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The relation between ADHD symptoms, perceived stress and binge drinking in college students

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ABSTRACT

Binge drinking is a major public health problem associated with various negative short-term and long-term clinical and social outcomes. If there is evidence to suggest a relationship between ADHD and alcohol use in college students, no study has investigated the role of ADHD symptomatology in binge drinking. Thus, this research was designed to explore the relative contributions of inattention and hyperactivity/impulsivity symptoms to binge drinking in a sample of French college students while controlling for effects of perceived stress. Participants ($N = 7011$; mean age = 20.9; 74.9% of females) completed self-report surveys assessing ADHD symptoms, perceived stress, sociodemographic characteristics, and binge drinking frequency. Multinomial logistic regression revealed significant associations between higher levels of ADHD symptoms in general, but not perceived stress, and increasing frequency of binge drinking. Moreover, higher levels of inattention and hyperactivity/impulsivity symptoms were independently associated with greater frequency of binge drinking. The association was stronger between high rates of binge drinking and inattention than for hyperactivity/impulsivity. These findings, which remained statistically significant after adjusting for a range of potential confounders (including perceived stress), suggest that the presence of ADHD symptoms may be an important factor related to binge drinking.

1. Introduction

Binge drinking, a behavior characterized by heavy ethanol intoxication followed by intermittent withdrawals, constitutes a major public health problem across countries, highly prevalent in youths and young adults (Gruza et al., 2009; Hibell et al., 2012; Patrick et al., 2013). This type of abusive drinking has generally been defined as the consumption of 5 or more drinks (4 or more for females) on one occasion within a 2-h interval (bringing blood alcohol concentrations around .08% or above), at least once in the last 2 weeks or in the last month (Courtney and Polich, 2009; National Institute of Alcohol Abuse and Alcoholism, 2004; Wechsler and Nelson, 2001).

It is not easy to estimate the prevalence of this dangerous pattern of alcohol consumption since published studies have reported different frequencies, ranging from a lifetime (Bartoli et al., 2014) to monthly (Hingson et al., 2009) and weekly (Kwan et al., 2013), in different populations, including adult, young adult, college students and

adolescents. We know, however, that in US samples, the prevalence of binge drinking is highest among 18–24-year-olds (Naimi et al., 2003) and especially in college students (Hingson et al., 2009).

It should be noted that this drinking pattern has been associated with a wide range of adverse health and social consequences, including alcohol poisoning (Centers for Disease Control and Prevention, 2013; Naimi et al., 2003), brain damage and neurocognitive impairments (Hermens et al., 2013; Maura et al., 2012), cardiovascular problems (Piano et al., 2017), unintentional injuries (Hingson et al., 2002; Hingson and Zha, 2009), self-inflicted harm and suicide (Borges and Loera, 2010; Norstrom and Rossow, 2016; Schaffer et al., 2008), violence and homicide (Brewer and Swahn, 2005; Svensson and Landberg, 2013), poor academic performance (Jennison, 2004; Powell et al., 2004; Singleton, 2007; Thombs et al., 2009), and development of alcohol use disorder (Chassin et al., 2002; Jennison, 2004; Viner and Taylor, 2007). Studies have also shown that binge drinkers are more likely than non-binge-drinkers to engage in risky sexual

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behaviors (Bryan et al., 2007; Tapert et al., 2001; Wen et al., 2012), with an increased risk of HIV infection and other sexually transmitted diseases (Shuper et al., 2010). Lastly, relative to all alcohol-related problems in the United States, binge drinking is “responsible” for half of the 80,000 estimated deaths, two thirds of the 2.3 million life years lost (Centers for Disease Control and Prevention, 2013), and three fourths of the \$200 billion economic costs annually (Stahre et al., 2014; Bouchery et al., 2011). Therefore, advancing knowledge on the risk factors for this type of binge drinking and using this research to prevent this highly prevalent and harmful behavior is a critically important endeavor.

One risk factor increasingly evaluated as a predictor of problem drinking over the last two decades is Attention-Deficit Hyperactivity Disorder (ADHD; Biederman et al., 1997; Rodriguez and Span, 2008; Smith et al., 2002; Weiss and Hechtman, 1993; Wilens et al., 1998). Characterized by developmentally inappropriate levels of inattention and/or hyperactivity-impulsivity (American Psychiatric Association, 1994; Barkley, 2006), this neurodevelopmental disorder was commonly believed to be a disorder of childhood. Nonetheless, it is now widely recognized that symptoms persist into adolescence and adulthood for the majority of children (Kessler et al., 2006; Polanczyk and Jensen, 2008). Previous studies have indeed shown that 50% to 75% of individuals diagnosed with ADHD in childhood continue to display symptoms into adolescence and adulthood (Barkley et al., 2002; Glutting et al., 2005). Research reports increasing number of individuals with ADHD who are enrolling in college (DuPaul et al., 2009; Lee et al., 2008; Weyandt and DuPaul, 2008), and recent estimates suggest that 2% to 8% of college students report symptoms consistent with ADHD (Weyandt and DuPaul, 2008).

