a). Moreover, BD habits generate cerebral and cognitive impairments that can initiate a vicious circle promoting the emergence of severe alcohol use disorder (Carbia et al., 2018; Lannoy et al., 2019). As a whole, despite not being classified as a specific alcohol-related disorder in the current nosographies, BD constitutes a major societal issue, particularly among youth. TUD is an uncontrolled pattern of tobacco use leading to clinically significant impairment (e.g., withdrawal symptoms, distress; McClernon and Kollins, 2008; American Psychiatric Association, 2013) and constituting the major cause of

* Corresponding author at: UCLouvain, Faculté de Psychologie, Place du Cardinal Mercier, 10, B-1348 Louvain-la-Neuve, Belgium.
E-mail address: pierre.maurage@uclouvain.be (P. Maurage).

https://doi.org/10.1016/j.pnpbp.2024.111138
Received 22 June 2024; Received in revised form 5 September 2024; Accepted 5 September 2024
Available online 11 September 2024
0278-5846/© 2024 Elsevier Inc. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

preventable death worldwide (Gubner et al., 2016). Among TUD predictors, heightened impulsivity during adolescence plays an important role (Trinidad and Johnson, 2002). Nicotine, the main psychoactive component contained in smoked tobacco, is a performance-enhancing drug (Feduccia et al., 2012) largely affecting cognition (e.g., sensory, psychomotor, attentional, and executive functions; Feduccia et al., 2012; Kumari et al., 2003). Because of its harmful effects on the brain and body, TUD represents a major societal issue in youth.

BD and TUD often co-occur (DeBaker et al., 2020; Edkins et al., 2017; Locker et al., 2016; VanderVeen et al., 2013): 20 % of smokers engage in heavy/binge drinking and heavy drinkers are 2–3 times more likely to smoke than non-heavy drinkers (Grant et al., 2015). This may be explained by brain changes during adolescence (van Duijvenvoorde et al., 2016), generating increased sensitivity to drugs rewarding effects (Zilverstand et al., 2018): exposure to one drug promotes the use of the other, due to a bidirectional cross-sensitization (DeBaker et al., 2020; Edkins et al., 2017; Gubner et al., 2016; Locker et al., 2016; VanderVeen et al., 2013). This complex interdependence is influenced by social but also pharmacological factors (Gubner et al., 2016; Locker et al., 2016), alcohol and nicotine both stimulating the brain reward system (Locker et al., 2016).

Many studies have explored BD and TUD effects on cognition (Carbia et al., 2018; Conti et al., 2019; Lannoy et al., 2019), suggesting that their joint presence accelerates cognitive decline (Hagger-Johnson et al., 2013). Conversely, research on emotions remains scarce and not integrated in a model of emotional processing (Lannoy et al., 2018; McKee et al., 2020). This limit hampers the development of theoretically-grounded exploration of emotional processes in BD and TUD, despite their key importance in the onset and maintenance of these disorders. Indeed, the efficient management of one's emotions is a protective factor against addictions (Leite et al., 2019). The inability to express and regulate emotions is correlated with substance abuse onset (Leite et al., 2019; Trinidad and Johnson, 2002). Conversely, adaptive emotional regulation is a protective factor against substance use (Kun and Demetrovics, 2010; Leite et al., 2019). Substance abuse is thus frequently conceptualized as a self-medication attempt to cope with intense negative feelings (Kun and Demetrovics, 2010), underlining the influence of emotions in the onset of addiction. However, evidence on emotional impairments mainly comes from studies exploring BD or TUD separately (without considering their joint influence) and focusing on young adults (Lannoy et al., 2021). Despite adolescence constitutes a specific vulnerability period for both addictive and emotional disorders, the exploration of emotional deficits related to BD/TUD in this age range (i.e., 12–18 years old) is currently based on a few scattered studies.

Our main aim was thus twofold: (1) offering the first scoping review of the available data supporting the presence of emotional processing deficits in BD, TUD, and their comorbidity in adolescence, to propose a clear description of the current knowledge regarding their distinct and joint influence on each emotional subcomponent. The first research question our review addressed was thus "What are the current evidence regarding the emotional impairments presented by adolescents with BD and/or TUD?"; (2) outlining innovative research avenues to move the field forward in the exploration of emotional deficits. The second research question tackled by our paper was thus: "What are the most relevant directions that future studies should follow to deepen our understanding of emotional impairments in BD and TUD?". Importantly, a key strength of this review is its theory-based approach, which organizes data according to the emotional subcomponents outlined by Phillips et al. (2003). This framework (Fig. 1, left part), which has received empirical support (Lannoy et al., 2021; Pessoa, 2017), identifies three emotional processes: (1) *Emotional appraisal/identification*, involving to detect and process the emotional significance of a stimulus, whether internal (e.g., self-emotional states) or external (e.g., situations or others' emotional expressions). This process is typically assessed through self-report questionnaires or tasks measuring the ability to recognize emotionally salient stimuli; (2) *Emotional response*, referring to the generation of a specific affective state in reaction to an emotional stimulus or situation. This stage includes cognitive, physiological, and behavioral responses, as well as conscious emotional experiences. It is often studied using paradigms that induce affective states (e.g., mood induction, fear conditioning) and measure the participant's resulting emotional response; (3) *Emotional regulation*, involving to manage affective state and emotional behavior, through the modulation/inhibition of emotional appraisal and/or response. This process is explored through self-reported questionnaires and tasks that require participants to control or modulate their responses to emotional stimuli.

2. Methods

2.1. Search strategy and article selection (Table 1)

This systematic review follows the guidelines of Preferred Reporting items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR; Tricco et al., 2018). We consulted two databases (27th March 2024), PubMed and Scopus. We preregistered the complete protocol at OSF (registration doi: 10.17605/OSF.IO/GK28Z). The following key terms were used: "tobacco use disorder", "nicotine consumption", "nicotine/tobacco smoking", "binge drinking" together with "emotional appraisal", "emotional identification", "emotional response", "emotions regulation", "emotional processing", "emotions"

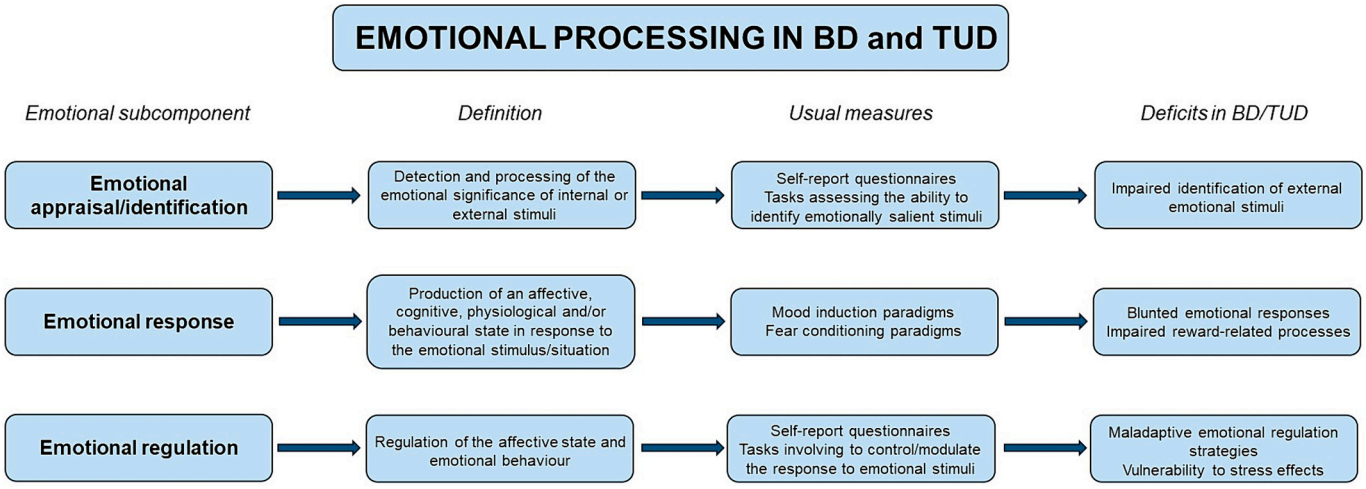


Fig. 1. Emotional processing subcomponents and their related deficits in binge drinking (BD) and tobacco use disorder (TUD).

