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Attentional bias in alcohol drinkers:

A systematic review of its link with consumption variables

Zoé Bollen[1], Matt Field[2], Pauline Billaux[3] & Pierre Maurage[1,*]

[1] Louvain Experimental Psychopathology research group (LEP), Psychological Science Research Institute, Université catholique de Louvain, Louvain-la-Neuve, Belgium.

[2] Department of Psychology, University of Sheffield, Sheffield, United Kingdom

[3] Institute of Psychology, University of Lausanne, Lausanne, Switzerland

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*All correspondence should be sent to:

Pierre Maurage, Université catholique de Louvain, Faculté de Psychologie

Place du Cardinal Mercier, 10, B-1348 Louvain-la-Neuve, Belgium

Tel: +32 10 479245. Fax: +32 10 473774. E-mail: pierre.maurage@uclouvain.be

Abstract

In severe alcohol use disorder (SAUD), attentional bias refers to the preferential allocation of attentional resources toward alcohol-related cues. Dominant models consider that this bias plays a key role in the emergence and maintenance of SAUD. We evaluate the available experimental support for this assumption through a systematic literature review, providing a critical synthesis of studies exploring the links between alcohol consumption and attentional bias. Using PRISMA guidelines, we explored three databases (PsycINFO, PubMed, Scopus) and extracted 95 papers. We assessed their methodological quality and categorized them based on the population targeted, namely patients with SAUD or subclinical populations with various drinking patterns. We also classified papers according to the measures used (i.e., behavioral or eye-tracking measures). Overall, subclinical populations present an alcohol-related bias, but many studies in SAUD did not find such bias, nor approach/avoidance patterns. Moreover, attentional bias fluctuates alongside motivational states rather than according to alcohol use severity, which questions its stability. We provide recommendations to develop further theoretical knowledge and overcome methodological shortcomings.

Keywords: attentional bias, severe alcohol use disorder, social drinkers, alcohol consumption

1. Introduction

Excessive alcohol use constitutes a major public health concern, being a key contributor to the burden of disease and mortality worldwide (Rehm et al., 2017). Severe alcohol use disorder (SAUD) is among the most prevalent psychiatric conditions (Rehm & Shield, 2019), and has well-established physical (Nutt et al., 2010), cognitive (Stavro et al., 2013), and cerebral (Bühler & Mann, 2011) consequences. Beyond SAUD, recent research showed an association between excessive alcohol use patterns (e.g., heavy, hazardous or binge drinking) and physical or mental health issues (Hermens et al., 2013; Jacobus & Tapert, 2013). These results suggested that some deleterious consequences of alcohol arise before the emergence of SAUD.

Dual-process models are among the dominant theoretical proposals conceptualizing the persistence of alcohol use (Wiers et al., 2007). They postulate that decision-making is determined by the interaction between: (1) the “reflective system”, responsible for the deliberative and controlled responses, and (2) the “impulsive system”, that initiates the automatic and appetitive behaviors (Mukherjee, 2010). SAUD would emerge from an imbalance, generated by the under-activation of the “reflective system” (resulting in reduced executive control and working memory abilities), and the over-activation of the “impulsive system”, inducing alcohol craving and attentional bias (AB) toward alcohol-related stimuli (Bechara, 2005; Wiers et al., 2007). Other neuroscientific theories of addictive states have underlined the key role played by the over-activation of the impulsive or reward system when confronted with substance-related stimuli. According to the incentive-sensitization theory (IST; Robinson & Berridge, 1993), the repetition of alcohol exposures sensitizes the dopaminergic response in brain reward areas, enhancing the incentive-motivational properties of alcohol-related cues through associative learning. Becoming more salient, these cues hijack consumer’s attention (generating an alcohol-related AB), acquire an attractive and desirable value, and guide behavior toward alcohol consumption. Most theoretical frameworks thus assume that AB, indexing the over-activation of the impulsive system, is a central feature of SAUD: AB would progressively emerge as a consequence of classical conditioning (according to learning models) and/or through repeated alcohol exposure reducing top-down control (according to dual-process models) and would then constitute a long-lasting characteristic of SAUD once established. Therefore, a first shared prediction of dominant theoretical models is that alcohol AB should be observed in most excessive drinkers, and that its magnitude would be related to the frequency and severity of alcohol exposure (for further discussion about current models' predictions, see Field et al., 2016). That is, individuals with SAUD would present a stronger alcohol-related AB than less intense drinkers. Moreover, a central tenet of these models is that these neuroadaptations (e.g. dopaminergic sensitization; Robinson & Berridge, 1993), resulting in alcohol-related AB, would be stable (i.e. constantly present once instantiated), and possibly permanent in individuals with an history of excessive alcohol use.

Nevertheless, narrative reviews (Christiansen et al., 2015a; Field et al., 2014) have raised doubts regarding AB stability. Indeed, they have underlined the presence of AB fluctuations, particularly according to current motivational states affected by environmental and internal factors (e.g., stress, subjective craving or alcohol cue exposure). The IST had already suggested a positive association between AB and subjective craving, both processes being defined as emotional and cognitive outputs of the sensitized dopaminergic system. An extension of this model (Franken, 2003) further depicts a mutual excitatory relationship between these two processes: when alcohol-related cues (e.g., sights, smells) become the focus of attention, subjective craving increases, which, in turn, enhances the "attention-grabbing" properties of the cues, leading to a vicious circle ultimately leading to alcohol consumption (Field et al., 2008). Therefore, a shared prediction by existing theories is that AB reflects an underlying appetitive motivational process, and is thus positively associated with subjective craving. Consequently, motivational state might influence the expression of AB (Robinson & Berridge, 1993). However, these models postulated that AB is constantly present in individuals with alcohol use disorder once the alcohol-related cues have acquired incentive salience. Hence, while they recognize that AB might slightly vary between or within individuals according to their motivational state, they assume that the attentional processing of these cues strongly differs from healthy subjects, regardless of the current motivational state.

Finally, the involvement of appetitive motivational processes in AB does not exclude a potential influence of aversive motivational processes and motivational conflict (i.e., ambivalence between appetitive and aversive processes) in AB (Field et al., 2016). Specifically, people who want to reduce their alcohol consumption might experience aversion or ambivalence about alcohol-related cues, and thus evaluate them negatively. Consequently, those people may attempt to override their alcohol-related AB in order to regulate their emotional response or subjective craving. SAUD patients recently or currently involved in a detoxification process and hence attempting to remain abstinent might exhibit a pattern of AB that is qualitatively different from the one seen in heavy drinkers, who are not attempting to abstain or reduce their drinking. An alternative theoretical account thus emerged whereby AB is the expression of the momentary motivational evaluation of substance-related stimuli (Field et al., 2016). Specifically, AB would arise from momentary changes in evaluations of these stimuli that can be positive (when the incentive value of the substance is high), negative (when individuals have a goal to stop drinking), or both (when individuals experience motivational conflict). These evaluations of substance-related stimuli could highly fluctuate between and particularly within individuals, questioning previous conceptualizations of alcohol AB as a relatively stable characteristic of alcohol use disorder once established (Robinson & Berridge, 1993; Wiers et al., 2007).

Capitalizing on the proposal that AB constitutes a key factor in alcohol use disorder, numerous experimental paradigms have emerged to quantify this bias (Table 1). Most tasks indirectly assess AB by comparing reaction times (RT) for alcohol-related cues to those for neutral cues. An initial narrative review of these studies presented encouraging results (Field & Cox, 2008): in line with dominant models, the authors suggested that alcohol-related AB is developed through classical conditioning and presents relationships with key alcohol-related factors (e.g., craving, impaired executive functions, abstinence motivation). Meta-analyses further demonstrated a weak but significant relationship between substance-related AB and craving or impulsivity (Field et al., 2009; Leung et al., 2017). However, other narrative reviews highlighted serious methodological and statistical limitations in studies linking AB and alcohol use (Christiansen et al., 2015a; Field et al., 2014). Indeed, the RT measures - derived from the most commonly used paradigms [i.e., visual probe task (VPT) and alcohol Stroop task] - show poor internal reliability (Ataya et al., 2012). Moreover, inferring AB exclusively through RT raises concerns, such measures only offering information about the location at which participants focused their attention at the specific time of probe onset, without indexing the global stream and successive steps of attentional processing involved in AB (Field & Cox, 2008). The interpretation of the direction of AB could be particularly ambiguous when using the modified Stroop task, as attempts to avoid processing alcohol-related words might also result in Stroop interferences for such words (Klein, 2007). A recent paper (Pennington et al., 2021) listed these methodological shortcomings, including the use of unreliable tasks and inappropriately matched control stimuli, or the high variability in design and statistical analyses across studies. An enhanced understanding of AB, beyond unreliable behavioral measures, is therefore needed to refine theoretical models. Such refining would clarify the genuine role played by AB in alcohol use disorders and could promote new interventions to reduce AB. The efficacy and clinical relevance of AB modification interventions in SAUD have been extensively discussed elsewhere (for reviews, see Boffo et al., 2019; Christiansen et al., 2015a; Cristea et al., 2016; Heitmann et al., 2018; Wiers et al., 2018) and will thus not be reviewed here.