There is a developing literature base in which researchers have been exploring the relationship between this disorder and alcohol use in college students, although mixed results are being reported. Actually, some studies provided evidence for the relationship between ADHD and an increased risk of alcohol use and alcohol-related problems (Blase et al., 2009; Glass and Flory, 2012; Heiligenstein and Keeling, 1995; Kolla et al., 2016) while others have found no significant difference in alcohol use between college students with and without ADHD (Weiss and Hechtman, 1993; Rabiner et al., 2008). Janusis and Weyandt (2010) even shown that college students with ADHD reported lower rates of alcohol use than did their peers without ADHD. However, a meta-analysis indicated that 23.1% of individuals with substance use disorder met DSM-criteria for comorbid ADHD (van Emmerik-van Oortmerssen et al., 2012), which is in line with the idea that individuals with ADHD use alcohol and other drugs to self-medicate the emotional distress arising from the academic, social, and occupational impairment associated with the disorder (Wilens, 1998). Consistent with this theory, emerging research suggests that individuals with ADHD during childhood may be at risk for developing alcohol use disorders (for a review, see Lee, Humphreys, Flory, Liu, and Glass, 2011). But what about the link between ADHD and binge drinking? Is presenting ADHD a predisposing factor leading to excessive alcohol consumption? If previous studies among university students repeatedly demonstrate that binge drinking is related to impulsivity traits (Caswell et al., 2015; Jones et al., 2014; Moreno et al., 2012; Stautz and Cooper, 2013), little is known about the specific contribution of ADHD and its two primary symptom clusters to this dangerous pattern of alcohol consumption. In fact, we found only one study that showed, with a prospective cohort, that participants with childhood or adulthood ADHD were less likely to report heavy alcohol use at age 21 than for those without ADHD (Wang et al., 2019). However, it appears that the slopes of depression and heavy drinking for the older subjects were highly variable and that older individuals with ADHD had significantly faster growth in depression. Thus, the authors suggest that individuals with ADHD may be at greater risk for co-occurring depression and binge drinking. Nonetheless, it should be noted that this research did not examine the potentially specific contributions of the different ADHD symptoms clusters

in excessive alcohol consumption.

In this context, the first goal of the present research was to explore the association between inattention and hyperactivity/impulsivity symptoms and binge drinking in a sample of college students. A recent study has indeed shown the importance of investigating and differentiating ADHD symptom clusters in their relations with problematic alcohol use (Kolla et al., 2016). Researchers have for example highlighted that in a representative of adults, hyperactive symptoms were significantly associated with problematic alcohol consumption in both men and women, while inattentive symptomatology predicted problems with alcohol only in women. This type of results clearly illustrates the value of the distinctive ADHD symptom profiles in alcohol misuse.

Nevertheless, as mentioned above, most of empirical studies investigating ADHD as a risk factor for alcohol use/abuse have yielded inconsistent findings. One explanation for this inconsistency may be that researchers have failed to control for related variables moderating the relationship between ADHD symptoms and alcohol consumption. That is why the current study compares the relative contributions of inattention and hyperactivity/impulsivity to binge drinking by controlling for effects of perceived stress, while analyzing separately the impact of this variable.

Perceived stress has indeed been shown to be associated with alcohol consumption and drinking problem (Ansari et al., 2014; Camatta and Nagoshi, 1995; Sebena et al. 2012). Using daily diary methodology, Armeli et al. (2000) even demonstrated that students consumed more alcohol on days that had events perceived as relatively more stressful, thus offering some consistency to the affect regulation model contending that stress and alcohol use are linked through a transactional process whereby stressors create distress, and individuals self-medicate with alcohol to lessen the unpleasantness of distress. This relationship between stress and alcohol use is also consistent with the tension reduction theory (Conger, 1956), which proposes that alcohol reduces tension and that people drink to experience relief from tension.