Table 1
Inclusion criteria for the selected studies

1. Articles must be in English or French.
2. Articles must be empirical studies (i.e., presenting original data).
3. Articles must be human studies.
4. Participants must be 12–18 years old.
5. Participants must be binge drinkers and/or tobacco smokers. If they consume other substances, alcohol and/or tobacco must be the main substances of use.
6. Articles must explore the relationship between binge drinking and/or tobacco smoking and emotional processing abilities.
7. Articles must mainly aim at examining the effects of binge drinking and/or tobacco on emotional abilities or, when other substance use groups are included, their experimental design must allow to isolate the specific effects of binge drinking and tobacco smoking.

and "adolescents", "youth". The full search algorithm was as follows: PubMed [("emotional appraisal" OR "emotional identification" OR "emotional regulation" OR "emotion* processing" OR "emotional response" OR "emotions") AND (("tobacco use disorder" OR "tobacco" OR "nicotine" OR "Tobacco smoking") OR ("binge drinking")) AND ("adolescents" OR "youth")] / Scopus: [(emotional AND appraisal OR emotional AND identification OR emotional AND response OR emotional AND regulation OR emotional AND processing OR emotions) AND ((tobacco AND use AND disorder OR tobacco OR nicotine OR tobacco AND smoking) AND (binge AND drinking)) AND (LIMIT-TO (SUBJAREA, "PSYC") OR LIMIT-TO (SUBJAREA, "NEUR")) AND (LIMIT-TO (EXACTKEYWORD, "Humans") OR LIMIT-TO (EXACTKEYWORD, "Human")) AND (LIMIT-TO (LANGUAGE, "English") OR LIMIT-TO (LANGUAGE, "French"))]. Two authors (EM and SS), working independently, selected the articles at each stage of the review by using Rayyan systematic review software (2022). Authors resolved disagreements through discussion and consensus. Among the 481 papers identified, the authors selected seven publications. Following the PRISMA-ScR guidelines, two authors (EM and SS) extracted data in tables independently. In order to determine papers' inclusion criteria, we referred to the PICOS procedure (Liberati et al., 2009) as follows: (1) Regarding the *Population*, only studies focusing on human adolescents (12–18 years old) were included, as this period is related to specific cerebral (i.e., differential maturation between impulsive and control brain systems), cognitive (i.e., greater reward sensitivity) and behavioral (i.e., increased risk-taking conducts) vulnerabilities towards BD/TUD; (2) Regarding the *Intervention*, studies were considered if they included a validated measure of binge drinking and/or of tobacco consumption. Additionally, this measure had to be included as a main variable in the analyses. However, not all the studies included a formal diagnosis of BD and TUD; (3) Regarding the *Comparator*, studies were considered if they offered a direct comparison between an experimental group of binge drinkers and/or tobacco smokers and a matched control group, that did not consume tobacco, alcohol, or any kind of drugs, or a group with lower/higher consumption rates; (4) Regarding the *Outcome*, studies were included if they explored the relationship between BD and/or TUD and emotional processing abilities as a dependent variable. When the effects of other substance use are included, the study design must allow to isolate the specific effects of BD and/or of tobacco smoking; (5) Regarding the *Setting*, studies were included when proposing comparisons between groups or experimental conditions (i.e., interventional, observational, cross-sectional), thus excluding single-case studies and studies without experimental data.

2.2. Selection process

We identified 502 articles through database search. We exported the articles to Rayyan to eliminate duplicates ($N = 21$). Screening of titles and abstracts led to the identification of 9 articles fulfilling our inclusion criteria. The main reasons for exclusion at the phase of "title/abstract reading" was the absence of original data ($N = 185$), the investigation of other topics (i.e., "no Emotional processing") ($N = 164$), the absence of a valid measure of BD and/or TUD ($N = 93$). After the "full text reading" phase, seven articles were found to meet the inclusion criteria and 2 studies were excluded (Fig. 2).

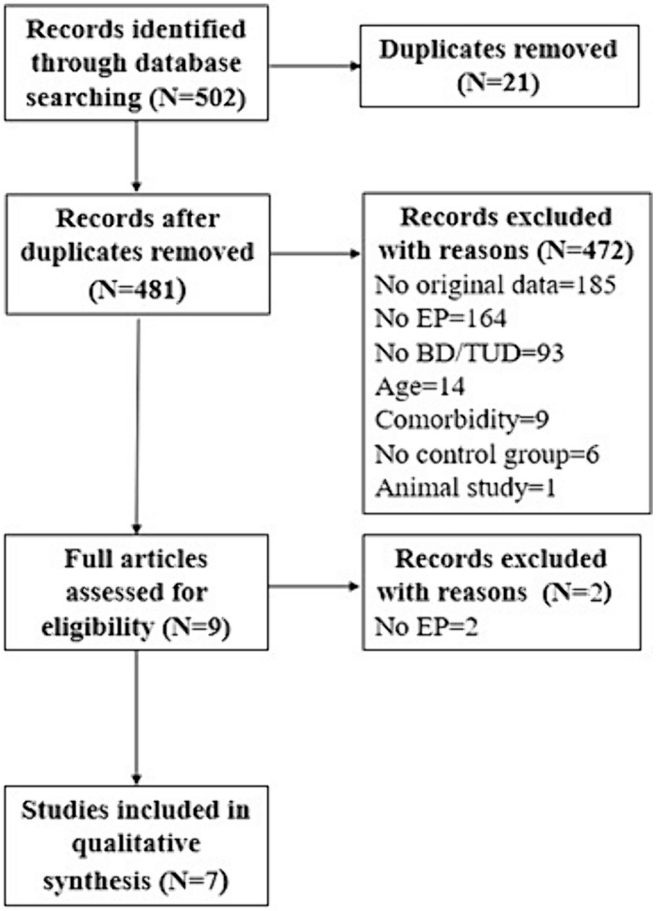


Fig. 2. PRISMA flow diagram showing the selection process of the included articles.

3. Results

3.1. Characteristics of the studies

Although publication date did not constitute an inclusion criterion during article selection, all the included studies were published after 2006, with 57 % published after 2015. This highlights that the interest in this topic is quite recent. Moreover, 28.5 % of the selected studies investigated emotional processing impairments related to BD, 28.5 % investigated emotional processing impairments related to TUD, and 43 % investigated emotional processing impairments related to both BD and TUD. Regarding specific emotional processing subcomponents, emotion regulation was the most investigated (71 %), followed by emotion appraisal/identification (57 %) and emotional response (14 %). Among the seven studies, three (43 %) explored emotional processing impairments related to more than one subcomponent. Studies were conducted in Europe (57 %) or North America (43 %). The main

characteristics of each study are summarized in Table 2.

3.2. Quality assessment

There is currently no gold-standard tool for assessing cross-sectional studies (Sanderson et al., 2007; Zeng et al., 2015). Therefore, we have decided to evaluate the methodological quality of each reviewed study using an adapted version of the quality assessment tool for observational cohort and cross-sectional studies, developed by the National Heart, Lung and Blood Institute (NHLBI, 2014). This scale appears as the most appropriate for our purpose since it has been recently used in systematic reviews on similar topics (e.g., Carbia et al., 2018; Maurage et al., 2021). To properly evaluate the studies included in the current paper, four items of the original scale have been removed from the evaluation scale.[1] The final assessment scale thus comprised 10 items with a binary answer (Yes/No), leading to a raw rating between 0 and 10. For each study, we computed a score (i.e., percentage of items with a "Yes" answer), leading to a global quality rating that allowed papers' classification as "poor" for scores below 50 %, "fair" for scores between 50 and 69 %, "good" for scores between 70 % and 79 %, and "strong" for scores of 80 % and beyond (adapted from Black et al., 2017). According to our rating (Table 3), most of the studies were rated as "fair" (71 %) and 29 % as "good". Therefore, the mean rating of the studies included in the current paper is "fair". It is important to mention that, since the original scale was modified to meet the requirements of this paper, our assessment of methodological quality was based on the specific information provided in each study. Consequently, this evaluation may reflect the quality of the methodological description rather than the actual methodological quality of the paper itself.

3.3. Emotional processing deficits in BD and TUD (Fig. 1, right part)

As mentioned above, for the sake of clarity, we have decided to categorize data from existing evidence following the terminology and subcomponents of the theoretical framework proposed by Phillips et al. (2003), distinguishing emotional appraisal/identification, emotional response and emotional regulation (Fig. 1, left part). The use of this framework to review existing evidence will also be useful to discuss and integrate further research avenues.

- Emotional processing deficits in BD: Regarding *emotional appraisal/identification*, results show that adolescents who engage in BD, compared to adolescents who do not, are more biased towards negative emotions (Ernst et al., 2010; Leganes-Fonteneau et al., 2020). In fact, BDs display better recognition of anger than non-users, suggesting that alcohol consumption may turn into a vulnerability characterized by an affective bias towards negative emotions (Ernst et al., 2010). However, according to Leganes-Fonteneau et al. (2020), high binge drinkers have more difficulty detecting fearful traits compared to low binge drinkers, show a blunted detection of positive emotions, and exhibit an increased detection of sad ones (Leganes-Fonteneau et al., 2020). These findings collectively suggest that BD correlates with biases towards negative emotions among adolescents. However, evidence is scarce regarding which specific emotions are more impacted. Furthermore, adolescents with higher levels of attention to their own emotions report higher levels of alcohol use. In contrast, those with better abilities to discriminate between different moods and emotions, as well as adolescents with higher abilities to perceive others' emotions, present lower probabilities of consuming alcohol (González Yubero et al., 2019). Regarding *emotional response*, we did not identify any study examining the relationship between BD and emotional response in adolescents. Finally, regarding *emotion regulation*, existing evidence suggests that higher levels of drunkenness are associated with low emotional control (García-Moya et al., 2017; Wills et al., 2011), particularly among adolescents who present a parent-child relationship of low quality and whose peers engage in heavy drinking (García-Moya et al., 2017). Furthermore, adolescents with a higher level of emotional repair tend to report lower probabilities of consuming alcohol and, when they do, exhibit lower intensities of consumption (González Yubero et al., 2019). Therefore, as a whole, available studies suggest that emotional impairments might be widespread in BD, but current evidence is still limited and scattered to allow drawing clear conclusions.