One way to determine the genuine usefulness of AB paradigms for applied research is to disentangle the processes involved in AB through innovative measurement tools such as eye-tracking. This non-invasive technique measures the consecutive gaze positions with a high temporal resolution, informing on the time course of eye movements (Popa et al., 2015). Indeed, eye-tracking studies can measure (1) the initial attentional capture occurring quickly and early during a trial, through first saccadic latency (time between stimulus onset and the start of the first saccade) and first area of interest visited (first zone of the stimulus targeted by a fixation); (2) processes related to the controlled maintenance of attention, through dwell time (overall fixation time on each area of interest) and number of fixations (number of times a fixation is made on an area). The combination of eye-tracking with behavioral tasks thus clarifies the spatial and temporal dynamics of AB and assesses the automatic nature of AB, postulated by dominant models. According to dual-process models, AB is considered as a behavioral output of impulsive system's over-activation, giving rise to automatic and uncontrolled behaviors (Wiers et al., 2007). Hence, AB should be related to early involuntary processing stages, which can be distinguished from later and more controlled processes through eye-tracking indexes. A recent systematic review focusing on eye-tracking studies (Maurage et al., 2021) showed incoherent results regarding the modulation of AB by drinking habits. Young heavy drinkers presented a robust AB toward alcohol-related stimuli, as indexed by dwell time, while individuals with long-term abstinence did not show such AB. Moreover, the alcohol-related AB was increased by alcohol expectancy, craving and ambivalence in some studies, but not in others. AB was mostly observed at the late and controlled stages of attentional processing (i.e. longer dwell time for alcohol), raising doubts about its automatic and uncontrolled nature. Finally, some researchers developed novel paradigms to enhance the reliability of AB measures and explore its underlying components (i.e. attentional engagement, shift or disengagement; Heitmann et al., 2020; 2021; Sharbanee et al., 2013). Such approach could help to determine whether AB is also characterized by a difficulty to disengage attention from alcohol-related stimuli, beyond the increased attentional engagement towards these stimuli (Field et al., 2016; Soleymani et al., 2020).

Our paper provides the first comprehensive and systematic review of studies conducted during the last two decades on alcohol drinkers to explore the association between alcohol-related AB and alcohol consumption through behavioral and eye-tracking measures. Following preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines, we compared studies investigating the impact of alcohol use on alcohol-related AB in SAUD and subclinical populations, and assessed their methodological quality. We addressed the three main theoretical issues identified above: (1) the presence of alcohol-related AB in alcohol drinkers and its links with alcohol use intensity; (2) the time course of AB (from early to later processing stages) and its underlying attentional processes (attentional engagement, shift or disengagement); (3) the stability of the bias according to momentary motivational states. We thus selected studies exploring the relationship between alcohol-related AB and alcohol consumption, and also focused on the specific influence of variables related to motivational state. Finally, we evaluated the methodology of the reviewed studies and the added usefulness of eye-tracking to enhance the reliability of AB measures.

2. Methods

2.1. Articles selection

2.1.1. Eligibility criteria

We used the PICOS procedure (Population, Intervention/Exposure, Comparator, Outcome, Setting; Liberati et al., 2009) to determine the inclusion criteria. Regarding the

Population, we only considered studies on human samples, which had to include (a) participants identified as presenting excessive alcohol consumption, determined through standardized diagnosis tools (e.g., DSM-5 criteria for alcohol use disorder) or through alcohol consumption measures with validated cut-offs [e.g., score higher than 7 at the Alcohol Use Identification Test (AUDIT, Saunders et al., 1993), indexing risky consumption], or (b) a valid measure of alcohol consumption [e.g., AUDIT; Timeline Followback (TLFB, Sobell and Sobell, 1992)] and the analysis of this measure as a main variable. We thus excluded animal studies and studies in which alcohol-related measures were only considered as control/secondary variables. Regarding the Intervention/Exposure, we selected studies if they included a validated measure of previous alcohol consumption (i.e., lifetime/recent alcohol exposure). Regarding the Comparator, studies were considered if they offered a direct comparison between an experimental group with alcohol exposure and a matched control group with no/limited alcohol consumption, or a main analysis including alcohol-related measures (e.g., a correlational analysis exploring the influence of alcohol consumption on dependent variables). Regarding the Outcome, we included studies if they proposed an alcohol-related AB measure as a dependent variable. Regarding the Setting, only studies proposing comparisons between groups or experimental conditions (i.e., interventional, observational, cross-sectional) were considered, thus excluding single-case or case series studies, as well as studies without experimental data (i.e., review, meta-analysis, reply, commentary, erratum, conference proceedings, study protocol).

2.1.2. Literature search

We conducted this systematic review following the PRISMA guidelines. We conducted an electronic database search using three databases (PsycINFO, Pubmed, Scopus). The procedure focused on peer-reviewed articles published in English between January 1st 2000 and July 12th 2021. The search phrase combined AB words (i.e., "bias*" AND “attention*”) and a large range of alcohol-related terms (i.e., "alcoholism" OR "alcohol dependence" OR "alcohol use disorder" OR "binge drink*" OR "heavy drink*" OR "social drink*" OR "episodic drink*" OR "college drink*" OR "alcohol"). The initial search identified 1089 papers (299 in PsycINFO, 216 in Pubmed, 574 in Scopus).

We then selected the papers according to a 3-step procedure (Figure 1): First, duplicates were removed, leading to the identification of 619 unique papers. Second, title and abstracts were screened, and papers presenting at least one of the following exclusion criteria were removed: (1) no experimental data; (2) no human sample (i.e., animal study); (3) no AB measure; (4) no substance-use measure. When the title/abstract screening did not allow a clear-cut decision regarding the inclusion of the paper, it was included in the full-text reading phase. This step led to the exclusion of 363 papers. Third, we screened the 256 remaining papers through full-text reading. This led to the exclusion of 161 papers, because they (1) only considered alcohol consumption measures as control variables and/or were centrally focused on other substance abuse or psychiatric/neurological disorders and/or did not report alcohol-related results; or (2) did not include participants with diagnosed SAUD, or with a validly evaluated and clearly labelled excessive alcohol consumption pattern, or did not propose a valid measure of alcohol consumption habits; or (3) did not propose a valid measure of AB toward visual alcohol-related stimuli and/or did not report AB results before intervention. We excluded several studies that, while evaluating alcohol consumption through validated questionnaires, did not (1) report indices of drinking habits (e.g., AUDIT score, drinking frequency/quantity); (2) evaluate the influence of alcohol consumption variables on AB through correlation analyses or between-group comparisons (i.e., low versus high alcohol consumers). In the same vein, whereas many studies investigated the effect of acute intoxication on alcohol AB, our systematic review included solely those conducted on populations with chronic alcohol consumption. To increase the procedure reliability, two independent judges (ZB and PB) performed the literature search. This procedure ended up in the inclusion of 95 papers in the systematic review process.

2.2. Methodological quality assessment (Supplementary Table S1)

We evaluated the methodological quality of each study using an adapted version (Maurage et al., 2020) 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 appeared as the most appropriate for the cross-sectional studies included. However, we performed several adaptations to address our specific needs. Firstly, we removed two items that were not pertinent (i.e., item 3: "Was the participation rate of eligible persons at least 50%?"; item 13: "Was loss to follow-up after baseline 20% or less?"). Secondly, we split some items including sub-questions (i.e., item 4 for participants' selection, item 5 for statistical analyses, item 9 for exposure measures, item 11 for outcome measures and item 14 for confounding variables). The adapted version of the methodological assessment scale used here thus comprised 19 items with a binary answer (Yes/No, corresponding to scores of 1/0), leading to a maximum score of 19. The percentage of "Yes" items was computed, leading to a global quality rating (poor: <50%; fair: 50%-69%; good: 70%-79%; strong: 80% and beyond, adapted from Black et al., 2017). To increase the procedure reliability, two independent judges (ZB and PB) performed the quality assessment. Assessment discrepancies were then discussed with the last author (PM) to obtain a consensus.

2.3. Data extraction and synthesis (Table 2)

We used a systematic data extraction procedure to individually determine the main characteristics of the included studies regarding five categories of variables, adapted from the PICOS protocol: (1) Population (sample size, age, gender ratio, exclusion criteria); (2)

Exposures (psychiatric diagnosis or subclinical characteristics, alcohol consumption measure, psychopathological comorbidities); (3) Comparator [control group (presence and size), matching variables (pre-specified or not statistically differing between groups)]; (4) Experimental design (processes measured, tasks, questionnaires, stimuli used in the AB task, methodology, AB measurements); (5) Outcomes (results regarding alcohol AB, limitations reported, key conclusions regarding alcohol AB).

Firstly, the main results related to quality assessment are described. Secondly, a brief overview of the characteristics presented by the selected studies is reported. Finally, the main outcomes obtained in the included studies concerning alcohol AB are reviewed. For the sake of clarity, this latter part is organized in two sections according to the study population (SAUD patients, subclinical populations), each divided in subsections either focusing on the most commonly used behavioral paradigms (i.e. VPT and alcohol Stroop tasks), alternative ones or eye-tracking data. Finally, each subsection successively presents the findings of studies investigating the three aims of the systematic review: (1) the relationship between alcohol-related AB and alcohol use; (2) the time course and components of AB; and (3) the impact of current psychological state on the association between alcohol-related AB and alcohol use. We chose to emphasize between-group analyses in the result section and we thus only report correlations between AB and alcohol-use variables when studies did not perform between-group comparisons to explore the influence of chronic drinking habits on AB (note that all results are described in Table 2). Moreover, findings regarding the influence of other variables (e.g., comorbidities, demographics, environmental contexts) on the relationship between AB and alcohol use are described in Supplementary Materials.

3. Results

3.1. Quality assessment (Supplementary Table S1)

According to the criteria of the quality assessment tool, five studies presented strong quality, 23 good quality, 62 fair quality and five poor quality. All studies clearly defined their measures of alcohol consumption and alcohol AB, and analyzed AB outcomes based on prior alcohol consumption. Most studies had clear research objectives and characterized participants' drinking pattern through standardized diagnostic tools (e.g., DSM-5 or ICD-10) or valid questionnaires (mostly AUDIT or TLFB). Moreover, the vast majority used established paradigms (mainly the VPT or alcohol Stroop task) with a controlled comparison between alcohol-related and neutral stimuli, and/or between lighter and heavier drinkers, and proposed at least two levels of alcohol consumption to investigate the relationship between alcohol use and alcohol AB. However, key limitations were frequent in the reviewed studies: several studies assessed chronic alcohol consumption using a short timeframe (i.e., less than 6 months), which could reduce the ability to detect the existence of an association between alcohol use and alcohol AB. Other studies did not sufficiently identify characteristics of the sample or confounding variables, as several recruited their participants in the general population, with very limited exclusion criteria and a weak control of comorbidities. Most studies also omitted sample size justification (most studies relying on small samples) and statistical power or effect size computation to estimate the strengths of their findings.