Concerning binge drinking as such, another daily process study conducted by Grzywacz and Almeida (2008) highlighted that the odds of binge drinking were higher on days that individuals experienced more severe stressors in contrast to no-stress days. This result suggests that this type of abusive drinking may be a maladaptive coping strategy for stress. Nonetheless, more research is needed to understand the role of stress in binge drinking. The i-Share cohort, which is one of the largest epidemiological studies conducted in European students, offers precisely a new possibility to test whether stress contributes to the risk of being involved in binge drinking.

Thus, if we summarize, the overall aim of the present study was to examine, independently and in combination, the effects of stress and ADHD symptoms on binge drinking in a cohort of college students. Clarifying the respective and cumulative contributions of these two psychopathological dimensions to binge drinking in students could thus open new avenues for designing innovative and effective prevention interventions. Especially since the interconnection between stress, ADHD and binge drinking has never been investigated until now.

2. Method

2.1. Study design and participants

Study subjects were participants in the Internet-based Students Health Research Enterprise (i-Share) project, a prospective population-based cohort study of students of French-speaking universities and higher education institutions. The objectives of i-Share project are to evaluate important health aspects among university students over the course of 10 years, including mental health, risk behaviors, addictions, accidents, infections, and migraines. To be eligible to participate, a student had to be officially registered at a university or higher education institute (within the Universities of Bordeaux, Versailles, and

Nice), be at least 18 years of age, able to read and understand French, and provide informed consent for participation. Participants were invited to participate thanks to a recruitment campaign that started in February 2013. Students were informed about the purpose and aims of the study through promotion campaigns (via information stands at registration, lectures, flyers, social media and newsletters) (see www.i-Share.fr). Furthermore, a group of trained students informed their peers about the study and collected information to initiate the online recruitment process.

Enrollment followed a two-step process. First, a formal pre-registration on the i-Share online portal was required. Then, students were allocated a personal password and could finalize the registration process and completed self-administered online questionnaires. Only students who completed the baseline questionnaire were eligible for our analyses. The baseline questionnaire inquiry collected information on the participant's mental and physical health status, personal and family medical histories, sociodemographic characteristics, and lifestyle habits. Note that the i-Share cohort is still ongoing. For this specific study, we used data available as of May 2016. The i-Share project from which this study was derived was approved by the Commission Nationale de l'Informatique et des Libertés (CNIL) [DR-2013-019].

2.2. Measures

2.2.1. Outcome variable: Binge drinking

Binge drinking was assessed through the question: 'How often have you had five or more drinks of alcohol on one occasion?'. Response options were 'never', 'once a year', 'several times a year', 'once a month', 'once a week', '2 to 3 times a week', '4 to 6 times a week', 'all days'. According to their response, individuals were divided into 4 groups: (a) non-binge drinkers who consumed alcohol (who responded 'never' to the question mentioned above); (b) occasional binge drinkers (who responded 'once a year' or 'several times a year'); (c) intermediate binge drinkers (who responded 'once a month' or 'once a week'); and (d) frequent binge drinkers (who responded '2 to 3 times a week', '4 to 6 times a week', or 'every day'). These categories, commonly used in publications on excessive alcohol consumption (see for example [Gubner et al., 2016](#)), were chosen to characterize frequencies of binge drinking that would correspond with typical patterns of alcohol use among young adults (e.g., less than, equal, or greater than weekend binge drinking, ~4-8 days per month; [Jackson et al., 2010](#); [Kuntsche and Labhart, 2012](#); [Livingston et al., 2010](#)). This distinction between different types of binge drinkers based on binge drinking frequency seemed indispensable. The extent of binge drinking (not just prevalence) is indeed an important factor to consider specific risks and contribute to more effective screening and tailored intervention methods.

2.2.2. Explanatory variables

ADHD symptoms were ascertained using the short-form screener of the Adult ADHD Self-Report Scale Version 1.1 (ASRS; [Kessler et al., 2005](#)), which consists of a checklist of six symptoms that are consistent with the DSM-IV criteria and correspond to the presentation of ADHD symptoms in adults ([Adler et al., 2006](#); [Kessler et al., 2005](#)). Each of the six items explores how often a particular symptom of ADHD has occurred over the past 6 months, using a 5-point Likert-type scale ranging from 'never' (0) to 'very often' (4). Four items relating to inattention symptoms and two to hyperactivity/impulsivity symptoms. To be considered positive, the first three questions require a response ranging from 'sometimes' to 'very often' while the remaining three require an 'often' or 'very often' response. According to the ASRS instructions, participants who have at least four positive responses are at risk of ADHD and may consider taking part in a follow-up assessment with a clinician. The ASRS is indeed a screening tool and not a diagnostic instrument.