- Emotional processing deficits in TUD: Research in tobacco use disorder (TUD) highlights the impact of emotional processes on smoking behaviors. First, regarding *emotional appraisal/identification*, non-smokers show more errors in recognizing angry faces compared to adolescents with TUD (Ernst et al., 2010). Additionally, adolescents with heightened emotional attention are more likely to use tobacco, as well as those with lower emotion perception skills that also exhibit higher tobacco use probabilities (González-Yubero et al., 2020). Furthermore, regarding *emotional response*, Piper and Curtin (2006) in their study found that, during tobacco withdrawal, emotional response intensity is the same in adolescents with TUD and non-smokers. Finally, regarding *emotional regulation* abilities in TUD, research presents a nuanced landscape. While low levels of emotional control are linked with higher tobacco use (García-Moya et al., 2017; Wills et al., 2011), the association appears even stronger among adolescents with high depression scores (García-Moya et al., 2017). Moreover, the probability of tobacco use is higher among adolescents with less ability to repair emotions (González-Yubero et al., 2020). Intriguingly, Piper and Curtin (2006) report intact voluntary emotion regulation skills among adolescents with TUD during tobacco withdrawal. Additionally, both abstinent and non-abstinent smokers seem to show no increased difficulty in volitionally regulating their emotional response to external stressors (Piper and Curtin, 2006). However, given the divergent findings and limited research in this area, the evidence remains scarce and contradictory. In conclusion, while some preliminary evidence suggests that TUD in youth is associated with emotional processing impairments, further exploration is needed to understand the intensity and scope of these deficits in adolescents. Clarifying these nuances will be crucial in developing targeted interventions to address emotional regulation challenges in individuals with TUD.

- Emotional processing deficits in comorbid BD and TUD: Out of the seven studies reviewed, only three delved into the impact of poly-consumption on specific emotional processing aspects (Ernst et al., 2010; García-Moya et al., 2017; Wills et al., 2011). Ernst et al. (2010) examined *emotion identification* among non-users, single-substance users, and poly-consumers. They found that both poly-consumers and single-substance users exhibited enhanced recognition of anger compared to non-users, suggesting a potential vulnerability among drug-initiating adolescents towards negative emotions. Conversely, García-Moya et al. (2017) and Wills et al. (2011) focused on *emotion regulation* abilities among non-users, single-substance users, and poly-consumers. Their findings indicated that self- control and emotion regulation serve as broad protective factors against emotional risks linked to substance use in adolescents. However, emotional control alone did not appear to have a significant impact without accompanying risk factors. Despite these insights, relying on just three studies limits our understanding of emotional processing deficits in co-occurring BD and/or TUD during adolescence, as it is still impossible to disentangle the effects of poly-consumption from those of single-substance consumption. To address this, future research should tackle two primary challenges identified in existing literature. Firstly, previous studies have employed a scattered approach to explore emotional processing, which could benefit from a more comprehensive model delineating various

[1] ***item 3***: "Was the participation rate of eligible persons at least 50 %?"; ***item 6***: "For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?"; ***item 7***: Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?"; ***item 13***: "Was loss to follow-up after baseline 20 % or less?".

Table 2
Main characteristics of the studies

Authors (year)	Population				Exposure			Comparator		Design			Outcomes		
	Sample (N)	*Mean age (SD)*	*Gender ratio (% females)*	*Exclusion criteria*	*Substance (s) consumed*	*Substance consumption measure*	*Psychopathological measures*	*Control group (N)*	*Matching variables*	*Processes measured*	*Task*	*Complementary measures*	*Main results*	*Mentioned limitations*	*Key conclusions*
Ernst et al. (2010)	$N = 52$ (10 used one, 14 used two and 28 used all 3 substances)	12.7 (0.7) at study entry 16.3 (1.7) at follow up	29.9 %	- age < 12 and > 14 - missing three or more consecutive follow-up visits - History of any substance use - IQ <70 - chronic mental illness - treatment with psychoactive medications (except psychostimulants) - axis I psychiatric disorders except conduct disorder, oppositional defiant disorder and ADHD with or without comorbid mood disorder	Alcohol, Tobacco, (Marijuana)	Drug Use Screening Inventory	DICA	$N = 25$ (33 %) At follow-up they hadn't initiated any substance use	NA	Emotional identification	- Facial expression recognition task (DANVA)	- Behavioral ratings; - Cognitive testings; -Urine drug screen; -Physical examination; -Sexual maturation Tanner staging; -Questionnaires updating family, school, social functioning, pharmacotherapy and substance-use status.	- youths who had not initiated any substance use made more errors on the angry faces than those who had initiated all three substances, as well as compared to users of a single substance (i.e., alcohol, tobacco and marijuana); - a significant substance-use by emotion interaction was found for the three substances	NA	Substance-users displayed better recognition of anger this than non-users. This suggests that adolescents who initiate drug use may present vulnerability, in the form of affective bias, towards negative emotions.
García-Moya et al. (2017)	$N = 1752$	15.42 (0.52)	49.5 %	None	Alcohol, Tobacco, (Marijuana)	Days they have smoked and drank in the last 30 days (derived from the ESPAD study)	CES-D	NR	-Gender -Age	Emotional regulation	- Completing questionnaires: (HBSC, ERICA)	- ESPAD -Quality of parent-child relationships	- Low levels of emotional control were significantly associated with higher tobacco use but the association was higher with adolescents with high depression scores; - Higher drunkness levels are associated with low emotional control, especially for	Cross-sectional design. Adolescents' self-reports tend to overestimate their similarities with their friends, which may have resulted in some inflation of the associations between peer variables and adolescents' substance use.	Emotional control tends to serve a generalised risk-buffering role among adolescents exposed to emotional risk factors for substance use. Use. However, emotional control alone resulted unimportant in the absence of risk factors.

(*continued on next page*)

Table 2 (*continued*)

Authors (year)	Population				Exposure			Comparator		Design			Outcomes		
	Sample (N)	*Mean age (SD)*	*Gender ratio (% females)*	*Exclusion criteria*	*Substance (s) consumed*	*Substance consumption measure*	*Psychopathological measures*	*Control group (N)*	*Matching variables*	*Processes measured*	*Task*	*Complementary measures*	*Main results*	*Mentioned limitations*	*Key conclusions*
													adolescents that didn't have a good quality parent-child relationship and whose peers drank a lot.		
González Yubero et al. (2019)	$N = 844$	14.49 (1.17)	51.8 %	-age < 12 or > 16	Alcohol	Questionnaire about alcohol consumption (BD defined as the consumption of 5 or more alcoholic drinks in a period of approximatively 2 h over the past month)	None	NR	-Gender -Age -School year	Emotional appraisal and identification Emotional regulation	- Completing questionnaires: (TMMS, TIEFBA)	Alcohol use questionnaire (ESTUDES). Socio-demographic questionnaire.	-Adolescents with higher levels of attention to their own emotions report higher levels of alcohol use; -Adolescents with better abilities to discriminate between moods and emotions presented lower probabilities of consuming alcohol; -Adolescents with higher abilities to perceive others' emotions have lower probabilities of consuming alcohol; -Adolescents with higher level of emotional repair report lower probabilities of consuming alcohol and, when they do, lower	Cross-sectional design.	Youths that have greater abilities to perceive external emotions and to attend to their own emotions in a moderated manner, who can use emotional information to facilitate cognition and strategies to repair negative emotional states, have lower chances of engaging in elevated or excessive levels of alcohol consumption.

(*continued on next page*)

Table 2 (*continued*)

Authors (year)	Population				Exposure			Comparator		Design			Outcomes		
	Sample (N)	*Mean age (SD)*	*Gender ratio (% females)*	*Exclusion criteria*	*Substance (s) consumed*	*Substance consumption measure*	*Psychopathological measures*	*Control group (N)*	*Matching variables*	*Processes measured*	*Task*	*Complementary measures*	*Main results*	*Mentioned limitations*	*Key conclusions*
													intensities of consumption.		
González-Yubero et al. (2020)	$N = 799$	NA	51.8 %	-age < 12 or > 16 -not filling out the questionnaire in full by the end of the second session	Tobacco	-Tobacco use questionnaire	None	NA	-Gender -Age -School context	Emotional appraisal and identification Emotional regulation	- Completing questionnaires: (TMMS, TIEFBA)	Tobacco use questionnaire (ESTUDES). Socio-demographic questionnaire.	The probability of being a tobacco user is higher among adolescents with a high level of emotional attention than those with a lower level. The probability of being a tobacco user is higher among adolescents with less ability to understand, repair and perceive emotions than those with higher skills.	Cross-sectional design. It would be interesting to study the directionality between EI and tobacco use, as well as the effect that other variables such as attitudes towards smoking and coping strategies have at these ages.	Adolescents with higher abilities to perceive emotions and who are capable of understanding and repairing their own negative emotional states, are less likely to initiate and increase tobacco use. The results obtained underline the need to consider the training of social and emotional skills in the preventive field.
Leganes-Fonteneau et al. (2020)	N = 24 (12 low binge drinkers, 12 high binge drinkers)	HS: 15.4 (0.49)	50 %	- No native Spanish Speakers - No normal or corrected-to-normal vision - Psychological or neurological problems	Alcohol	Questionnaires about alcohol consumption (AUQ, AUDIT)	None	None	-Gender	Emotional identification	-Facial emotion identification task-NimStim database (Tottenham et al., 2009), -Emotional perception threshold task-Pictures of Facial Affect database (Ekman and Friesen, 1976)	UPPS Impulsive Behavior Scale	Facial emotion identification task: low binge drinkers perceived significantly more times fearful faces when prompted than high binge drinkers Emotional perception threshold task: low binge drinkers showed a lower threshold for joy compared	Cross-sectional design Didn't include some factors (reason to drink, alcohol expectancies) and some measures of emotional processing, mood or anxiety	High binge drinkers have more difficulty in detecting fearful traits compared to low binge drinkers High binge drinkers showed a blunted detection of positive emotion and an increased detection of sad ones.