3.2. Global overview

Studies explored the presence and nature of alcohol AB in populations with a vast range of drinking patterns. Twenty-five focused on clinical populations of patients under detoxification treatment diagnosed with SAUD (DSM-V criteria) or alcohol dependence (DSM-IV, DSM-IV-TR or ICD-10 criteria). For the sake of clarity, these patients will be described as SAUD patients. The 'control group' will refer to healthy individuals with low alcohol consumption, when not stated otherwise. The other studies recruited subclinical populations with excessive alcohol use patterns (e.g., heavy drinkers, binge drinkers, social drinkers), which had neither been diagnosed as presenting SAUD nor been involved in an alcohol-related treatment. Some studies focused solely on the relationship between alcohol AB and alcohol consumption, while others also investigated the influence of psychological variables on the association between alcohol AB and drinking habits. Sixty-six studies assessed the presence and magnitude of alcohol AB exclusively through behavioral measures. Among them, 55 used the two most classical tasks, namely the VPT (31 studies) and the alcohol Stroop task (28 studies). Ten studies combined behavioral paradigms with eye-tracking measures and 14 performed newly developed tasks focusing on eye-tracking indexes.

3.3. Study findings

3.3.1. Clinical population

3.3.1.1. Classical behavioral paradigms (VPT and alcohol Stroop task)

Relationship between alcohol AB and alcohol use. Twenty-one studies used behavioral measures to explore AB in SAUD. Sharma et al. (2001) measured alcohol AB through an alcohol Stroop task (see Table 1 for a full description) among detoxified SAUD inpatients and undergraduate students with light or heavy alcohol consumption. Compared to light drinkers, both patients and heavy drinking students showed an alcohol AB indexed by longer RT for alcohol-related words. Other studies found similar findings using the alcohol Stroop task with higher Stroop interferences (Fadardi & Cox, 2006; Lusher et al., 2004; Müller-Oehring et al., 2019) or higher error rates (Duka et al., 2002) for alcohol-related words in detoxified inpatients compared to controls.

Nevertheless, several studies did not replicate these findings, and identified no AB in SAUD. Two studies compared the Stroop performance of abstinent outpatients with controls and did not find a greater AB interference in SAUD (Fridrici et al., 2014; Ryan, 2002). Bollen et al. (2021) used a VPT and found no difference with the control group regarding RT for alcohol-related or neutral stimuli. Den Uyl et al. (2018) investigated the effect of training interventions on alcohol AB in detoxified patients. Their performance at baseline on the VPT did not correlate with alcohol problems. Fridrici et al. (2013) investigated the alcohol AB in detoxified outpatients with regard to individualized (i.e., preferred alcohol drink of each participant) versus general alcohol-related words in an alcohol Stroop task. They found similar RT for the different word categories in patients, while controls showed slower RT for individualized alcohol words, thus indexing the presence of an AB toward individualized alcohol-related stimuli in controls but not in patients. Using a VPT, Van Hemel-Ruiter et al. (2016) showed that adolescents with SAUD do not present alcohol AB just after detoxification or 6 months later. Moreover, changes in SAUD severity was not predicted by changes in AB. However, this might be explained by a substantial dropout rate for this part of the study. In contrast to theoretical models, Townshend and Duka (2007) have even supported the presence of an avoidance AB pattern in detoxified inpatients: they found a negative AB score in patients but not in controls, suggesting the presence of an avoidance AB for alcohol-related stimuli in SAUD, potentially influenced by intensive psychotherapy.

Findings from other studies further suggested that the presence and extent of alcohol AB in SAUD might be related to treatment outcomes. Cox et al. (2002) assessed the variation of AB with time and treatment. Inpatients and matched controls performed an alcohol Stroop task before starting treatment (T1), 4 weeks later (T2) and 3-month after discharge. Patients who remained abstinent or had only a brief drinking episode showed a similar pattern of alcohol AB than controls across time. Relapsing patients showed a strong increase in alcohol interference scores from T1 to T2. However, the large number of heavy social drinkers in the control group call for caution when interpreting those results. In Rettie et al. (2018), while patients before discharge did not differ from controls regarding alcohol interference scores, patients with successful detoxification had lower alcohol interference than relapsing ones, suggesting a predictive role of AB in relapse.

Time course and components of AB. Three studies (Beraha et al., 2018; Noël et al., 2006; Vollstadt-Klein et al., 2009) investigated AB time course in detoxified SAUD patients by manipulating stimuli duration in the VPT. They used different stimulus onset asynchronies (SOAs) to distinguish initial orienting (e.g., at 50ms) from attentional maintenance (e.g., at 500ms or 1250ms). While using similar methodologies, findings from Beraha et al. (2018) and Noël et al. (2006) suggested the presence of an approach-avoidance attentional pattern, dependent upon stimuli duration, specific to detoxified inpatients whereas Vollstädt-Klein et al. (2009) found this pattern in both controls and outpatients with long-term abstinence. Noël et al. (2006) found an initial orienting AB toward alcohol-related stimuli in detoxified patients at very short SOA, but not in controls, followed at a SOA of 500ms by an alcohol AB in controls, but not in patients. No AB was found in both groups when stimuli were presented for 1250ms. Beraha et al. (2018), who explored the effect of Baclofen treatment on AB in detoxified inpatients, showed, at baseline, that patients presented an AB toward alcohol at 500ms and an avoidance AB away from alcohol at 1500ms. In contrast, Vollstädt-Klein et al. (2009) found faster RT for alcohol-related stimuli at very short SOA in both groups, and an avoidance AB for alcohol-related stimuli for long SOA in controls and detoxified outpatients. Another study dissociated the fast/slow processes of alcohol AB (Clarke et al., 2015). Both patients and controls showed a Stroop interference on alcohol-related words (indexing fast processes), but also on the following neutral words (indexing slow processes). Alcohol interference thus occurred on the alcohol-related cue itself, but was also carried over onto subsequent neutral words. The authors underlined the fact that instructions inadvertently primed participants to respond to alcohol-related cues, which might have raised expectancy salience and be responsible for the similar pattern of AB across groups.

Influence of the current state on the relationship between AB and alcohol use. Three studies investigating the relation between AB and subjective craving generated inconclusive findings (den Uyl et al., 2018; Field et al., 2013; Wiers et al., 2016). In Wiers et al. (2016), male detoxified inpatients and controls did not differ regarding RT in the VPT and their performance was not correlated with craving. In den Uyl et al. (2018), patients' performance at VPT did not correlate with craving. In Field et al. (2013), while detoxified outpatients were overall slower at color-naming alcohol-related words compared to neutral ones (unlike controls), no association was found between Stroop interference scores and craving. Conversely, VPT showed no general alcohol AB in patients compared to controls, but patients with high craving showed greater AB scores, and patients with low craving showed lower AB scores than controls for alcohol cues at 500ms. The weak evaluation of comorbidities and biasing variables, the small sample size and the hazardous consumption of control participants call for caution when interpreting those results. Moreover, the inconsistent findings on the relationship between AB and craving, even observed within the same experiment (Field et al., 2013), might be explained by the low level of craving usually reported by detoxified patients. Finally, Sinclair et al. (2016) investigated the influence of current drinking status by administrating a VPT to abstinent and non-abstinent outpatients. Results showed that alcohol-related AB was not correlated with SAUD or abstinence duration. Interestingly, an alcohol AB was present among drinking patients but not among abstinent ones, suggesting a robust association between alcohol AB and drinking status.

3.3.1.2. Alternative behavioral paradigms

Relationship between alcohol AB and alcohol use. Four studies used novel behavioral paradigms to investigate the association between AB and alcohol-related problems. Using the flicker change induced-blindness paradigm, Jones and colleagues (2006) found that, unlike the matched control group, detoxified inpatients were quicker to detect alcohol-related changes compared to neutral changes, indexing an alcohol AB. Waters and Green (2003), using a dual task paradigm, showed that patients, but not controls, were slower to perform peripheral lexical decisions concerning alcohol-related words compared to neutral words. This was also observed at the central odd/even decision task, when patients were exposed to peripheral alcohol-related words compared to neutral words. They concluded that patients show an automatic AB, as their performance was poorer in the presence of alcohol-related stimuli. Finally, Garland (2011) measured AB through a spatial cueing task in long-term abstinent patients. Patients did not show any AB, but AB score was positively associated with previous alcohol consumption.

Time course and components of AB. One study dissociated the engagement and disengagement components of alcohol AB in SAUD outpatients using the Odd-One-Out task (Heitmann & de Jong, 2021). Results did not show higher engagement or disengagement biases in patients compared to controls, but participants made many errors in the task which might have reduced its sensitivity to detect AB.

3.3.1.3. Eye-tracking data

Relationship between alcohol AB and alcohol use. So far, only one study used eye-tracking technology in SAUD population to explore alcohol-related AB (Bollen et al., (2021). By combining VPT with eye-tracking measures, they showed the absence of early automatic attraction toward alcohol cues among patients, as indexed by first fixation direction and duration. However, patients avoided processing alcohol-related stimuli after a first fixation on non-alcohol stimuli, as indexed by less second fixations toward alcohol compared to controls. Moreover, patients presented shorter dwell times for alcohol-related stimuli. Eye-tracking indexes achieved excellent reliability and suggested the presence of a late avoidance AB in detoxified inpatients.

Influence of the current state on the relationship between AB and alcohol use. Bollen et al. (2021) found a positive correlation among SAUD patients between dwell times for alcohol-related cues and craving at testing time.