Although the dichotomous-scoring method is traditionally used to assess ASRS responses, the advantages of evaluating ADHD symptoms

along a continuum have also been reported ([Overbey et al., 2011](#)). For the present study, we calculated three different scores by summing the items: (1) a global score (6 items); (2) an inattention symptoms score (4 items); (3) a hyperactivity symptoms score (2 items). Scores were then dichotomized according to the 75th percentile of the score distribution. This cutoff was chosen in order to identify a subgroup with a high level of ADHD symptoms in the absence of a validated cutoff in French university students. Note that the ASRS has demonstrated good reliability and validity in community samples and has been reported as an easy to use and cost-effective tool to assess the symptoms of ADHD in college students ([Gray et al., 2014](#)).

Perceived stress was assessed using the short version of the Perceived Stress Scale (PSS-4; [Cohen et al., 1983](#)), a self-report questionnaire which measures the degree to which situations in one's life over the past month are appraised as stressful, that is, how unpredictable, uncontrollable, and overloaded respondents find their lives. The PSS-4 consists of four items with possible responses rated on a scale from 0 ('never') to 4 ('very often'). The global score was obtained by summing all four items with reverse coding for scoring items 2 and 3. Higher scores corresponded to higher perceived stress. As the PSS-4 is not a diagnostic instrument, no cutoff was available to designate individuals as "stressed", but rather, individuals were compared based on their relative stress levels. In our study, scores were categorized as <75th percentile versus \geq 75th percentile. Students in the top 25% were identified as having elevated stress levels. It is important to note that the PSS has demonstrated good reliability and validity in college student samples ([Cohen et al., 1983](#)).

2.2.3. Covariates

Based on the scientific literature on Binge Drinking, we built the following variables using the self-administered online questionnaire: gender (male/female), and student variables (including current place of living [parents' home/student residence/apartment], family financial help [yes/no], job activity [yes/no], sport practice [yes/no], and grade level [first, second, third, and fourth or higher year of university]).

2.3. Statistical analysis

First, we described the sample's characteristics overall and by levels of binge drinking (i.e. non-binge drinkers, occasional binge drinkers, intermediate binge drinkers, and frequent binge drinkers). Second, we performed multinomial logistic regressions using odds ratios (ORs) and 95% confidence interval (CIs) to test the associations between different binge drinking patterns and (a) perceived stress and (b) level of ADHD symptoms. We then examined separately and independently the role of inattention and hyperactivity/impulsivity symptoms in binge drinking, while controlling for potential confounders. In this model, the explanatory variables and covariates (or confounder variables) were introduced simultaneously. Odds ratios and 95% confidence intervals (CI) are presented to reflect association strength. All statistical analyses were conducted with R software (R Core Team, 2013) and statistical significance levels were fixed at $P < .05$.

3. Results

The total sample comprised 7011 participants. [Fig. 1](#) shows the flow chart of the study population. Of the 11,186 individuals who pre-registered on the i-Share study homepage, 7883 fully registered by changing their password and customizing their identification number. For the present study, we included the 7011 participants who met the inclusion criteria and fully completed the baseline questionnaire. [Table 1](#) summarizes the characteristics of the final sample by binge drinking patterns.

The mean age of the participants was 20.9 years (SD = 2.3) and 74.9% were females. The prevalence of never, occasional, intermediate and frequent binge drinking was respectively 16.35 % (1146/7011),