(*continued on next page*)

Table 2 (*continued*)

Authors (year)	Population				Exposure			Comparator		Design			Outcomes		
	Sample (N)	*Mean age (SD)*	*Gender ratio (% females)*	*Exclusion criteria*	*Substance (s) consumed*	*Substance consumption measure*	*Psychopathological measures*	*Control group (N)*	*Matching variables*	*Processes measured*	*Task*	*Complementary measures*	*Main results*	*Mentioned limitations*	*Key conclusions*
													to the rest of emotions; no differences in responses for happy faces were found in high binge drinkers.		
Piper and Curtin (2006)	-24-h nicotine withdrawal condition: $N = 24$ -continued smoking condition: N = 24	NA	NA	-age < 18 years -not English reading and writing proficiency -physical or psychological condition that would contraindicate study participation	Tobacco	-Smoking history -CO - FTND	None	$N = 48$ -no current or past daily cigarette use -had consumed <100 cigarettes in their lifetime	-Gender	Emotional response Emotional regulation	Voluntary emotion regulation task (Jackson et al., 2000)	Startle eyeblink reflex. WISDM WSWS	Normal emotional response intensity and intact voluntary emotion regulation skill during tobacco withdrawal. Both abstinent and non-abstinent smokers do not display increased difficulty volitionally regulating their emotional response to external, punctate stressors.	Regulation of negative emotion to an exogenous stressor for only a brief period. Just one session to examine the time course of withdrawal effects.	The absence of impairments in voluntary negative emotion regulation during tobacco withdrawal may have important implications for the development of smoking cessation treatment programs.
Wills et al. (2011)	$N = 1307$	16 (0.7)	52 %	None	Alcohol, Tobacco, (Marijuana)	Substance use questionnaires	None	NR	-Gender -Race	Emotional regulatioin	Good behavioral self-control questionnaire (Chen et al., 2004; Eysenck and Eysenck, 1978; Kendall & Wilcox,1979; Simons and Carey, 2002; Zimbardo & Boyd, 1999), Poor behavioral regulation questionnaire (Chen et al., 2004; Eysenck	Questionnaires about demographics, family structure, ethnicity and level of education for father and mother Academic involvment questionnaire Negative life events questionnaire Friends substance use questionnaire Adolescent's substance use level	Significant interaction between poor self-control and poor emotion regulation in prediction of adolescent substance use	Cross-sectional design; Sample of adolescents with higher incomes than the average; The measures for good self-control and poor regulation were correlated more highly than in previous	Poor regulation on substance use is lower among persons with good self-control.

(*continued on next page*)

Table 2 (*continued*)

Authors (year)	Population				Exposure			Comparator		Design			Outcomes		
	Sample (N)	*Mean age (SD)*	*Gender ratio (% females)*	*Exclusion criteria*	*Substance (s) consumed*	*Substance consumption measure*	*Psychopathological measures*	*Control group (N)*	*Matching variables*	*Processes measured*	*Task*	*Complementary measures*	*Main results*	*Mentioned limitations*	*Key conclusions*
											and Eysenck, 1978; Kendall & Wilcox,1979; Simons and Carey, 2002; Zimbardo & Boyd, 1999), Good emotional self-control questionnaire (from Kendall and Wilcox, 1979; Zeman et al., 2001), Poor emotional regulation questionnaire (from Kendall and Wilcox, 1979; Simons and Carey, 2002; Zeman et al., 2001).	questionnaire Adolescent's substance use problems questionnaire		studies; Measures asked about the consequences associated with substance use but were not designed to produce diagnostic indices.	

AUDIT = Alcohol Use Disorders Identification Test (Saunders et al., 1993); AUQ = A questionnaire measure of habitual alcohol use (Mehrabian and Russell, 1978); CES-D = Center for Epidemiological Studies-Depression scale (Roberts and Sobhan, 1992); DANVA = Diagnostic Analysis of Nonverbal Accuracy (Nowicki Jr and Carton, 1993Nowicki and Carton, 1993); DICA = Diagnostic Interview for Children and Adolescents (Reich, 2000); ERICA = Emotion Regulation Index for Children and Adolescents (MacDermott et al., 2010); ESPAD = European School Survey Project on Alcohol and other Drugs (Hibell et al., 2000); ESTUDES = Encuesta sobre uso de drogas en enseñanzas secundarias en España (de la Droga, 2016); FTND = Fagerström Test of Nicotine Dependence (Heatherton et al., 1991); HBSC = Health Behavior in School-aged Children (Gaspar de Matos et al., 2009); NA = Not Available; NR = Not Reported; TIEFBA = Test of emotional intelligence by the Fundación Botín for adolescents (Špolc et al., 2019); TMMS = Trait Meta-Mood Scale (Salovey et al., 1995); UPPS = Urgency, (lack of) Premeditation, (lack of) Perseverance, and Sensation Seeking (Whiteside et al., 2005); WISDM = Wisconsin Inventory of Smoking Dependence Motives (Piper et al., 2004); WSWS = Wisconsin Smoking Withdrawal Scale (Welsch et al., 1999).

Table 3
Quality assessment scores according to the NHLBI Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Quality rating
Ernst et al. (2010)	Yes	No	Yes	No	Yes	Yes	Yes	Yes	NA	Yes	**6/10**
García-Moya et al. (2017)	Yes	Yes	Yes	No	Yes	No	No	Yes	NA	Yes	**6/10**
(González Yubero et al., 2019)	Yes	No	Yes	No	Yes	No	No	Yes	NA	Yes	**5/10**
González-Yubero et al. (2020)	Yes	No	Yes	No	Yes	No	No	Yes	NA	Yes	**5/10**
(Leganes-Fonteneau et al., 2020)	Yes	Yes	Yes	No	NA	Yes	No	Yes	NR	Yes	**6/10**
Piper and Curtin (2006)	Yes	Yes	Yes	Yes	NA	Yes	No	Yes	NR	Yes	**7/10**
Wills et al. (2011)	Yes	Yes	Yes	No	Yes	Yes	No	Yes	NR	Yes	**7/10**

List of abbreviations: NA = Not Applicable; NR = Not Reported.

emotional subcomponents. Second, there has been a notable lack of integrated exploration between BD and TUD. Given their frequent co-morbidity in youth, investigating them in isolation may not fully capture the heightened emotional deficits they entail compared to singular BD or TUD diagnoses. Third, the few studies that examined both single- and poly-consumption do not provide a clear understanding of the potential differences between single and combined substance use. Studies designed to explore all three levels of consumption - no consumption, single consumption, and poly-consumption - could more clearly highlight the effects associated with each degree of substance use.

To sum up, BD, TUD and their comorbidity in adolescence appear linked to biases towards negative emotions and reduced emotional regulation abilities. The studies included in this review do not allow to draw conclusion regarding the influence of BD and/or TUD on emotional response processes. Further research is needed to clearly differentiate the effects of poly-consumption versus single-substance use and to fully understand the emotional deficits involved.

4. Discussion

4.1. The three subcomponents of emotional processing

No theory-grounded exploration of the distinct subcomponents of emotional processing (i.e., emotional appraisal/identification, emotional response, emotional regulation) has been proposed yet in BD and/or TUD (Stephens and Duka, 2008) during adolescence. Therefore, to get more insights about emotional processes in BD and TUD, a new conceptualization of the processes explored, based on validated theoretical models, is required. The theoretical framework proposed by Phillips et al. (2003), might help clarifying existing findings and developing an organized exploration of emotional processing. This model of emotional processing is supported by neuroscience data, which suggests that although specific neural regions, such as the amygdala and insula, may be involved in multiple processes, different neural systems underlie each of these processes. For emotional identification, the amygdala (Adolphs et al., 1994), insula (Calder et al., 2004), ventral striatum and thalamus (Phillips et al., 1997) have a crucial role in recognizing and identifying emotions. Emotional response is primarily governed by the amygdala (Aggleton and Brown, 1999), insula (Casey et al., 1996) and orbitofrontal cortex (Francis et al., 1999). Emotional regulation involves the anterior cingulate gyrus, especially its dorsal (Raichle et al., 1994) and rostral regions (Gusnard et al., 2001), as well as the paracingulate gyrus, which appears to have a role in awareness (Lane, 2000). The dorsomedial (Simpson Jr et al., 2001) and dorsolateral (Goldman-Rakic, 1988) prefrontal cortices are also engaged in the regulation of attention and emotional states. Emotional processing thus results from the interaction of these three subcomponents but they also work, to some extent, independently. A detailed exploration of each of the three subcomponents would therefore be helpful to pave the way for a more comprehensive and organized understanding of emotional processing in BD and/or TUD. This would ultimately lead to the possibility of disentangling the substances distinct effects in the comorbid condition and determining which of the two drives the main effects on emotional abilities impairments. Despite the lack of extensive evidence on the topic, there is a notable imbalance in the investigation of the three stages of emotional processing. While emotional appraisal/identification and emotional regulation have been the primary focus of studies, emotional response remains underexplored. Notably, only one study (Piper and Curtin, 2006) examined emotional response in TUD, with no significant findings. In both TUD and BD, impairments are particularly evident in emotional appraisal/identification and emotional regulation (Ernst et al., 2010; García-Moya et al., 2017; González Yubero et al., 2019; González-Yubero et al., 2020; Leganes-Fonteneau et al., 2020). These data provide an encouraging foundation for further studies, following Phillips et al. (2003) emotional processing framework, to address this imbalance and enhance our understanding of emotional processing in these conditions.