3.3.2. Subclinical populations

3.3.2.1. Classical behavioral paradigms

Relationship between alcohol AB and alcohol use. Nineteen studies explored the presence of AB in subclinical populations using classical behavioral paradigms. Elton et al. (2021) reported higher AB in individuals reporting greater current binge drinking. Similar findings were found in Langbridge et al. (2019), who evaluated alcohol AB in binge drinkers before intervention. Higher alcohol AB scores were found at baseline in binge drinkers compared to non-binge drinkers. The small sample size of non-binge drinkers calls for caution when interpreting their findings. Using a longitudinal design, Janssen et al. (2015) and Pieters et al. (2014) investigated whether alcohol AB would be predicted by alcohol use and/or whether it would predict the development of adolescent alcohol use. In Pieters et al. (2014), alcohol-related AB did not predict changes in alcohol use. In Janssen et al. (2015), data regarding weekly alcohol use were collected at four time points (within a six-month interval) and alcohol AB was assessed at T1 and T4 through VPT and Stroop tasks. Results showed that: (1) alcohol AB at baseline was not correlated with alcohol use at any time point, (2) alcohol AB, measured by VPT, significantly predicted weekly alcohol use at each time point except T1. Alcohol AB thus did not predict early alcohol use but predicted later drinking intensity. In van Duijvenbode et al. (2012), light, moderate and heavy drinkers did not differ for RT in the VPT, showing no association between AB and drinking patterns. The composition of groups was however based on invalid AUDIT cut-off scores. Three other studies on problematic and light drinkers also found no alcohol AB among these groups (van Duijvenbode et al., 2016; 2017a; 2017b). Luehring-Jones et al. (2017) administered a VPT to young social drinkers before intervention but did not find any association between AB and alcohol use. Van Hemel-Ruiter et al. (2015) showed that alcohol AB did not correlate with adolescent alcohol use, and did not mediate the relationship between reward sensitivity and alcohol use. In Willem et al. (2013), alcohol consumption in the last 3 months did not correlate with alcohol AB in adolescents and young adults. Interestingly, three studies found an association between AB and alcohol consumption in specific populations: Emery and Simons (2015) showed a positive association between AB and alcohol use in men. Conversely, Groefsema et al. (2016) found that women presented higher AB. Finally, Pieters et al. (2011) showed an association between AB and (1) alcohol frequency/intensity only in early adolescents with an OPRM1 (i.e., polymorphism reflecting both liking and wanting processes) risk genotype; (2) problem drinking only in young adult men with DRD4 (i.e., polymorphism reflecting wanting processes) risk genotype.

Among the VPT studies, six investigated how stimuli properties might influence AB. Townshend and Duka (2001) administered a VPT using words or pictures in heavy and occasional social drinkers. Heavy drinkers showed greater AB than occasional drinkers only in the picture task. Miller and Fillmore (2010) compared AB toward simple (isolated alcohol-related cue) and complex (alcohol-related cue inserted in an elaborated scene) images in adult regular drinkers. AB was present only with simple stimuli and was associated with heavy drinking. Nevertheless, complex stimuli require the processing of non-alcohol-related features and increase the need for visual search and scan, which could lower the attentional capture by alcohol-related stimuli. The association between AB and alcohol consumption is however not consistent across studies. Groefsema et al. (2016) determined whether social drinkers show AB specific to social alcohol-related stimuli. Participants performed a VPT with alcohol-related and soft drink pictures depicting social or non-social contexts. AB was not correlated with weekly alcohol use and AUDIT. Moreover, participants presented longer RT for social pictures - independently of drink type -, suggesting stronger AB for social stimuli compared to alcohol-related stimuli in social drinkers. Bollen et al. (2020) measured AB in binge drinking and clarified the specificity of AB for alcohol-related stimuli, compared to other appetitive stimulations. Binge drinkers did not differ from controls when performing VPTs that compared alcohol-related stimuli with soft drink or food stimuli. However, RT-based AB measures presented poor internal reliability. Christiansen et al. (2015b) showed that the reliability of the VPT and the intensity of RT-based AB was higher when using personalized stimuli among social drinkers. However, no correlation was observed between AB and alcohol consumption, thus indexing poor construct validity. Jones et al. (2018) included personalized stimuli, repeated time measurements and different variations to improve the VPT. Results showed that: (1) AB did not change across time, (2) AB was not correlated with alcohol consumption, (3) alcohol AB toward personalized cues did not differ from AB to standardized cues. Altogether, these findings raise concerns regarding AB assessment using the VPT as its poor reliability was consistently evidenced across stimuli, analyses, and protocols.

More significant findings were observed in the eleven studies using the alcohol Stroop task. Fadardi and Cox (2008) showed that alcohol consumption was positively predicted by alcohol Stroop interference in social drinkers. Murphy and Garavan (2011) showed that AB could discriminate problem from non-problem drinkers. In Albery et al. (2015), alcohol Stroop interferences were found in heavy social drinkers (but absent in light social drinkers) - with groups based on only two AUDIT questions. In Fadardi and Cox (2009), higher alcohol Stroop interferences were found in harmful and hazardous drinkers compared to social drinkers before intervention. In a similar intervention study (Luehring-Jones et al., 2017), alcohol Stroop interference at baseline was correlated with the number of drinks per occasion in young social drinkers, but not with AUDIT score or the number of occasions per week. In Carrigan et al. (2004), alcohol Stroop interference was associated with alcohol dependence, but not with drinking frequency/quantity. Bruce and Jones (2004) explored AB through a pictorial Stroop task in light or heavy social drinkers - based on their alcohol consumption during the heaviest drinking day of the previous week. Despite the limited evaluation of chronic consumption and small sample size, the authors concluded for the presence of alcohol-related AB, indexed by higher alcohol Stroop interferences, in heavy social drinkers. In Christiansen and Bloor (2014), undergraduate social drinkers performed three versions of the task: control Stroop (containing soft drink-related words), general alcohol Stroop (containing alcohol-related words) and individualized alcohol Stroop (containing words related to participants' favorite alcohol beverages). Whereas RT did not differ across tasks, only the individualized alcohol Stroop task predicted variance in alcohol involvement, thus showing a higher predictive value for alcohol consumption when exposed to their favorite beverages. However, potential carry-over effects, due to blocked format of the tasks, might have exaggerated the AB in the individualized Stroop task.

Conversely, three of those studies did not observe such relationship between AB and alcohol consumption, even when investigating the psychometric properties of the alcohol Stroop task through ecological momentary assessment (EMA) settings (Spanakis et al., 2018; Suffoletto et al., 2019). In van den Wildenberg (2006), alcohol Stroop interference in male heavy drinkers was unrelated to alcohol use and problems. In Spanakis et al. (2018), social beer drinkers performed a general and an individualized alcohol Stroop task either on a computer in laboratory settings or on a smartphone at home (EMA settings). They showed slower responses to alcohol-related words compared to neutral words in the general Stroop task, but no difference regarding the type of images in the individualized Stroop task. AB in both tasks did not predict alcohol consumption, regardless of the settings. The alcohol Stroop task showed better psychometric reliability in ecological settings, but the absence of association between AB and alcohol consumption showed its poor predictive validity. Suffoletto et al. (2019) investigated AB through EMA over 14 weeks using smartphone apps.

Young adult risky drinkers performed an alcohol Stroop task weekly and reported their alcohol consumption twice per week. AB did not correlate with baseline consumption and did not predict same day binge drinking. Ecological assessments of AB among risky drinkers are thus not robustly related with baseline or same-day consumption.

Time course of AB. Four studies investigated the temporal dynamics of AB in subclinical drinkers by adapting classical paradigms. Field et al. (2004) dissociated initial orienting from attention maintenance in AB, by manipulating stimuli duration in the VPT. Heavy drinkers had greater AB scores than light drinkers for stimuli with longer exposure durations (500-2000ms) but not for shorter ones (200ms). Despite a limited sample size, they concluded that heavy social drinkers presented an AB in the maintenance but not in the initial orienting of attention. The task was further manipulated by two online studies using a cued VPT (Gladwin, 2017; Gladwin et al., 2020). The former study (Gladwin, 2017) firstly investigated the variability of AB (i.e., short-time fluctuation in AB) among students by focusing on intra-individual variability rather than median/mean value of VPT measure. Their results showed that high AB variability was associated with riskier drinking. Secondly, they used a cued VPT with arbitrary cues signaling the location of subsequent alcohol or non-alcohol stimuli. Participants with risky drinking behavior were slower for probes appearing at the location of cues predicting soft drinks stimuli, suggesting that predictive cues could capture the attention related to alcohol use. However, the effects from this cued version were weaker and required a longer training period. The latter study (Gladwin et al., 2020) tested the reliability of anticipatory alcohol AB assessed by the cued VPT, and determined whether its reliability might be attributed to various aspects of the predictive cues. To do so, participants performed several variations of the task, including the use of non-predictive cues. Only participants who performed predictive versions of the task showed an AB, but without association between AB and risky drinking. The alcohol Stroop task has also been modulated to dissociate the time course of AB in subclinical drinkers. Hallgren and McCrady (2013) investigated the association between AB and alcohol involvement in college students with recent binge drinking, by using an alcohol Stroop task with immediate (i.e., current-trial responding) and delayed (i.e., subsequent-trial responding) interference measure. Participants responded more slowly when two alcohol words (compared to two neutral words) were presented sequentially. They also analyzed participants' performances based on their alcohol involvement. No RT difference was found regarding drinking frequency or problematic alcohol use but high-intensity drinkers showed a delayed interference effect of alcohol-related words.

Influence of the current state on the relationship between AB and alcohol use. Twelve studies explored the impact of motivational and/or temporary variables on AB among subclinical drinkers using classical paradigms. Baker et al. (2014) investigated the role of motivational orientations (approach/avoidance motivation for alcohol) on AB in heavy drinkers. Participants were randomly allocated in different groups of implicit priming: alcohol-appetitive, alcohol-aversive or neutral primes. They performed a VPT, each trial being subliminally preceded by a word prime. Results showed: (1) no effect of subliminal priming of alcohol-appetitive or alcohol-aversive motivational states on AB; (2) the presence of an avoidance AB for alcohol cues presented for 50ms and no AB when presented for 500ms; (3) a small but positive correlation between AUDIT and AB. However, the use of a response window, while maximizing masked priming effects, might have invalidated RT measures.