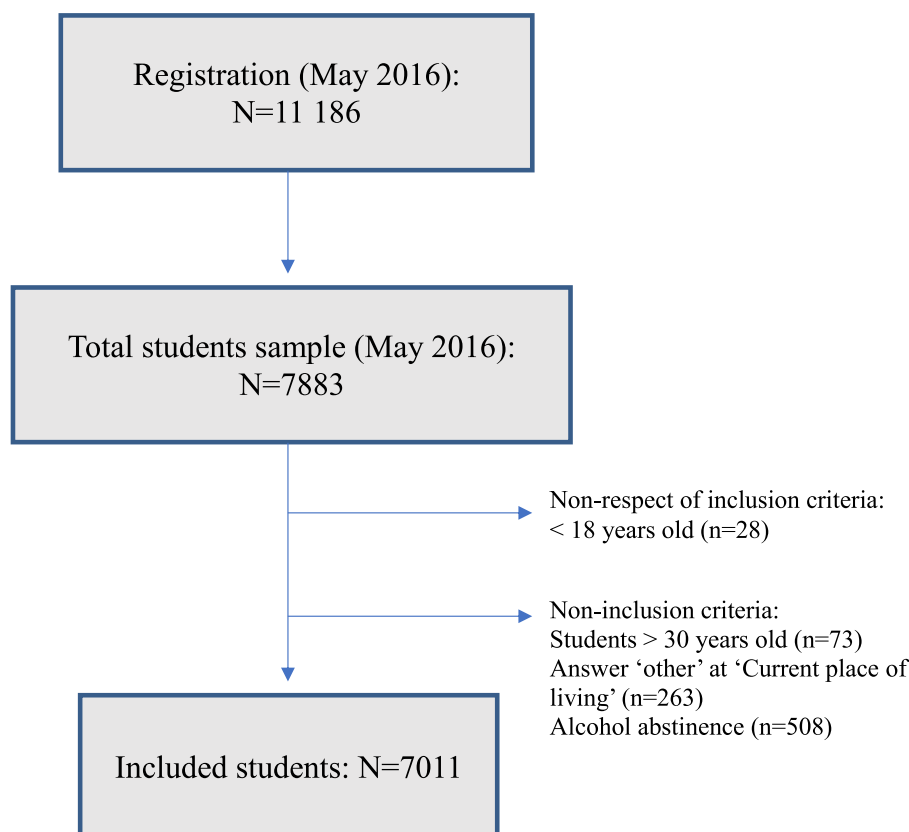


Fig. 1. Participants flow diagram.

Table 1

Characteristics of the Study Population According to Levels of Binge Drinking: i-Share cohort (N = 7011).

	Binge Drinking Types					X^2 test p value
	Total sample (n = 7011) % (n)	Nonbinge drinkers (n = 1471) % (n)	Occasional binge drinkers (n = 2786) % (n)	Intermediate binge drinkers (n = 2417) % (n)	Frequent binge drinkers (n = 337) % (n)	
Gender						<.0001
Male	25.1 (1763)	15.4 (226)	21.7 (604)	31.2 (753)	53.4 (180)	
Female	74.9 (5248)	84.6 (1245)	78.3 (2182)	68.8 (1664)	46.6 (157)	
Study level						<.0001
First year	41.2 (2890)	49.4 (727)	45.5 (1267)	33.1 (799)	28.8 (97)	
Second year	19.3 (1348)	16.4 (241)	15.6 (435)	24.0 (580)	27.3 (92)	
Third year	14.9 (1045)	11.6 (170)	14.1 (393)	17.1 (413)	20.5 (69)	
Fourth or more higher year of university	24.6 (1728)	22.6 (333)	24.8 (691)	25.8 (625)	23.4 (79)	
Current place of living						<.0001
Parents' home	32.3 (2268)	40.3 (593)	33.5 (934)	27.3 (661)	23.7 (80)	
Student residence	11.0 (771)	13.9 (204)	11.2 (311)	9.5 (229)	8.0 (27)	
Apartment	56.7 (3972)	45.8 (674)	55.3 (1541)	63.2 (1527)	68.3 (230)	
Family financial help						.563
No	17.7 (1237)	18.6 (274)	17.8 (497)	16.9 (409)	16.9 (57)	
Yes	82.3 (5774)	81.4 (1197)	82.2 (2289)	83.1 (2008)	83.1 (280)	
Job activity						<.0001
No	59.1 (4142)	66.5 (979)	60.9 (1696)	53.6 (1296)	50.7 (171)	
Yes	40.9 (2869)	33.5 (492)	39.1 (1090)	46.4 (1121)	49.3 (166)	
Sport activity						<.0001
No	52.0 (3648)	53.8 (792)	48.2 (1343)	44.2 (1069)	47.2 (159)	
Yes	48.0 (3363)	46.2 (679)	51.8 (1443)	55.8 (1348)	52.8 (178)	
Perceived stress level						.902
Low	91.5 (6417)	75.8 (1342)	91.4 (2546)	91.8 (2219)	92.0 (310)	
High	8.5 (594)	24.2 (129)	8.6 (240)	8.2 (198)	8.0 (27)	
ADHD symptoms						<.01
Low	95.0 (6664)	96.3 (1417)	94.9 (2643)	94.8 (2292)	92.6 (312)	
High	5.0 (347)	3.7 (54)	5.1 (143)	5.2 (125)	7.4 (25)	

P-values from one-way analysis of variance (non-parametric) and Chi-square tests.