4.2. Research perspectives

Capitalizing on the above-mentioned theoretical framework, each emotional processing ability could be separately explored in BD, TUD and their comorbidity. We think that designing experiments with these three groups could help disentangle the effects that belong to each of the substances and their comorbid use. In the current literature, several papers explored the effects of BD on emotions while including TUD patients in the sample, presenting non-controlled comorbidity of TUD and BD (Lannoy et al., 2018; Loeber and Duka, 2009; Muench et al., 2021), including two of the studies screened in this scoping review (González Yubero et al., 2019; Leganes-Fonteneau et al., 2020). The potential confounding effect of the interaction between BD and TUD has often been neglected, leading to the assumption that the observed effects were only due to the presence of BD. Therefore, we find of the utmost importance to address this limitation in future studies. Due to the complex nature of emotional processing, we propose here a multidisciplinary approach, going beyond behavioral paradigms by jointly using behavioral and psychophysiological indices.

First, regarding *emotional appraisal and identification*, a critical way to increase our understanding is to identify the differential deficits across emotional contents. This proposal is supported by existing evidence suggesting emotion-specific impairments, especially when dealing with negative emotions (Ernst et al., 2010; Leganes-Fonteneau et al., 2020). To expand our knowledge, it would thus be interesting to explore the visual exploration pattern during emotional decoding by using eye-tracking measures. Indeed, eye-tracking is a useful tool to disclose the nature of attentional processes in alcohol-related disorders (Maurage et al., 2020b). It would provide additional information about which specific emotions are affected the most and about the intensity of the impairment in BD, TUD and their co-occurrence (Lannoy et al., 2018; Meyers et al., 2015; Sazhin et al., 2020). It would also document the underlying processes involved in such a deficit (e.g., modified visual exploration pattern, increased focus on irrelevant parts of the stimulus to identify the emotion expressed).

Second, regarding *emotional response*, evidence in adolescents is non-existent. Among the papers included in the current review, only one study by Piper and Curtin (2006) examined emotional response in TUD, with no significant findings. However, some studies performed in adults show that these two groups of individuals display blunted emotional

responses to different types of stimuli, compared to healthy subjects (Kutlu et al., 2018; Lannoy et al., 2018; Muench et al., 2021). Available research has assessed these impairments mostly through tasks measuring fear conditioning processes, especially avoidance responses (Cherek et al., 1989; Loeber and Duka, 2009). However, results about avoidance responses are contrasted in BD and TUD: while in BD there is a reduction of avoidance responses (Loeber and Duka, 2009) and reduced physiological reactions to aversive stimuli (Stephens et al., 2005), these are increased in TUD (Cherek et al., 1989). It would thus be interesting to replicate the studies on fear conditioning and avoidance responses in adolescents, by assessing both behavioral (i.e., avoidance tasks) and psychophysiological responses (e.g., Skin Conductance and Startle Eyeblink Reflex) in BD, TUD and their comorbidity. This combination of behavioral and psychophysiological measures would allow a deep understanding of emotional response deficits in the comorbid group. Additionally, because of blunted emotional responding, it can be hypothesized that there is little variation among different moods, in these group of participants. Therefore, assessing mood variation across groups (e.g., via a mood state manipulation task), would be a useful complementary tool for assessing emotional response deficits.

Third and finally, *emotional regulation* in BD, TUD and their co-occurrence is still poorly conceptualized. The existing limited evidence on the topic (Ehret et al., 2013; Poncin et al., 2017), suggests that emotional regulation abilities might be impaired in BD and TUD during adolescence (García-Moya et al., 2017; González Yubero et al., 2019; González-Yubero et al., 2020). For this reason, emotion regulation abilities could be assessed by investigating both physiological responses (e.g. Skin Conductance) and self-reported measures of emotion regulation (e.g., Difficulty in Emotion Regulation Scale, Gratz and Roemer, 2004) The use of a multidisciplinary approach that includes behavioral, psychophysiological and self-reported measures of emotion regulation after stress induction may provide a reliable framework of emotional regulation abilities in BD, TUD and the comorbid group.

Furthermore, beyond the two main objectives of this paper, it might be useful to identify the modulation of emotional processing deficits according to several categories of variables, known to influence addictive states, and particularly (1) *Personal/psychological factors, including age, biological sex and impulsivity*. Alcohol consumption and cigarette smoking are characterized by an early age of onset, this being an index of substance use severity itself (Lopes et al., 2017). In fact, both BD and TUD are highly prevalent among young adults (Ernst et al., 2010; García-Moya et al., 2017; González Yubero et al., 2019; González-Yubero et al., 2020; Leganes-Fonteneau et al., 2020; Piper and Curtin, 2006). An earlier age of onset, related to the faster development of motivational systems compared to cognitive control ones, may be a risk factor for the development of comorbid BD/TUD. Alcohol and tobacco use have also both been associated with high impulsivity and low self-control capacity (Fernández-Artamendi et al., 2013), but the interaction between these factors and emotional processes is still to be understood. However, the number of studies investigating emotional processing deficits in adolescents is very limited. Finally, biological sex, beyond influencing consumption intensity (the rate of substance abuse and dependence being higher among men) might influence the age of onset (i.e., women usually start later) and the reasons for smoking (i.e., women often start in order to medicate mood disturbances and have a significantly higher prevalence of comorbid psychiatric disorders than men) (Brady and Randall, 1999); (2) *Other comorbidities:* BD and TUD are often associated with marijuana, cocaine, and other drug consumptions, which might also influence emotional processing (Ernst et al., 2010; García-Moya et al., 2017). Additionally, the co-occurrence of addictive and psychiatric disorders, especially anxiety, depression, eating disorders (mostly binge eating and bulimia nervosa) and schizophrenia, has been well established in the literature (Bierhoff et al., 2019; Edkins et al., 2017; Fornaro et al., 2022; García-Moya et al., 2017; Ramón-Arbués et al., 2020; Solmi et al., 2016; Walters et al., 2018). Evidence suggests that adolescents with substance use issues are more likely to experience anxiety (Addolorato et al., 2018), depressive symptoms (García-Moya et al., 2017), and engage in suicidal behaviors (Deas and Brown, 2006). Conversely, psychiatric disorders with a high prevalence during adolescence (e.g., eating disorders; Fornaro et al., 2023) might increase the risk to use alcohol and/or tobacco. Future studies should thus further explore the distinct and joint influence of psychiatric and addictive disorders on emotional processes. Ultimately, it should also be underlined that, beyond comorbidities, the absence of standardized diagnosis for BD and the large heterogeneity in BD/TUD across individuals (e.g., regarding consumption's frequency/intensity) raise significant challenges, as studies included individuals with varying levels of alcohol and cigarette consumption. It is crucial for future work to adopt standardized diagnostic/consumption criteria to enable direct comparisons of results and improve the reliability of findings.

5. Conclusion

Our preregistered scoping review identified preliminary evidence of impaired emotional processing abilities among adolescents with BD and TUD. However, a systematic exploration of emotional processing subcomponents remains absent. Moreover, the combined impact of co-occurring BD and TUD on emotional processing in adolescence, compared to their isolated effects, has received limited attention. Consequently, discerning which substance predominantly influences emotional deficits remains elusive. Therefore, we advocate for a foundational approach to address these inquiries. By employing a theoretical model that delineates various emotional subcomponents and adopting a multidisciplinary methodology, we underscore the importance of investigating distinct emotional abilities in BD and/or TUD. At the clinical level, recognizing and understanding the presence and repercussions of emotional processing deficits in BD and/or TUD could inform targeted interventions. Such interventions may aid individuals with substance misuse in enhancing their emotional regulation skills, mitigating negative affect, and avoiding associated behavioral ramifications. Considering this, we propose novel experimental perspectives aimed at cultivating a theory-driven and comprehensive examination of emotional impairments in BD and/or TUD among young individuals. This endeavor aims to lay the groundwork for a deeper comprehension of these disorders.

Author Statement File.

Financial support

This work benefitted from the financial support allocated by the Belgian Fund for Scientific Research (F.R.S.-FNRS) to EM (Junior Research Associate) and PM (Senior Research Associate).

CRediT authorship contribution statement

Elisa Martini: Writing – original draft, Methodology, Investigation, Conceptualization, Formal analysis. **Sorenza Semeraro:** Writing – review & editing, Visualization, Investigation, Formal analysis, Conceptualization. **Séverine Lannoy:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization. **Pierre Maurage:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest

All the authors declare no conflict of interest.

Data availability

No data was used for the research described in the article.

Acknowledgements

Pierre Maurage (Senior Research Associate) is funded by the Belgian Fund for Scientific Research (F.R.S.-FNRS, Brussels, Belgium). This funding source did not exert any influence or censorship on the present

References

Addolorato, G., Vassallo, G.A., Antonelli, G., Antonelli, M., Tarli, C., Mirijello, A., Gasbarrini, A., 2018. Binge drinking among adolescents is related to the development of alcohol use disorders: results from a cross-sectional study. Sci. Rep. 8 (1), 1–9. https://doi.org/10.1038/s41598-018-29311-y.