Three studies showed how *in vivo* alcohol cue exposure impacts AB in students. In Cox et al. (2003), participants performed an alcohol Stroop task immediately after being exposed to either an alcohol or non-alcohol beverage. Results showed that alcohol interference scores were predicted (1) solely by consumption (as calculated by annual absolute alcohol intake scores), (2) only in heavier consumers and (3) when previously exposed to an alcohol beverage. Nevertheless, the reliability of such results might be questioned since the task was administered through physical cards and RT were measured using a watch. Moreover, no information was provided regarding the experimental groups (e.g., sample size, matching variables). In Ramirez et al. (2015a), underage college student drinkers performed a VPT after being exposed to a beer or water cue-reactivity procedure in two separate sessions. Participants showed faster RT for alcohol-related stimuli only in alcohol-CR session, and the AUDIT was negatively correlated with AB only in water-CR session. In-vivo exposure to alcohol cues thus led to a stronger AB in student drinkers. The authors further examined whether momentary decreases in craving were associated with reduced AB by extending the duration of alcohol-cue exposure protocols (Ramirez et al., 2015b). AB at baseline did not correlate with craving nor consumption. Both brief and extended alcohol-cue exposure increased craving and AB, and craving changes predicted AB changes among women in the long exposure group.

Five studies measured subjective craving to explore its influence on AB. In Field et al. (2005), social drinkers were split into low/high craving groups. Results showed that: (1) higher cravers presented greater AB scores in the VPT; (2) AB positively correlated with craving but not with alcohol-seeking behavior or alcohol consumption. These findings were however constrained by a small sample size. The positive association between AB and craving was also found in other studies. Field et al. (2004) found a positive correlation between craving and AB scores, when social drinkers performed the VPT with long stimulus duration. In Field et al. (2007), adolescent heavy drinkers, but not light drinkers, were slower at naming alcohol-related words than neutral words, these interference scores being correlated with craving. However, alcohol-related AB did not correlate with craving in other previously described studies (Christiansen et al., 2015b; Jones et al., 2018).

Finally, three studies investigated the effects of acute intoxication or hangover on AB. In Duka and Townshend (2004), social drinkers were randomly allocated in the placebo, 0.3g or 0.6g/kg alcohol pre-load conditions. Only the low alcohol dose group showed a significant AB in the VPT. A negative correlation was found in the high alcohol dose group between AB and consumption. When performing the alcohol Stroop task, results showed no difference on RT between conditions or stimuli. The high alcohol dose group, however, made more errors for the alcohol-related words. Findings from the VPT showed that the administration of low alcohol dose prime AB, whereas high alcohol dose might induce a state of satiation and, thus, decrease the salience of alcohol-related stimuli. However, besides the low sample size, findings from the VPT are inconsistent with the errors made in the alcohol Stroop task - which were increased only by the priming of high alcohol dose. In Fernie et al. (2012), both moderate and heavy drinkers were administered 0.4g/kg alcohol or placebo in a within-subject design and performed a VPT at both sessions. Results showed no difference in RT between moderate and heavy drinkers, or between alcohol or placebo condition. AB was therefore unaffected by drinking habits or intoxication. Participants were however not asked to abstain from alcohol in the previous days, which might have affected results regarding the alcohol or placebo condition. Gunn et al. (2021) examined the influence of hangover on cognitive processes. Student drinkers performed a VPT the day following consumption (hangover condition) and at least 24h after alcohol consumption (no-hangover condition). Hangover did not influence performance, and no AB was found, regardless of hangover (as AB scores did not differ from zero in either condition) or drinking habits (AUDIT scores).

3.3.2.2. Alternative behavioral paradigms

Relationship between alcohol AB and alcohol use. As the most widely used tasks of AB repeatedly showed poor reliability (Ataya et al., 2012), eight studies developed new AB tasks. Three studies showed an association between AB and alcohol consumption in subclinical populations, using the flicker change induced-blindness paradigm. Jones et al. (2002) investigated alcohol AB in social drinkers using the flicker paradigm with a visual scene containing both an alcohol-related and a neutral change. Participants who detected the alcohol-related change showed higher consumption than those who detected the neutral change. In Jones et al. (2003), heaviest drinkers detected the alcohol-related change faster than lightest drinkers, and quicker than the neutral change. Moreover, lightest drinkers detected the neutral change faster than heaviest drinkers, and quicker than alcohol-related change. However, these two studies based their conclusions on a single trial and based their evaluation of chronic consumption solely on report of the heaviest drinking day in the last week, which hampers the generalization of these findings. In Hobson et al. (2013), students had to detect the change in complex stimuli either depicting real world scenes or a grid of alcohol-related and neutral pictures. They showed that heavier drinking patterns were associated with increased percentage of alcohol-related changes detections in real world scenes. Using a similar task, Knight et al. (2018) investigated AB in heavy and light social drinkers using an alcohol-change detection task. Heavy drinkers were more sensitive to alcohol changes in neutral-alcohol trials (i.e., all images originally neutral, one changing into an alcohol-related image) than light drinkers, indexing the presence of an AB. Pennington et al. (2020), who explored the psychometric properties of their newly developed visual conjunction search task in social drinkers, reported similar results. Participants showed, overall, faster RT for alcohol-related cues, indexing the presence of an alcohol AB predicted by AUDIT and alcohol consumption. Heitmann et al. (2020) also investigated the psychometric properties of newly developed alcohol AB measures using a visual search task. Its validity was tested by examining the association between AB index with alcohol use quantity/frequency or alcohol use problems. Their results showed however that AB presented a positive but weak association only with alcohol use frequency. Nikolaou et al. (2013) investigated AB in social drinkers using a concurrent flanker/alcohol AB task. The flanker effect difference score (i.e., flanker effect in the presence of alcohol minus neutral pictures) was associated with higher alcohol consumption. Finally, Brown et al. (2018) determined whether goal-driven mechanisms could account for involuntary AB toward task-irrelevant alcohol distractors in social drinkers. They conducted various versions of the rapid serial visual presentation paradigm to test the replicability of their effects. Overall, results showed that distractor interference was not correlated with consumption.

Time course and components of AB. Beyond the modulation of classical tasks, novel paradigms were also developed to investigate the temporal dynamics of AB. Three studies examined AB at encoding through an attentional blink paradigm (DePalma et al., 2017; Elton et al., 2021; Tibboel et al., 2010). DePalma and colleagues (2017) administered word-based and pictorial-based versions of the task in binge drinkers. They explored whether AB was due to increased efficiency of attentional processing of alcohol cues at early encoding levels, thus reflecting more automatic processes. Binge drinkers did not show any attentional blink for alcohol cues, indexing an increased efficiency to process these cues at early levels. They, however, presented a delayed attentional blink for non-alcohol cues. Non-binge drinkers showed an early attentional blink, similar for alcohol and non-alcohol word cues, but reduced for alcohol compared to control images. Binge drinkers might therefore be more efficient in the processing of alcohol-related cues at early encoding levels than non-alcohol targets or non-binge drinkers, indexing the presence of an AB. Similar findings were reported in Tibboel et al. (2010), as heavy drinkers showed a smaller attentional blink effect for alcohol-related words compared to soft drink words, this effect being identical for both words in light drinkers. Under high cognitive load (i.e., at smaller lag), alcohol-related stimuli were processed more efficiently than soft drinks in heavy drinkers, reflecting an AB at encoding. Nevertheless, the low reliability of the task, the small sample size and the near-ceiling performance call for caution when interpreting these findings. Finally, Elton et al. (2021) showed that AB – indexed here by greater attentional blink following an alcohol distractor – was associated with greater binge patterns of drinking during adolescence.

Four studies investigated the engagement and disengagement processes of alcohol AB in subclinical drinkers. In Gladwin et al. (2013), social drinkers had to perform a spatial cueing task with approach-alcohol (i.e. instructions to direct attention towards alcohol and away from non-alcohol cues) and avoid-alcohol (i.e. opposite instructions) blocks to evoke conflict between automatic alcohol AB and task instructions. Their results showed that social drinkers were faster to shift their attention to an invalidly cue location following alcoholic versus non-alcoholic cues. Two other studies dissociated engagement/disengagement components of AB using the Odd-One-Out task (Heitmann et al., 2020, 2021). Firstly, they tested its validity by examining the association between AB indices with drinking quantity/frequency or alcohol use problems (Heitmann et al., 2020). The index of attentional disengagement showed a positive but weak association with drinking quantity/frequency, while the engagement index was associated with drinking frequency only in males. Alcohol AB processes related to attentional disengagement was thus associated with consumption in students. Secondly, they improved the low reliability of the task to provide a solid assessment of engagement/disengagement bias toward alcohol-related stimuli (Heitmann et al., 2021). The adapted Odd-One-Out task had more distinct contrast stimuli, more trials, practice trials and was administered in an alcohol-related context (i.e., a bar). High drinkers presented a greater engagement AB toward alcohol-related cues when performing the adapted task. Groups did not differ regarding disengagement AB index or when performing the original task. The internal consistency of the adapted task was increased but remained under acceptable threshold. Moreover, the study design did not distinguish contextual effects (bar/laboratory) from task modifications. The dissociation between engagement and disengagement processes was further explored through a selective-attention/action-tendency task (Sharbanee et al., 2013). Social drinkers were divided based on consumption regulation abilities. Results showed that: (1) dysregulated drinkers presented a greater AB in disengagement trials, while groups did not differ on alcohol AB in engagement trials; (2) disengagement AB scores predicted variance of drinking-group status. AB, indexed by a difficulty to disengage from alcohol cues, thus contributes to dysregulated drinking. To sum up, three studies showed an AB specifically observed at the disengagement level (Gladwin et al., 2013; Heitmann et al., 2020; Sharbanee et al., 2013) while another one located the AB at the engagement level (Heitmann et al., 2021).

Influence of the current state on the relationship between AB and alcohol use. Four studies explored the impact of craving on alcohol AB in subclinical drinkers. Hobson and colleagues (2013) showed that both higher consumption and higher craving were associated with increased percentage of alcohol-related changes detection in a flicker induced-blindness change paradigm. However, alcohol-related AB did not correlate with craving in some previously described studies (Heitmann et al., 2020; Pennington et al., 2020; Tibboel et al., 2010).