Table 2
Association between Perceived Stress, ADHD symptoms and Binge Drinking Patterns (multinomial regression models): i-Share cohort (N = 7011)

Binge Drinking Types			Stress and ADHD Adjusted		
Unadjusted	Intermediate Binge Drinkers	Frequent Binge Drinkers	Occasional Binge Drinkers	Intermediate Binge Drinkers	Frequent Binge Drinkers
OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Perceived stress level					
Low Reference	Reference	Reference	Reference	Reference	Reference
High 0.98 (0.78-1.23)	0.92 (0.73-1.17)	0.90 (0.58-1.40)	0.95 (0.75-1.19)	0.90 (0.71-1.13)	0.83 (0.54-1.30)
ADHD symptoms					
Low Reference	Reference	Reference	Reference	Reference	Reference
High 1.42* (1.03-1.96)	1.43* (1.03-1.96)	2.1* (1.28-3.43)	1.43* (1.03-1.98)	1.45* (1.04-2.02)	2.16* (1.31-3.54)

Note: Results for multinomial logistic regression models with high level of binge drinking as dependent variable. Calculated ORs had three reference categories, two for the both explanatory variables (low perceived stress and low level of ADHD symptoms) and one for the outcome (nonbinge drinkers category). OR: odds ratio; CI: confidence interval;

* $p < 0.05$.

39.74 % (2786/7011), 34.47 % (2417/7011), and 4.81 % (337/7011).

Frequent binge drinkers were more likely to be male, to be at a higher level of study, to live in an apartment, and to have a job activity (all $p < 0.0001$). They were also more likely to report a high level of ADHD symptoms ($p < 0.01$). However, there were no statistically significant differences in the level of perceived stress according to the frequency of binge drinking.

Table 2 displays the associations between perceived stress, ADHD symptoms in general and frequency of binge drinking. In the unadjusted model, we found significant associations between a high level of ADHD symptoms (global score) and an increasing frequency of binge drinking. There was no significant relationship between the level of perceived stress and the different frequencies of binge drinking. When adjusting for perceived stress, the interconnection between the highest levels of ADHD symptoms and a high frequency of binge drinking remained unchanged. The odds ratios (OR) steadily increased across the low (occasional binge drinkers) and the very high modalities (frequent binge drinkers) of binge drinking patterns. Thus, students with the highest levels of ADHD symptoms reported an OR (95% CI) of 2.16 ($p < .05$) for the high frequency of binge drinking when compared with students with low ADHD symptoms who reported a lower frequency of binge drinking (or not at all).

Given this significant relationship between ADHD symptoms in general and increasing frequency of binge drinking, we then explored the respective influence of each of inattention and hyperactivity/impulsivity symptoms through a multinomial logistic regression, controlling for gender, age, study level, current place of living, job activity, family financial help, sport activity, and perceived stress. This division of ADHD symptoms into inattention and hyperactivity/impulsivity allows determining whether there is a different relation between ADHD symptoms and alcohol use depending on the presentation of ADHD. There is empirical evidence that supports clinically meaningful differences between subtypes of ADHD, as shown by Glass and Flory (2012), who divided ADHD symptoms into inattention and hyperactivity/impulsivity and found that inattention was related to alcohol-related problems, while hyperactivity/impulsivity was not related to alcohol use or alcohol-related problems. The results of this distinction (presented in Table 3) revealed significant associations between a high rate of inattention symptoms and increasing frequency of binge drinking. The odds ratios increased between the intermediate and the very high modalities of binge drinking frequencies. Thus, we can see that students with higher levels of inattention symptoms were more likely to report a very high frequency of binge drinking (OR, 95% CI: 1.96, 95% CI: 1.38-2.79) than those with low levels of inattention symptoms. We also found significant associations between a high level of hyperactivity/impulsivity symptoms and increasing frequency of binge drinking. We can see, for example, that students with the higher levels of hyperactivity/impulsivity symptoms reported an OR (95% CI) of 1.44 [1.00-

Table 3

Associations Between Inattention and Hyperactivity/Impulsivity symptoms and Binge Drinking Patterns (multinomial regression models): i-Share cohort (N = 7011)

	Occasional Binge Drinkers	Intermediate Binge Drinkers	Frequent Binge Drinkers
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Inattention			
Low Reference	Reference	Reference	Reference
High 1.20 (0.97-1.49)	1.46* (1.17-1.81)	1.96* (1.38-2.79)	
Hyperactivity/impulsivity			
Low Reference	Reference	Reference	Reference
High 1.23* (1.00-1.52)	1.26* (1.01-1.56)	1.44* (1.00-2.08)	

Note: Results for multinomial logistic regression models with high level of binge drinking as dependent variable. Calculated ORs had three reference categories, two for the both explanatory variables (low symptoms of inattention and low level of hyperactivity/impulsivity symptoms) and one for the outcome (non-binge drinkers category). Full models adjusted on age, gender, study level, current place of living, job activity, family financial help, sport activity, and perceived stress. OR: odds ratio; CI: confidence interval;

* $p < 0.05$.