Adolphs, R., Tranel, D., Damasio, H., Damasio, A., 1994. Impaired recognition of emotion in facial expressions following bilateral damage to the human amygdala. Nature 372 (6507), 669–672.

Aggleton, J.P., Brown, M.W., 1999. Episodic memory, amnesia, and the hippocampal–anterior thalamic axis. Behav. Brain Sci. 22 (3), 425–444. https://doi.org/10.1017/S0140525X99002034.

American Psychiatric Association, 2013. Diagnostic and statistical manual of mental disorders (5th ed.).

Bierhoff, J., Haardörfer, R., Windle, M., Berg, C.J., 2019. Psychological risk factors for alcohol, cannabis, and various tobacco use among young adults: a longitudinal analysis. Subst. Use Misuse 54 (8), 1365–1375. https://doi.org/10.1080/10826084.2019.1581220.

Black, M.H., Chen, N.T.M., Iyer, K.K., Lipp, O.V., Bölte, S., Falkmer, M., Girdler, S., 2017. Mechanisms of facial emotion recognition in autism spectrum disorders: insights from eye tracking and electroencephalography. Neurosci. Biobehav. Rev. 80, 488–515. https://doi.org/10.1016/j.neubiorev.2017.06.016.

Brady, K.T., Randall, C.L., 1999. Gender differences in substance use disorders. Psychiatr. Clin. N. Am. 22 (2), 241–252. https://doi.org/10.1016/S0193-953X(05)70074-5.

Calder, A.J., Keane, J., Lawrence, A.D., Manes, F., 2004. Impaired recognition of anger following damage to the ventral striatum. Brain 127 (9), 1958–1969. https://doi.org/10.1093/brain/awh214.

Carbia, C., López-Caneda, E., Corral, M., Cadaveira, F., 2018. A systematic review of neuropsychological studies involving young binge drinkers. Neurosci. Biobehav. Rev. 90, 332–349. https://doi.org/10.1016/j.neubiorev.2018.04.013.

Casey, K.L., Minoshima, S, Morrow, T.J., Koeppe, R.A., 1996. Comparison of human cerebral activation pattern during cutaneous warmth, heat pain, and deep cold pain. J. Neurophysiol. 76 (1), 571–581. https://doi.org/10.1152/jn.1996.76.1.571.

Cherek, D.R., Bennett, R.H., Kelly, T.H., Steinberg, J.L., Benowitz, N.L., 1989. Effects of nicotine gum and tobacco smoking on human avoidance responding. Pharmacol. Biochem. Behav. 32 (3), 677–681. https://doi.org/10.1016/0091-3057(89)90017-8.

Conti, A.A., McLean, L., Tolomeo, S., Steele, J.D., Baldacchino, A., 2019. Chronic tobacco smoking and neuropsychological impairments: a systematic review and meta-analysis. Neurosci. Biobehav. Rev. 96, 143–154. https://doi.org/10.1016/j.neubiorev.2018.11.017.

Deas, D., Brown, E.S., 2006. Adolescent substance abuse and psychiatric comorbidities. J. Clin. Psychiatry 67, 18. https://doi.org/10.4088/JCP.0706e02.

DeBaker, M.C., Robinson, J.M., Moen, J.K., Wickman, K., Lee, A.M., 2020. Differential patterns of alcohol and nicotine intake: *combined alcohol and nicotine binge consumption behaviors in mice*. Alcohol 85, 57–64. https://doi.org/10.1016/j.alcohol.2019.09.006.

Edkins, T., Edgerton, J.D., Roberts, L.W., 2017. Correlates of binge drinking in a sample of Canadian university students. Int. J. Child Youth Family Stud. 8 (1), 112–144. https://doi.org/10.18357/ijcyfs81201716944.

Ehret, P.J., Ghaidarov, T.M., LaBrie, J.W., 2013. Can you say no? Examining the relationship de la Droga, O. E. (2016). las Toxicomanías (OEDT), Delegación Nacional del Gobierno para el Plan Nacional sobre Drogas (DGPNSD), Ministerio de Sanidad, Servicios Sociales e Igualdad (MSSSI). Encuesta sobre uso de drogas en enseñanzas secundarias en España (ESTUDES), 2014-2015 between drinking refusal self-efficacy and protective behavioral strategy use on alcohol outcomes. Addict. Behav. 38 (4), 1898–1904. https://doi.org/10.1016/j.addbeh.2012.12.022.

Ekman, P., Friesen, W.V., 1976. Measuring facial movement. Environ. Psychol. Nonverbal Behav. 1, 56–75. https://doi.org/10.1007/BF01115465.

Ernst, M., Luckenbaugh, D.A., Moolchan, E.T., Temple, V.A., Jenness, J., Korelitz, K.E., Kimes, A.S., 2010. Decision-making and facial emotion recognition as predictors of substance-use initiation among adolescents. Addict. Behav. 35 (3), 286–289. https://doi.org/10.1016/j.addbeh.2009.10.014.

Eysenck, S.B., Eysenck, H.J., 1978. Impulsiveness and venturesomeness: their position in a dimensional system of personality description. Psychol. Rep. 43 (3_suppl), 1247–1255. https://doi.org/10.2466/pr0.1978.43.3f.1247.

Feduccia, A.A., Chatterjee, S., Bartlett, S.E., 2012. Neuronal nicotinic acetylcholine receptors: neuroplastic changes underlying alcohol and nicotine addictions. Front. Mol. Neurosci. 5, 83. https://doi.org/10.3389/fnmol.2012.00083.

Fernández-Artamendi, S., Secades-Villa, R., Fernandez Hermida, J.R., García-Fernández, G., García-Rodríguez, O., 2013. Gender differences in early alcohol and tobacco use as a risk factor in Spanish adolescents. Subst. Use Misuse 48 (6), 429–437. https://doi.org/10.3109/10826084.2013.776085.

Fornaro, M., Carvalho, A.F., De Prisco, M., Mondin, A.M., Billeci, M., Selby, P., Iasevoli, F., Berk, M., Castle, D.J., de Bartolomeis, A., 2022. The prevalence, odds, predictors, and management of tobacco use disorder or nicotine dependence among people with severe mental illness: systematic review and meta-analysis. Neurosci. Biobehav. Rev. 132, 289–303. https://doi.org/10.1016/j.neubiorev.2021.11.039.

Fornaro, M., Mondin, A.M., Billeci, M., Fusco, A., De Prisco, M., Caiazza, C., Micanti, F., Calati, R., Carvalho, A.F., de Bartolomeis, A., 2023. Psychopharmacology of eating disorders: systematic review and meta-analysis of randomized controlled trials. J. Affect. Disord. 338, 526–545. https://doi.org/10.1016/j.jad.2023.06.068.

Francis, S., Rolls, E.T., Bowtell, R., McGlone, F., O'Doherty, J., Browning, A., Smith, E., 1999. The representation of pleasant touch in the brain and its relationship with taste and olfactory areas. Neuroreport 10 (3), 453–459.

García-Moya, I., Ortiz Barón, M.J., Moreno, C., 2017. Emotional and psychosocial factors associated with drunkenness and the use of tobacco and cannabis in adolescence: independent or interactive effects? Subst. Use Misuse 52 (8), 1039–1050. https://doi.org/10.1080/10826084.2016.1271431.

Gaspar de Matos, M., Van der Sluijs, W., Sánchez-Queija, I., Muñoz-Tinoco, V., Tomé, G., Ferreira, M., The Peer Focus Group, 2009. Social contexts of health and health behaviour: Peer culture. In: *HBSC research protocol for* 2009/10 survey. *Section II scientific rationales for focus areas*. Unpublished manuscript.

Goldman-Rakic, P.S., 1988. Topography of cognition: parallel distributed networks in primate association cortex. Annu. Rev. Neurosci. https://doi.org/10.1146/annurev.ne.11.030188.001033.

González Yubero, S., Palomera Martín, R., Lázaro Visa, S., 2019. Trait and ability emotional intelligence as predictors of alcohol consumption in adolescents. Psicothema. https://doi.org/10.7334/psicothema2018.315.

González-Yubero, S., Lázaro-Visa, S., Palomera Martín, R., 2020. The protective association of trait and ability emotional intelligence with adolescent tobacco use. Int. J. Environ. Res. Public Health 17 (18), 6865. https://doi.org/10.3390/ijerph17186865.

Grant, B.F., Goldstein, R.B., Saha, T.D., Chou, S.P., Jung, J., Zhang, H., Hasin, D.S., 2015. Epidemiology of DSM-5 alcohol use disorder: results from the National Epidemiologic Survey on alcohol and related conditions III. JAMA Psychiatry 72 (8), 757–766. https://doi.org/10.1001/jamapsychiatry.2015.0584.

Gratz, K.L., Roemer, L., 2004. Multidimensional assessment of emotion regulation and dysregulation: development, factor structure, and initial validation of the difficulties in emotion regulation scale. J. Psychopathol. Behav. Assess. 26 (1), 41–54. https://doi.org/10.1023/B:JOBA.0000007455.08539.94.

Gubner, N.R., Delucchi, K.L., Ramo, D.E., 2016. Associations between binge drinking frequency and tobacco use among young adults. Addict. Behav. 60, 191–196. https://doi.org/10.1016/j.addbeh.2016.04.019.