3.3.2.3. Eye-tracking data

Relationship between alcohol AB and alcohol use. Six previously described studies used eye-tracking to enhance the reliability of AB measures. Miller and Fillmore (2010) explored the effect of stimuli properties on AB using a VPT with simple and complex images. AB indexed by dwell times was found only for simple images in regular drinkers. Nevertheless, eye-tracking measures constituted a more robust evaluation of alcohol AB than behavioral ones, the effect size of AB indexed by dwell times being twice larger. Christiansen et al. (2015b) showed that the joint use of eye-tracking measures (dwell times), and personalized stimuli increased task reliability up to .76. The validity of the task was however questioned, as no correlation was found between AB and alcohol use. In van Duijvenbode et al. (2012), participants with long term abstinence were grouped in light or heavy drinkers for eye-tracking analyses. Participants did not present AB, independently of their past consumption. Van Duijvenbode et al. (2017a) identified the presence of AB (based on eye-tracking measures) in a large sample of participants. However, AB intensity did not differ according to alcohol consumption. The increased reliability of the VPT by using eye-tracking measures was not found in Jones et al. (2018): eye-tracking measures showed poor reliability and validity, which questions the use of the VPT to assess AB. More surprisingly, the global behavioral AB found in a flicker paradigm used by Hobson et al. (2013) was not observed among heavy drinkers when analyzing eye-tracking measures. This could be partly explained by the instructions, which limited the maintenance of attention on the target stimulus.

Four studies investigated alcohol-related AB only through eye-tracking. In Weafer and Fillmore (2012), beer drinkers performed a free viewing task. Higher drinkers showed longer dwell times toward alcohol-related scenes, thus showing that AB was related to alcohol consumption. Three studies investigated AB through a gaze contingency paradigm, an eye-tracking task measuring the ability to inhibit the orientation of attention toward peripherally appearing alcohol-related stimuli (Brown et al., 2020; Qureshi et al., 2019; Wilcockson & Pothos, 2015). Wilcockson and Pothos (2015) found a positive correlation between break frequency (inability to inhibit saccade toward peripheral stimulus) for alcohol-related stimuli and weekly consumption in male undergraduate students. However, the mean break frequency rate for alcohol-related and neutral stimuli was only 1.10 and 1.02 respectively for 32 trials in total, indicating a very low error rate. In Qureshi et al. (2019), problem and non-problem drinkers performed a gaze contingency paradigm with appetitive alcohol, appetitive non-alcohol, and non-appetitive stimuli. For centrally-located stimuli, problem drinkers showed higher break frequency for non-appetitive stimuli compared to alcohol ones. In contrast, they observed, for peripheral stimuli, a higher break frequency toward both appetitive (i.e., alcohol and non-alcohol) stimuli among problem drinkers. Inhibitory control on saccadic movements for appetitive stimuli might thus be improved when covert attentional processing is possible, and AB was not specifically related to alcohol stimuli. Finally, Brown et al. (2020) found a positive correlation between AUDIT and alcohol-related break frequency, as well as higher break frequency for alcohol-related stimuli when comparing high against low hazardous drinkers. High hazardous drinkers were thus more frequently distracted by alcohol stimuli.

Time course and components of the AB. Eight studies dissociated initial orienting and maintenance of attention using eye-tracking. Ceballos et al. (2009) used a free exploration paradigm when presenting images (alcohol-related stimuli, household objects, or both) among college drinkers. Positive correlations were found between consumption (quantity-frequency index) and eye-tracking. The authors suggested that consumption intensity among college students was simultaneously related to a higher automatic attraction toward alcohol and to a stronger tendency to focus voluntarily on alcohol-related stimuli. However, the imprecise alcohol consumption measure, combined with the low global consumption in this sample and the continuous approach chosen, raise questions regarding the role played by alcohol consumption in the results. Soleymani et al. (2020) investigated the psychometric value of a free-viewing eye-tracking task to assess AB. Students freely explored 4x4 matrices of alcohol and soft drink images. In the first session, longer dwell times and higher number of first fixations on alcohol-related cues, as well as shorter first fixation latency on soft drinks, were associated with stronger alcohol problems. Findings from the second session showed weaker evidence for criterion validity, with only first alcohol fixations being associated with AUDIT scores. Bollen et al. (2020) explored the time course of AB by dissociating early and late processing stages in binge drinkers. All participants performed the drink, drink-food and food conditions of the VPT. Binge drinkers and controls did not differ on eye-tracking measures of early processing in any condition. Dwell times, however, highlighted the presence of AB toward soft drinks and healthy food among controls, without global alcohol AB in binge drinkers.

Three studies distinguished automatic and controlled processes of AB among adolescents (McAteer et al., 2015; 2018; McGivern et al., 2021). In McAteer et al. (2015), heavy, light and non-drinkers performed a free visual exploration task. None of them showed an automatic orienting to alcohol stimuli (location/speed of the initial fixation). Heavy drinkers showed a significant increase in dwell times for alcohol-related stimuli, particularly during the second part of stimuli presentation (1500-2500ms), indexing prolonged or fixed attention. The authors concluded that AB might be underpinned by controlled rather than automatic processes. They further explored AB on the free viewing task (McAteer et al., 2018) according to age (early adolescents, late adolescents, young adults) and drinking pattern (heavy, light and non-drinkers). Results replicated previous findings, as heavy drinkers showed longer dwell times for alcohol-related stimuli than light drinkers, independently of age. Moreover, an increased percentage of first fixation toward alcohol-related stimuli was observed in young adults when compared to late adolescents, independently of consumption. Heavy drinking thus appears associated with AB and underpinned by controlled processes. Age is related to a higher automatic capture of attention, indexing a progressive rise of the automatic attention hijack by alcohol-related stimuli with age. Here again, the absence of genuine AB and results going against the main conclusions (e.g., no age or alcohol consumption effect on early or late attentional processes) strongly reduced insights brought by this study. Using the same methodology, McGivern et al. (2021) explored the different components of alcohol AB in a small sample of adolescents. Heavy drinkers performed longer first fixations toward alcohol than abstainers, indicating the presence of a delayed disengagement bias. They also showed more fixations and longer dwell times for alcohol-related stimuli than abstainers, indexing a maintenance bias. Heavy and light drinkers did not differ from abstainers regarding the direction of their first fixations, suggesting the absence of a vigilance bias in adolescents. Finally, heavy drinkers showed longer alcohol dwell times than light drinkers and abstainers in the first half of stimuli presentation (indexing early attentional processes), while both heavy and light drinkers showed longer alcohol dwell times than abstainers in the second half (indexing late attentional processes).

Roy-Charland et al. (2017) proposed a more dynamic exploration of attention, by analyzing the global pattern of saccadic eye movements produced by undergraduate students when freely exploring complex visual scenes (with/without alcohol cues). The first experiment did not show any AB or any correlation between eye-tracking indexes and consumption. The second one, where participants had to memorize a visual scene, demonstrated a positive correlation between consumption and the number of saccades toward and away from alcohol-related zones (measuring the tendency to draw back their attention to these zones). The number of saccades toward alcohol-related stimuli in complex scenes was associated with consumption only when instructions motivated the participants to attend to them. Monem and Fillmore (2017) explored alcohol AB in natural settings. Portable eye-tracking glasses were combined with video recording while participants freely explored, during two sessions, a recreational room containing objects, including alcohol beverages and matched soft drinks. Results showed (1) no AB during the first session, (2) a habituation effect during the second session for soft drinks (i.e., reduced dwell times) but not for alcohol stimuli, indicating an alcohol AB, (3) a correlation between AB and consumption intensity.

Influence of the current state on the relationship between AB and alcohol use. Six studies investigated the effect of craving on subclinical drinkers by using eye-tracking measures. Hobson et al. (2013) demonstrated that eye-tracking indices of AB were related to craving but not to consumption. Indeed, they did not find any global AB in heavy drinkers, but showed faster saccades toward alcohol-related stimuli in real world scenes among individuals with higher craving. Bollen et al. (2020) found longer dwell times for alcohol-related stimuli only in binge drinkers with high craving. Therefore, both studies suggested that the intensity of craving at testing time was a core determinant of AB magnitude. In Soleymani et al. (2020), stronger craving was associated with longer dwell times, higher proportion of first fixations and shorter first fixation latencies on alcohol-related cues. These findings indexed a powerful correlation between craving and direct AB measures. Van Duijvenbode et al. (2017a) also found a positive (but weak) correlation between AB and craving. Wilcockson et al. (2019) measured, in a within-subject design, the influence of current consumption intention on AB using a free visual exploration. Heavy drinkers showed AB (indexed by dwell times), regardless of consumption intentions. This AB was positively correlated with consumption intensity/frequency, only when use was intended and with negative expectancies toward alcohol. Finally, Christiansen et al. (2015b) did not find any association between AB (indexed by dwell times) and craving.

Two studies explored the effect that alcohol expectancies might have on AB using a free exploration task (Field et al., 2011; Jones et al., 2012). In Field et al. (2011), alcohol expectancy was modulated at the beginning of each trial by a message indicating the probability (0/50/100%) of receiving a small amount of beer after the trial. The modulation of alcohol expectancy did not affect AB among heavy drinkers, showing higher dwell times for alcohol-related stimuli in all conditions. Conversely, light drinkers only presented higher alcohol dwell times when alcohol expectancies were high. AB thus appeared stable in heavy drinkers, while it depended on current expectancies in light drinkers. It should be noted that participants were administered non-alcohol beer, to prevent increased AB following intoxication. This might have resulted in reduced sensitivity to the expectancy manipulation. Jones et al. (2012) then explored whether the influence of alcohol expectancies was specific for alcohol-related cues or generalized toward other appetitive stimuli. Social drinkers performed a free exploration task with alcohol/neutral or chocolate/neutral pairs of images. Reward expectancy was also modulated by a message indicating the probability (0/100%) of receiving a small amount of beer or chocolate. For both stimuli, increased expectancy was associated with longer dwell times for appetitive cues, this effect being reward-independent. The expectancy to receive a reward thus globally increased the AB toward appetitive cues. Nevertheless, participants did not actually receive and consume the rewards, and their preference regarding one reward for another was not evaluated.