2.08] for high frequency of binge drinking when compared with students with low hyperactivity/impulsivity who reported low frequency of binge drinking (or not at all). It is interesting to note that the odds ratios steadily increased across the low and the very high modalities of binge drinking frequencies but that effect sizes were lower in comparison with those for inattention.

4. Discussion

In this large sample of university students, we found significant associations between higher levels of ADHD symptoms in general and increasing frequency of binge drinking. Another important result raised by the present research is that higher levels of inattention and hyperactivity/impulsivity were independently associated with greater frequency of binge drinking. The association was stronger between high frequencies of binge drinking and inattention than for hyperactivity/impulsivity. These findings, which remained statistically significant after adjusting for a range of potential confounders, nuance the results reported by Wang et al. (2019) about the absence of significant relationship between ADHD and heavy drinking among young adults, while being in line with previous research on college students which demonstrated associations between ADHD symptoms and substance use (Kwak et al., 2015; Mesman, 2015), and in particular alcohol-related problems (Blase et al., 2009; Glass and Flory, 2012; Heiligenstein and Keeling, 1995). However, in contrast with these few studies whose sample sizes were moderate, our present research was conducted in a

large population of college students. But more importantly, this is the first study that focused on the contribution of ADHD symptoms (and not just ADHD diagnosis) to binge drinking. Thus, the finding that high levels ADHD symptoms were strongly associated with higher frequency of binge drinking may reflect the fact that students with ADHD use binge drinking as a self-medicating mechanism against the emotional distress arising from the academic, social, and occupational impairment associated with the disorder (see Wilens, 1998). At least that is a plausible interpretation, consistent with the theory that alcohol serves to regulate negative emotions and reduce tension or internal distress. Nonetheless, if we subscribe to this functionalist interpretation, it seems reasonable to suppose that the most stressed individuals should be more likely to report higher frequencies of binge drinking. But that is not the case. Indeed, we did not find any significant association between high levels of perceived stress and the likelihood of engaging in binge drinking.

The results presented in Table 3 allow us to go further and suggest the necessary consideration of impulsivity as an underlying but determining factor leading to binge drinking. Actually, the finding that a high level of hyperactivity/impulsivity symptoms was strongly associated with higher frequencies of binge drinking complements previous research among college-aged students indicating a significant relationship between impulsivity traits and heavy drinking (Caswell et al., 2015; Jones et al., 2014; Moreno et al., 2012; Stautz and Cooper 2013). Therefore, our results and those of earlier research emphasize that binge drinking may result from impulsive decision making and reduced inhibitory control, two key components of impulsivity. The central role attributed to this variable, however, must be nuanced, especially if we take into account the significant association that we found between high levels of inattention and increasing frequency of binge drinking.

Let's remember that the association with binge drinking was stronger for inattention than for hyperactivity/impulsivity symptoms, suggesting that inattention is a predominant factor in propensity to engage in binge drinking. This unprecedented finding is consistent with the results of Glass and Flory (2012) who showed that inattention was predictive of alcohol-related problems even while controlling for childhood conduct disorder symptoms. More recently, Mesman (2015), in a sample of college students, found that inattention, but not hyperactivity/impulsivity, was related to alcohol-related problems even after adjusting for antisocial behavior. Note that this predominance of inattentive symptomatology in the prediction of binge drinking could be explained by the nature of our sample, mostly composed of women. Kolla et al. (2016) have indeed emphasized, from an adult sample, that inattention was related to problematic alcohol use in women, but not in men.

At least, our study provides additional support that inattention may be an important predictor of alcohol-related problems, and binge drinking especially. But how can this finding be interpreted? Mesman (2015) postulates the existence of intermediary causal factors underlying the interconnection between inattention and alcohol-related problems. Based on the premises that (1) youth with ADHD, predominantly inattentive are more likely those with ADHD, combined to present internalizing disorders such as depression and anxiety (Weiss et al., 2003), and that (2) internalizing disorders in college students have been found to be linked to an increased likelihood of alcohol use (Fenzel, 2005; Miller et al., 2002; Mesman 2015) assume that the predictive role of inattention symptoms in alcohol related-problems may be due to the comorbid conditions that are more commonly associated with ADHD, predominantly inattentive. This hypothesis can be transposed to our own result, with the idea that frequent comorbid psychiatric conditions of inattention symptoms may explain why students with higher levels of inattention were more likely to report binge drinking. Note that a recent longitudinal study (Wang et al., 2019) tends to corroborate this idea, showing a significant association between depression and heavy drinking as well as increasing depression for adults with ADHD histories.