Gusnard, D.A., Akbudak, E., Shulman, G.L., Raichle, M.E., 2001. Medial prefrontal cortex and self-referential mental activity: relation to a default mode of brain function. Proc. Natl. Acad. Sci. 98 (7), 4259–4264. https://doi.org/10.1073/pnas.071043098.

Hagger-Johnson, G., Sabia, S., Brunner, E.J., Shipley, M., Bobak, M., Marmot, M., Singh-Manoux, A., 2013. Combined impact of smoking and heavy alcohol use on cognitive decline in early old age: Whitehall II prospective cohort study. Br. J. Psychiatry 203 (2), 120–125. https://doi.org/10.1192/bjp.bp.112.122960.

Heatherton, T.F., Kozlowski, L.T., Frecker, R.C., FAGERSTROM, K. O., 1991. The Fagerström test for nicotine dependence: a revision of the Fagerstrom tolerance questionnaire. Br. J. Addict. 86 (9), 1119–1127. https://doi.org/10.1111/j.1360-0443.1991.tb01879.x.

Hibell, B., Andersson, B., Ahlström, S., Balakireva, O., Bjarnasson, T., Kokkevi, A., Morgan, M., 2000. The 1999 European School Survey Project on Alcohol and Other Drugs (ESPAD) Report. Alcohol and Other Drug Use among Students in 30 European Countries. The Swedish Council for Information on Alcohol and Other Drugs (CAN) and The Pompidou Group at the Council of Europe, Stockholm, Sweden.

Jackson, D.C., Malmstadt, J.R., Larson, C.L., Davidson, R.J., 2000. Suppression and enhancement of emotional responses to unpleasant pictures. Psychophysiology 37 (4), 515–522. https://doi.org/10.1111/1469-8986.3740515.

Kendall, P.C., Wilcox, L.E., 1979. Self-control in children: development of a rating scale. J. Consult. Clin. Psychol. 47 (6), 1020. https://doi.org/10.1037/0022-006X.47.6.1020.

Kumari, V., Gray, J.A., Mitterschiffthaler, M.T., Das, M., Zachariah, E., Vythelingum, G. N., Williams, S.C., Simmons, A., Sharma, T., 2003. Cognitive effects of nicotine in humans: an fMRI study. Neuroimage 19 (3), 1002–1013. https://doi.org/10.1016/s1053-8119(03)00110-1.

Kun, B., Demetrovics, Z., 2010. Emotional intelligence and addictions: a systematic review. Subst. Use Misuse 45 (7–8), 1131–1160. https://doi.org/10.3109/10826080903567855.

Kutlu, M.G., Marin, M.F., Tumolo, J.M., Kaur, N., VanElzakker, M.B., Shin, L.M., Gould, T.J., 2018. Nicotine exposure leads to deficits in differential cued fear conditioning in mice and humans: a potential role of the anterior cingulate cortex. Neurosci. Lett. 673, 142–149. https://doi.org/10.1016/j.neulet.2018.03.002.

Laghi, F., Liga, F., Pompili, S., 2018. Adolescents who binge eat and drink: the role of emotion regulation. J. Addict. Dis. 37 (1–2), 77–86. https://doi.org/10.1080/10550887.2018.1553458.

Lane, R.D., 2000. Neural correlates of conscious emotional experience. In: Lane, R.D., Nadel, L. (Eds.), Cognitive Neuroscience of Emotion. Oxford University Press, pp. 345–370.

Lannoy, S., Sullivan, E.V., 2021. Trajectories of brain development reveal times of risk and factors promoting resilience to alcohol use during adolescence. Int. Rev. Neurobiol. 160, 85–116. https://doi.org/10.1016/bs.irn.2021.08.002.

Lannoy, S., Dormal, V., Brion, M., Gaudelus, B., Billieux, J., Maurage, P., 2018. Affective impairments in binge drinking: investigation through emotional facial expression