Two studies investigated whether acute intoxication influences AB in heavy and moderate drinkers through a VPT, followed by a bogus taste test (Fernie et al., 2012; Weafer & Fillmore, 2013). Participants received either 0.4g/kg doses of alcohol or placebo in a within-subject design in Fernie et al. (2012). Higher dwell times for alcohol-related stimuli were observed only after intoxication in moderate drinkers, and after both alcohol and placebo administration in heavy drinkers. AB therefore increased after alcohol administration in moderate drinkers, while heavy drinkers showed a stable AB. These findings were not replicated in Weafer and Fillmore (2013), who administered a placebo and 0.45g/kg and 0.65g/kg doses. Heavy drinkers displayed greater AB than moderate drinkers following placebo, this AB predicting the amount of *ad libitum* consumption. However, heavy drinkers displayed a dose-dependent decrease of AB following alcohol, whereas intoxication had no impact on AB in moderate drinkers. These results suggested that AB would play a role in the initiation of drinking episodes, but not in their perpetuation once initiated.

4. Discussion

The results section has shown the complexity of the current literature related to AB in alcohol-related disorders, and the large inconsistencies across experimental outputs. However, to move the field forward, we will identify the main conclusions that can be drawn from available studies, at theoretical and methodological levels, before proposing recommendations for future ones.

4.1. Results overview and theoretical implications

The main aim of this systematic review was to evaluate the assumptions made by dominant models regarding AB in alcohol-related disorders and to discuss their experimental validity when confronted with existing behavioral and eye-tracking findings. We identified three major questions regarding alcohol-related AB, namely whether: (1) AB is a key and long-lasting characteristic of alcohol use disorders, its magnitude being directly associated with the severity/frequency of the alcohol use; (2) AB is underpinned by automatic/early or controlled/later attentional processes, since AB is considered as a behavioral expression of impulsive system's over-activation, giving rise to automatic and uncontrolled saccades towards alcohol-related stimuli (dual-process models; Bechara, 2005; Wiers et al., 2007); and (3) AB is a stable feature of alcohol use disorders once established, due to an over-sensitized dopaminergic system following repeated alcohol exposures (IST; Robinson & Berridge, 1993) or is strongly affected by momentary motivational processes, either appetitive, aversive or both (Field et al., 2016).

4.1.1. Is alcohol-related AB associated with the severity and frequency of alcohol use?

What do we know about SAUD patients? Among the 25 studies focusing on alcohol-related AB in SAUD, nine suggested a stronger alcohol-related AB in patients compared to controls (e.g., Jones et al., 2006; Lusher et al., 2004; Müller-Oehring et al., 2019) or reported a positive correlation between AB scores and alcohol consumption (Garland, 2011). However, 14 studies did not observe such difference (e.g., Fridrici et al., 2014; Rettie et al., 2018; Vollstadt-Klein et al., 2009) or did not show any correlation between AB and alcohol consumption (den Uyl et al., 2018; Sinclair et al., 2016). Three studies even reported an avoidance bias in SAUD, indexed by lower AB scores for alcohol-related stimuli compared to controls (Bollen et al., 2021; Fridrici et al., 2013; Townshend & Duka, 2007). Beyond the SAUD diagnosis, alcohol-related AB appears related to higher quantity and frequency of alcohol consumption (e.g., Clarke et al., 2015; Fadardi & Cox, 2006; Garland, 2011), earlier age of

SAUD onset (Müller-Oehring et al., 2019) and higher number of previous SAUD treatment (Jones et al., 2006; Noël et al., 2006). However, it is not associated with SAUD duration (Lusher et al., 2004; Noël et al., 2006; Sinclair et al., 2016) or abstinence duration (Garland, 2011; Sinclair et al., 2016; Wiers et al., 2016).

Such findings question the theoretical assumptions regarding the key role played by AB in SAUD (Bechara, 2005; Robinson & Berridge, 1993; Wiers et al., 2007). Indeed, a theoretical assumption directly resulting from dominant models is that the magnitude of AB would be related to the disorder's severity, individuals with SAUD presenting a stronger alcohol-related AB than moderate drinkers. Most studies were therefore expected to show an AB toward alcohol-related stimuli, since they focused on patients diagnosed with SAUD, presenting longer/stronger alcohol consumption. However, the mixed results observed, most studies showing no stronger AB (or even an avoidance AB) among detoxified SAUD patients compared to light drinkers, do not support this theoretical assumption. Importantly, recent modifications of the IST highlighted individual variations in the extent to which incentive salience is attributed to alcohol-related cues (Robinson et al., 2014). Indeed, individuals prone to approach reward cues (sign-trackers) would attribute greater motivational value to interoceptive cues than do individuals less prone to approach reward cues (goal-trackers; see Colaizzi et al., 2020 for a review). Moreover, each motivational property acquired by incentive stimuli (i.e. alcohol-related AB, subjective craving and seeking behavior) may contribute to alcohol use in different but complementary pathways (described as the "three routes to relapse"; Milton & Everitt, 2010). Therefore, AB might play a major role in the development of SAUD for some individuals but be far less crucial for others.

What do we know about subclinical populations? Alcohol-related AB was positively related with alcohol consumption in most studies conducted in social drinkers, often recruited among students (e.g., Albery et al., 2015; Field et al., 2011; Hobson et al., 2013). Many studies also showed a stronger alcohol-related AB in more specific drinking patterns (e.g., heavy or binge drinkers) compared to light drinkers (Baker et al., 2014; DePalma et al., 2017; Tibboel et al., 2010), especially among adolescents (e.g., McAteer et al., 2015, 2018; McGivern et al., 2021). To sum up, studies conducted on subclinical populations appear more consistent regarding the association between alcohol-related AB and alcohol consumption, most showing that AB is directly linked to drinking habits intensity. These findings therefore support the theoretical assumption that the magnitude of AB would be related to consumption's intensity.

How can we develop knowledge? Whereas the association between alcohol use and AB appears more consistent in subclinical populations, the comparison across studies is dampened by discrepancies in terminology, inclusion criteria and consumption thresholds. Indeed, the sample is often poorly specified, as participants are mostly recruited among the general population or among college students, assuming the presence of high consumption levels in this population. Moreover, the control of potentially biasing variables (e.g., presence of psychiatric comorbidities, demographics) is usually limited. A key priority for future studies is to provide a better characterization of their experimental sample, through valid and standardized alcohol use assessment. As most studies used the AUDIT and TLFB, these two tools could constitute the minimal alcohol consumption measures, potentially complemented by tools evaluating specific drinking habits (e.g., binge drinking; Townshend & Duka, 2002, 2005). Moreover, most studies focusing on SAUD did actually evaluate the relationship between the severity of alcohol use and AB (through between-group comparisons). Conversely, studies on subclinical populations usually mixed consumption-related measures (evaluating the intensity/frequency of alcohol consumption, mostly through the TLFB or AUDIT-C) with dangerousness/problems measures (evaluating the consequences and issues resulting from alcohol consumption, mostly through the AUDIT or Short-Michigan Alcoholism Screening Test) for their correlational or between-group analyses. Future studies should distinguish the respective effects of alcohol consumption from those related to alcohol-related problems on AB, as these aspects differentially predict addictive behaviors and could explain the mixed findings in the reviewed studies. Furthermore, the terms labelling the targeted population are heterogeneous and should also be standardized (Maurage et al., 2021). A valid assessment of alcohol consumption and its associated variables is also needed in SAUD, since self-reported measures are usually unreliable in this population. Future studies could provide additional measures reported from relatives, or physiological indices of alcohol use severity (e.g., liver condition). Finally, future research might account for the different pathways to addiction when exploring AB in a certain population and distinguish individuals more or less prone to rewards cues (i.e., sign-trackers versus goal-trackers; Robinson et al., 2014), in order to determine the conditions and psychological factors determining the individual involvement of AB in the emergence of alcohol-related disorders.

4.1.2. What is the time course of AB?

What do we know about SAUD patients? Two studies suggested the presence of an approach-avoidance pattern depending on stimulus duration - with an initial orienting AB, followed by attentional disengagement – specific to this population (Beraha et al., 2018; Noël et al., 2006). This latter finding was supported by eye-tracking measures showing an avoidance bias at later processing stages in SAUD (Bollen et al., 2021). Altogether, these preliminary results on SAUD patients highlighted the relevance of investigating the time course of AB in populations usually characterized by motivational conflict regarding alcohol-related cues.

What do we know about subclinical populations? AB in subclinical populations appeared mostly at the controlled stages of attentional processing. The maintenance of attention toward alcohol was reflected by AB at longer stimuli duration (Field et al., 2004), delayed Stroop interferences (Hallgren & McCrady, 2013), specific assessment of disengagement processes of AB (Gladwin et al., 2013; Heitmann et al., 2020; Sharbanee et al., 2013) or by eye-tracking indexes such as dwell times or number of fixations (e.g., McAteer et al., 2015, 2018; Monem & Fillmore, 2017). Alcohol-related AB in subclinical populations would thus rely on later and controlled processes, suggesting that the automaticity in AB, postulated by dominant models, is absent in this population (McAteer et al., 2015).

How can we develop knowledge? Future studies should systematically go beyond behavioral measures, centrally by using eye-tracking methods, as this tool provides major insights regarding the time course of AB by directly measuring the consecutive steps involved in attention (Armstrong & Olatunji, 2012; Popa et al., 2015). Moreover, we need to fill the gap between the numerous eye-tracking studies on subclinical populations and the nearly inexistent ones in SAUD. Finally, newly developed experimental paradigms (e.g., attentional blink task, odd-one-out task) could also offer a more accurate exploration of AB. Altogether, these findings highlighted the need to refine theoretical assumptions regarding the time course of AB, since (1) it can fluctuate from approach to avoidance AB according to the duration of stimulus presentation in SAUD patients, and (2) its automatic nature is strongly questioned in subclinical populations.

4.1.3. Is AB a stable reflection of the impulsive system over-activation?

What do we know about patients with SAUD? AB might be increased by high craving at testing time (Bollen et al., 2021; Field et al., 2013) and current drinking status (Sinclair et al., 2016). These findings provided experimental support for Field et al.'s (2016) proposal, as AB might fluctuate alongside motivational states related to craving and drinking status. This could explain the inconsistencies across previous studies exploring AB in SAUD without measuring the psychological state at testing time. Indeed, most patients were abstinent and undergoing detoxification treatment, such states being frequently related to aversive or ambivalent alcohol evaluations. Therefore, the available results do not rule out the possibility that AB is globally absent in the various stages of SAUD, but they nonetheless suggest that, during the detoxification process, patients with SAUD do not present a strong and stable AB toward alcohol.