This study has a variety of strengths. These include the large community sample of college students, the high rate of females, the standardized assessment of perceived stress, inattention and hyperactivity/impulsivity symptoms, the adjustment for a large range of potential confounders, the homogeneous nature of our cohort that may reduce confounding, and the age group considered, allowing a focus on important phases of developmental transition (i.e., late adolescence, transition to adulthood). Moreover, dimensions of ADHD (i.e., inattention and hyperactivity/impulsivity) were discriminated to better understand potential differences in the presentation of ADHD and its links with binge drinking.

A set of limitations should, however, be considered to properly interpret the findings. First, the cross-sectional nature of our design makes temporal sequences not strictly evaluable, which limits causal inferences. As such the association between ADHD symptoms and binge drinking could reflect the role of inattention or impulsivity in causing engagement in excessive alcohol consumption, but it is also plausible that binge drinking precedes the emergence of these symptoms by disrupting attention abilities and reducing the capacity for self-regulation or inhibitory control. Therefore, future research should incorporate a longitudinal design which would be a way to elucidate the causal structure of this link between ADHD symptoms and binge drinking. Second, biases on measures are possible owing to the use of self-reports. However, self-report measures have been frequently used to confirm ADHD symptomatology in college-aged students, and it has been shown that adults were reliable reporters of current ADHD symptoms (Murphy and Schachar, 2000). In addition, the PSS has demonstrated good reliability and validity in college student samples (Cohen et al., 1983). Third, students were invited to participate in the study and participants were studying at the Universities of Bordeaux, Versailles, and Nice. Therefore, generalizability to other settings may be limited. Fourth, it would also have been of value to control for current antisocial behaviors, which appear to be frequently associated with ADHD diagnoses (Wilens et al., 2002) and alcohol use in college students (Crawford et al., 2004). Besides, given the strong relation existing between internalizing disorders and alcohol-related problems (Fenzel, 2005; Miller et al., 2002; Weitzman, 2004), future investigations controlling for the presence of depression or anxiety would provide additional support of the relation between ADHD symptoms and binge drinking. Last, this study was designed to examine attention and hyperactivity/impulsivity problems independent of a clinical diagnosis of ADHD. Furthermore, due to the Internet-based nature of this survey, both stress and ADHD symptom assessments were based on relatively brief measurement tools. Therefore, generalizability to clinical samples may be limited. Future research would benefit from examining these issues in a clinically diagnosed group.

Despite these limitations, the data presented in this article throw new light on the psychiatric correlates of binge drinking among college students that have important implications for students, health care professionals, and administrators on university campuses. The finding that higher levels of ADHD symptoms were related to an increasing likelihood of reporting higher frequencies of binge drinking even while controlling for perceived stress highlight the importance for universities to implement screenings to better detect ADHD symptoms among college students so that adequate support may be given. In addition, mental health professionals on college campuses should screen students engaged in binge drinking for ADHD symptoms when they first meet them and routinely assess for their presence throughout the course of counseling to determine if they need to be addressed as well.

Because inattention appears to be the most important factor related to binge drinking, professionals who may be providing academic support services for students with ADHD or ADHD symptoms should help them develop compensatory strategies for their inattention (e.g., organization skills, memory enhancement strategies, study skills), which may lessen their risk for heavy ethanol intoxication. This significant relationship between symptoms of inattention and binge drinking

should also encourage more awareness regarding the negative effects of excessive alcohol consumption on attention abilities. Our findings also suggest that targeting hyperactivity/impulsivity symptoms may be particularly important for interventions designed specifically to prevent the phenomenon of binge drinking. Finally, college administrators should provide college students with ADHD or ADHD symptoms psychoeducation about their symptoms and other issues that they may be at risk for while they are in college. This material should include resources for them on campus (e.g., academic support services, mental health services) and how to access it. As a preventive measure, this information could be presented to college freshmen during orientation so that they may be able to access these services before they begin to develop difficulties with their ADHD or ADHD symptoms and adopt inappropriate behaviors such as binge drinking.

Ethics

The authors assert that all procedures contributing to this work comply with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. All participants gave their informed consent prior to their inclusion in the study.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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