decoding. Compr. Psychiatry 83, 59–63. https://doi.org/10.1016/j.comppsych.2018.03.004.
Lannoy, S., Billieux, J., Dormal, V., Maurage, P., 2019. Behavioral and cerebral impairments associated with binge drinking in youth: a critical review. Psychol. Belg. 59 (1), 116–155. https://doi.org/10.5334/pb.476.
Lannoy, S., Duka, T., Carbia, C., Billieux, J., Fontesse, S., Dormal, V., Maurage, P., 2021. Emotional processes in binge drinking: a systematic review and perspective. Clin. Psychol. Rev. 84, 101971 https://doi.org/10.1016/j.cpr.2021.101971.
Leganes-Fonteneau, M., Pi-Ruano, M., Tejero, P., 2020. Early signs of emotional recognition deficits in adolescent high-binge drinkers. Subst. Use Misuse 55 (2), 218–229. https://doi.org/10.1080/10826084.2019.1662810.
Leite, K.P., Martins, F.D.M.P., Trevizol, A.P., Noto, J.R.D.S., Brietzke, E., 2019. A critical literature review on emotional intelligence in addiction. Trends Psychiatry Psychother. 41, 87–93. https://doi.org/10.1590/2237-6089-2018-0002.
Locker, A.R., Marks, M.J., Kamens, H.M., Klein, L.C., 2016. Exposure to nicotine increases nicotinic acetylcholine receptor density in the reward pathway and binge ethanol consumption in C57BL/6J adolescent female mice. Brain Res. Bull. 123, 13–22. https://doi.org/10.1016/j.brainresbull.2015.09.009.
Loeber, S., Duka, T., 2009. Acute alcohol decreases performance of an instrumental response to avoid aversive consequences in social drinkers. Psychopharmacology 205 (4), 577–587. https://doi.org/10.1007/s00213-009-1565-9.
Lopes, B.M., Gonçalves, P.D., Ometto, M., Dos Santos, B., Cavallet, M., Chaim-Avancini, T.M., Cunha, P.J., 2017. Distinct cognitive performance and patterns of drug use among early and late onset cocaine users. Addict. Behav. 73, 41–47. https://doi.org/10.1016/j.addbeh.2017.04.013.
MacDermott, S.T., Gullone, E., Allen, J.S., King, N.J., Tonge, B., 2010. The emotion regulation index for children and adolescents (ERICA): a psychometric investigation. J. Psychopathol. Behav. Assess. 32, 301–314. https://doi.org/10.1007/s10862-009-9154-0.
Maurage, P., Lannoy, S., Mange, J., Grynberg, D., Beaunieux, H., Banovic, I., Naassila, M., 2020a. What we talk about when we talk about binge drinking: towards an integrated conceptualization and evaluation. Alcohol Alcohol. 55 (5), 468–479. https://doi.org/10.1093/alcalc/agaa041.
Maurage, P., Masson, N., Bollen, Z., D'Hondt, F., 2020b. Eye tracking correlates of acute alcohol consumption: a systematic and critical review. Neurosci. Biobehav. Rev. 108, 400–422. https://doi.org/10.1016/j.neubiorev.2019.10.001.
Maurage, P., Bollen, Z., Masson, N., D'Hondt, F., 2021. Eye tracking studies exploring cognitive and affective processes among alcohol drinkers: a systematic review and perspectives. Neuropsychol. Rev. 31 (1), 167–201. https://doi.org/10.1007/s11065-020-09458-0.
McClernon, F.J., Kollins, S.H., 2008. ADHD and smoking: from genes to brain to behavior. Ann. N. Y. Acad. Sci. 1141, 131. https://doi.org/10.1196/annals.1441.016.
McKee, K., Russell, M., Mennis, J., Mason, M., Neale, M., 2020. Emotion regulation dynamics predict substance use in high-risk adolescents. Addict. Behav. 106, 106374 https://doi.org/10.1016/j.addbeh.2020.106374.
Mehrabian, A., Russell, J.A., 1978. A questionnaire measure of habitual alcohol use. Psychol. Rep. 43 (3), 803–806. https://doi.org/10.2466/pr0.1978.43.3.803.
Meyers, K.K., Crane, N.A., O'Day, R., Zubieta, J.K., Giordani, B., Pomerleau, C.S., Langenecker, S.A., 2015. Smoking history, and not depression, is related to deficits in detection of happy and sad faces. Addict. Behav. 41, 210–217. https://doi.org/10.1016/j.addbeh.2014.10.012.
Muench, C., Charlet, K., Balderston, N.L., Grillon, C., Heilig, M., Cortes, C.R., Lohoff, F. W., 2021. Fear conditioning and extinction in alcohol dependence: evidence for abnormal amygdala reactivity. Addict. Biol. 26 (1), e12835 https://doi.org/10.1111/adb.12835.
National Heart, Lung, and Blood Institute, 2014. Quality assessment tool for observational cohort and cross-sectional studies. In: Available at: National Heart, Lung, and Blood Institute. MD, Bethesda. http://www.nhlbi.nih.gov/health-pro/guidelines/in-develop/cardiovascular-risk-reduction/tools/cohort.
National Institute on Alcohol Abuse and Alcoholism, 2016. Drinking levels defined. https://www.niaaa.nih.gov/alcohol-health/overview-alcohol-consumption/moderate-binge-drinking/ (accessed 20 June 2022).
Nowicki Jr., S., Carton, J., 1993. The measurement of emotional intensity from facial expressions. J. Soc. Psychol. 133 (5), 749–750. https://doi.org/10.1080/00224545.1993.9713934.
Pessoa, L., 2017. A network model of the emotional brain. Trends Cogn. Sci. 21 (5), 357–371. https://doi.org/10.1016/j.tics.2017.03.002.
Phillips, M.L., Young, A.W., Senior, C., Brammer, M., Andrew, C., Calder, A.J., David, A. S., 1997. A specific neural substrate for perceiving facial expressions of disgust. Nature 389 (6650), 495–498.
Phillips, M.L., Drevets, W.C., Rauch, S.L., Lane, R., 2003. Neurobiology of emotion perception I: the neural basis of normal emotion perception. Biol. Psychiatry 54 (5), 504–514. https://doi.org/10.1016/S0006-3223(03)00168-9.
Piper, M.E., Curtin, J.J., 2006. Tobacco withdrawal and negative affect: an analysis of initial emotional response intensity and voluntary emotion regulation. J. Abnorm. Psychol. 115 (1), 96. https://doi.org/10.1037/0021-843X.115.1.96.
Piper, M.E., Piasecki, T.M., Federman, E.B., Bolt, D.M., Smith, S.S., Fiore, M.C., Baker, T. B., 2004. A multiple motives approach to tobacco dependence: the Wisconsin inventory of smoking dependence motives (WISDM-68). J. Consult. Clin. Psychol. 72 (2), 139. https://psycnet.apa.org/doi/10.1037/0022-006X.72.2.139.
Poncin, M., Vermeulen, N., De Timary, P., 2017. Distress response to the failure to an insoluble anagrams task: maladaptive emotion regulation strategies in binge drinking students. Front. Psychol. 1795 https://doi.org/10.3389/fpsyg.2017.01795.
Raichle, M.E., Fiez, J.A., Videen, T.O., MacLeod, A.M.K., Pardo, J.V., Fox, P.T., Petersen, S.E., 1994. Practice-related changes in human brain functional anatomy during nonmotor learning. Cereb. Cortex 4 (1), 8–26. https://doi.org/10.1093/cercor/4.1.8.
Ramón-Arbués, E., Gea-Caballero, V., Granada-López, J.M., Juárez-Vela, R., Pellicer-García, B., Antón-Solanas, I., 2020. The prevalence of depression, anxiety and stress and their associated factors in college students. Int. J. Environ. Res. Public Health 17 (19), 7001. https://doi.org/10.3390/ijerph17197001.
Reich, W., 2000. Diagnostic interview for children and adolescents (DICA). J. Am. Acad. Child Adolesc. Psychiatry 39 (1), 59–66. https://doi.org/10.1097/00004583-200001000-00017.
Roberts, R.E., Sobhan, M., 1992. Symptoms of depression in adolescence: a comparison of Anglo, African, and Hispanic Americans. J. Youth Adolesc. 21, 639–651. https://doi.org/10.1007/BF01538736.
Salovey, P., Mayer, J.D., Goldman, S.L., Turvey, C., Palfai, T.P., 1995. Emotional attention, clarity, and repair: exploring emotional intelligence using the trait Meta-mood scale. https://psycnet.apa.org/doi/10.1037/10182-006.
Sanderson, S., Tatt, I.D., Higgins, J.P., 2007. Tools for assessing quality and susceptibility to bias in observational studies in epidemiology: a systematic review and annotated bibliography. Int. J. Epidemiol. 36 (3), 666–676. https://doi.org/10.1093/ije/dym018.
Saunders, J.B., Aasland, O.G., Babor, T.F., De la Fuente, J.R., Grant, M., 1993. Development of the alcohol use disorders identification test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption-II. Addiction 88 (6), 791–804. https://doi.org/10.1111/j.1360-0443.1993.tb02093.x.
Sazhin, D., Frazier, A.M., Haynes, C.R., Johnston, C.R., Chat, I.K.Y., Dennison, J.B., Smith, D.V., 2020. The role of social reward and Corticostriatal connectivity in substance use. J. Psychiatr. Brain Sci. 5 https://doi.org/10.20900/jpbs.20200024.
Simons, J.S., Carey, K.B., 2002. Risk and vulnerability for marijuana use problems: the role of affect dysregulation. Psychol. Addict. Behav. 16 (1), 72.
Simpson Jr., J.R., Drevets, W.C., Snyder, A.Z., Gusnard, D.A., Raichle, M.E., 2001. Emotion-induced changes in human medial prefrontal cortex: II. During anticipatory anxiety. Proc. Natl. Acad. Sci. 98 (2), 688–693. https://doi.org/10.1073/pnas.98.2.688.
Solmi, M., Veronese, N., Sergi, G., Luchini, C., Favaro, A., Santonastaso, P., Vancampfort, D., Correll, C.U., Ussher, M., Thapa-Chhetri, N., Fornaro, M., Stubbs, B., 2016. The association between smoking prevalence and eating disorders: a systematic review and meta-analysis. Addiction 111 (11), 1914–1922. https://doi.org/10.1111/add.13457.
Špolc, M., Mravčík, V., Drbohlavová, B., Chomynová, P., 2019. Problem gambling among Czech adolescents: an exploration of its relationship to early initiation of tobacco smoking. J. Behav. Addict. 8 (1), 114–122. https://doi.org/10.1556/2006.8.2019.04.
Stephens, D.N., Duka, T., 2008. Cognitive and emotional consequences of binge drinking: role of amygdala and prefrontal cortex. Philos. Trans. R. Soc. B 363 (1507), 3169–3179. https://doi.org/10.1098/rstb.2008.0097.
Stephens, D.N., Ripley, T.L., Borlikova, G., Schubert, M., Albrecht, D., Hogarth, L., Duka, T., 2005. Repeated ethanol exposure and withdrawal impairs human fear conditioning and depresses long-term potentiation in rat amygdala and hippocampus. Biol. Psychiatry 58 (5), 392–400. https://doi.org/10.1016/j.biopsych.2005.04.025.
Tottenham, N., Tanaka, J.W., Leon, A.C., McCarry, T., Nurse, M., Hare, T.A., Nelson, C., 2009. The NimStim set of facial expressions: judgments from untrained research participants. Psychiatry Res. 168 (3), 242–249. https://doi.org/10.1016/j.psychres.2008.05.006.
Tricco, A.C., Lillie, E., Zarin, W., O'Brien, K.K., Colquhoun, H., Levac, D., Moher, D., Peters, M.D.J., Horsley, T., Weeks, L., Hempel, S., Akl, E.A., Chang, C., McGowan, J., Stewart, L., Hartling, L., Aldcroft, A., Wilson, M.G., Garritty, C., Lewin, S., Godfrey, C.M., Macdonald, M.T., Langlois, E.V., Soares-Weiser, K., Moriarty, J., Clifford, T., Tunçalp, Ö., Straus, S.E., 2018. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann. Intern. Med 169 (7), 467–473. https://doi.org/10.7326/M18-0850.
Trinidad, D.R., Johnson, C.A., 2002. The association between emotional intelligence and early adolescent tobacco and alcohol use. Personal. Individ. Differ. 32 (1), 95–105. https://doi.org/10.1016/S0191-8869(01)00008-3.
Van Duijvenvoorde, A.C., Peters, S., Braams, B.R., Crone, E.A., 2016. What motivates adolescents? Neural responses to rewards and their influence on adolescents' risk taking, learning, and cognitive control. Neurosci. Biobehav. Rev. 70, 135–147. https://doi.org/10.1016/j.neubiorev.2016.06.037.
VanderVeen, J.W., Cohen, L.M., Watson, N.L., 2013. Utilizing a multimodal assessment strategy to examine variations of impulsivity among young adults engaged in co-occurring smoking and binge drinking behaviors. Drug Alcohol Depend. 127 (1–3), 150–155. https://doi.org/10.1016/j.drugalcdep.2012.06.026.
Walters, K.S., Bulmer, S.M., Troiano, P.F., Obiaka, U., Bonhomme, R., 2018. Substance use, anxiety, and depressive symptoms among college students. J. Child Adolesc. Subst. Abuse 27 (2), 103–111. https://doi.org/10.1080/1067828X.2017.1420507.
Welsch, S.K., Smith, S.S., Wetter, D.W., Jorenby, D.E., Fiore, M.C., Baker, T.B., 1999. Development and validation of the Wisconsin smoking withdrawal scale. Exp. Clin.

Psychopharmacol. 7 (4), 354. https://psycnet.apa.org/doi/10.1037/1064-1297.7.4.354.
Whiteside, S.P., Lynam, D.R., Miller, J.D., Reynolds, S.K., 2005. Validation of the UPPS impulsive behaviour scale: a four-factor model of impulsivity. Eur. J. Personal. 19 (7), 559–574. https://doi.org/10.1002/per.556.
Wills, T.A., Pokhrel, P., Morehouse, E., Fenster, B., 2011. Behavioral and emotional regulation and adolescent substance use problems: a test of moderation effects in a dual-process model. Psychol. Addict. Behav. 25 (2), 279. https://doi.org/10.1037/a0022870.
Zeng, X., Zhang, Y., Kwong, J.S., Zhang, C., Li, S., Sun, F., Du, L., 2015. The methodological quality assessment tools for preclinical and clinical studies, systematic review and meta-analysis, and clinical practice guideline: a systematic review. J. Evid. Based Med. 8 (1), 2–10. https://doi.org/10.1111/jebm.12141.
Zilverstand, A., Huang, A.S., Alia-Klein, N., Goldstein, R.Z., 2018. Neuroimaging impaired response inhibition and salience attribution in human drug addiction: a systematic review. Neuron 98 (5), 886–903. https://doi.org/10.1016/j.neuron.2018.03.048.