What do we know about subclinical populations? Alcohol-related AB is increased by craving (Bollen et al., 2020; Field et al., 2004; 2005; 2007), *in vivo* alcohol cue exposure (Cox et al., 2003; Ramirez et al., 2015a; 2015b) and reward expectancies (Field et al., 2011; Jones et al., 2012). However, AB in heavy drinkers is not influenced by experimental procedure like subliminal priming or alcohol-related motivations (Baker et al., 2014). Hangover did not affect AB (Gunn et al., 2021) but alcohol intoxication might decrease it (Weafer & Fillmore, 2013), especially following high alcohol pre-load (Duka & Townshend, 2004).

The discrepancies between clinical and subclinical populations regarding the presence of AB might be explained by the role of motivational conflict. Field et al. (2016) suggested that SAUD patients in detoxification treatment might attempt to override alcohol-related AB to reduce concerns about drinking behavior and suppress craving. This could lead to different patterns of AB than subclinical drinkers who are not attempting to reduce their consumption. Finally, while experimental manipulations of alcohol-related motivations failed to influence AB, AB increased with subjective craving and *in vivo* alcohol cue exposure. Again, these findings support the theoretical account whereby AB arises from momentary changes in alcohol-related stimuli evaluations (Field et al., 2016).

How can we develop knowledge? Future studies should determine whether AB is consistent among subclinical and clinical populations or whether it is modulated by short-term environmental or internal contingencies. First, we need to further explore the inter-contextual stability of AB, as studies showed that AB is influenced by external factors (e.g., alcohol cue exposure) or motivational states (e.g., craving, alcohol-related motivations). Hence, the influence of these contextual variables on AB should be consistently investigated, notably by manipulating craving intensity through priming procedures. Moreover, further studies should evaluate alcohol-related AB in individuals with SAUD not seeking treatment and/or not presenting motivational conflict regarding alcohol. Second, we need to address the short-term intra-individual stability of AB, as most studies have only offered AB measures at one timepoint, without evaluating test-retest variations. Within-subject fluctuations in AB, according to craving level and perceived value of alcohol at testing time (Field et al., 2016), might mask between-groups differences. Finally, studies should explore the long-term intra-individual stability of AB, as it might vary through disease course. AB thus has to be tested across multiple sessions during the successive stages of the detoxification process (e.g., non-abstinent patients, early/late withdrawal, post-detoxification; Bollen et al., 2021).

4.2. Methodological considerations

The inconsistencies between studies are mostly related to their variability regarding experimental choices and to several methodological shortcomings that cast doubt over the robustness of their findings. In line with recent proposals (Pennington et al., 2021), we identified these methodological issues and provided suggestions to address them.

4.2.1. Appropriate use of stimuli

Matching control stimuli. Many studies compared alcohol-related stimuli to non-alcoholic and non-appetitive ones (e.g., household objects, office stationery). Although this selection prevents participants from associating the control stimuli with alcohol use, contrary to non-alcohol appetitive stimuli (e.g., soft drinks, potentially associated with cocktails or mixed alcoholic drinks), this methodological choice does not elude the possibility that AB toward alcohol might be generalized to other appetitive stimuli (soft drinks, monetary or erotic stimuli). Indeed, Qureshi and colleagues (2019) found stronger AB for both alcohol and non-alcohol appetitive cues in student drinkers. To isolate the mechanisms specifically related to the alcohol-related nature of AB, Pennington et al. (2021) suggested to consistently match experimental and control stimuli on incentive valence. Nevertheless, what can be considered as a neutral or appetitive non-alcohol stimulus remains unclear, since various studies used soft drinks or water pictures as neutral cues (Christiansen et al., 2015b; Heitmann et al., 2021), whereas others used them as appetitive cues (Pennington et al., 2020; Qureshi et al., 2019). Further work should clarify the concept of appetitiveness before challenging AB specificity, as a generalized AB toward all appetitive cues without preference for alcohol-related ones would generate an in-depth revision of the current assumptions regarding AB in SAUD. Research should therefore carefully select their control stimuli and measure their appetitive nature.

Selection and validation of stimuli. Pennington et al. (2021) highlighted the frequent opacity of stimuli selection and validation in alcohol-related AB research. Most studies do not disclose the source of their selected stimuli and do not report validation procedure. The use of validated image databases is recommended to reduce the noise generated by the varying visual properties of stimuli. Further studies should thus consistently report stimulus validation procedures. Alcohol-related stimuli could also be individualized (i.e. focused on the alcohol preferentially consumed by each participant). The relevance of the experimental stimuli for the targeted population is also important to account for, as databases such as the Amsterdam Beverage Picture Set (Pronk et al., 2015) provide images of beverages consumed in specific countries, which brands might be unfamiliar for other cultures. New databases using images of alcohol and non-alcohol beverages should be developed and openly available. Finally, it should be underlined that most alcohol-related cues presented in experimental settings (e.g., pictures of beer, alcoholic beverages words) only present a part of the features related to the cues that people experience in naturalistic settings (e.g. the sight and smell of their preferred drink, in the context of expecting to be able to consume it imminently). Therefore, all AB cues are to some extent artificial, but pictures might have a better ability than words to evoke an expectancy or memory of drinking via associative learning mechanisms.

4.2.2. Reliability and validity of AB measures and tasks

Reliability of AB measures and tasks. Most reviewed studies rely upon behavioral data, particularly percentage of correct answers (frequently related to ceiling effects, and thus of low informative value) and mean RT. RT measures are however affected by motor and cognitive processes, as the instructions request encoding stimuli, processing all the information needed for decision-making and finally executing the appropriate motor response (Hedge et al., 2018; Miller & Ulrich, 2013). Pennington et al. (2021) also highlighted measurement noises among studies relying upon difference scores to index AB. By subtracting two measures (i.e., RT for alcohol-related and control stimuli) usually intercorrelated, this method shows low reliability and potentially weakens the associations with other variables (Draheim et al., 2019; von Bastian et al., 2020). Altogether, the use of these noisy measures, combined to the variability of the image used across studies, the reduced number of stimuli and their repetitions, highly impact the reliability of the tasks used and the replicability of their findings. Ataya et al. (2012) criticized the psychometric qualities of the RT-based VPT, after demonstrating its low internal consistency (α=.00-.50; mean=.18). Several papers provided empirical recommendations to improve VPT reliability (Jones et al., 2018; Pennington et al., 2021; Price et al., 2019), among which the systematic report of AB measures reliability indices. They also proposed the use of individualized stimuli and eye-tracking measures. Indeed, previous studies demonstrated improved internal reliability for individualized stimuli compared to general ones (α=.73 compared to .19; Christiansen et al., 2015b) and for eye-tracking measures compared to RT ones (α=.94 compared to .14; Bollen et al., 2020). The VPT therefore appears as a reliable task for assessing AB, but only when combined with individualized stimuli and/or eye-tracking indices.

Validity of AB measures and tasks. Beyond their ability to provide reliable measures (i.e., how the measure is performed), tasks also raise questions regarding their construct validity (i.e., which process is measured). Regarding the VPT, inferring AB through RT, as done in most studies, raises concerns as such measures only offer information about the location at which participants focused their attention at probe onset. It therefore provides no information about the successive steps of attentional processing (Field & Cox, 2008). Depending on the visual exploration strategy (e.g., initial focus on alcohol-related stimulus and then avoidance of this stimulus), a non-existing AB might be measured or, conversely, a real AB might be ignored. Regarding the modified Stroop task, slower responses to alcohol-related words are interpreted as an automatic allocation of increased attention to the semantic processing of these words. These could also result from patients' attempts to avoid processing alcohol-related words (Klein, 2007), leading to a completely different interpretation. However, RT measures prevent from testing the direction of alcohol-related AB (approach/avoidance AB). The same limits apply to other classical tasks. The free viewing task combined with eye-tracking measures does not specifically request participants to pay attention to the cues, since they are neither presented as distractors nor goal-oriented stimuli. While being more ecological, the absence of goal-oriented instructions does not ensure that participants are paying attention to the cues when looking at the screen. Regarding the flicker induced-blindness paradigm, the structure of the grid might encourage the systematic use of strategic scanning, limiting attentional capture by the cues (Hobson et al., 2013).

5. Conclusion

We provided a comprehensive review of the literature on the association between alcohol-related AB and alcohol use. We highlighted major findings on the time course and components of AB, as well as experimental support to address the assumptions made by theoretical models (Bechara, 2005; Robinson & Berridge, 1993; Wiers et al., 2007). More precisely, we aimed to determine whether AB is stable through contexts and time or fluctuates alongside motivational state or alcohol use severity. Findings in SAUD showed that AB is independent of disorder's severity, but is unstable and influenced by craving or drinking status. Conversely, studies on subclinical drinkers supported the link between alcohol-related AB and alcohol consumption intensity. Although this population is not usually characterized by ambivalent motivations towards alcohol, experimental manipulations of motivational states also influenced AB, thus supporting the theoretical proposal of an overstatement of its stability (Field et al., 2016). When interpreting these outcomes, one should bear in mind that we focused on peer-review published studies, therefore excluding the grey literature. Although most studies did not find any association between AB and SAUD, a publication bias might have limited the publication of such null findings. In the same vein, a publication bias may have influenced conclusions regarding AB in subclinical populations, since most positive findings were observed in these easier-to-recruit populations. Importantly, future studies should more frequently perform an a priori power computation or at least justify their sample size, as most of the reviewed studies relied on small samples without justification and did not report any statistical power or effect size computation to estimate the strengths of their findings. This a priori power computation should even be included in a more systematic trend to pre-register the methods and hypotheses of the planned studies, a practice that has become common in several scientific domains but that unfortunately remains marginal in AB studies. Finally, our methodological quality evaluation of the studies allowed us to provide recommendations for future research to address the main methodological shortcomings (i.e., appropriate use of stimuli, reliability and validity of AB measures).

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Conflict of interest

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

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Figure captions

Figure 1. PRISMA flow diagram describing the selection and review process of the papers included.

Figure 1.

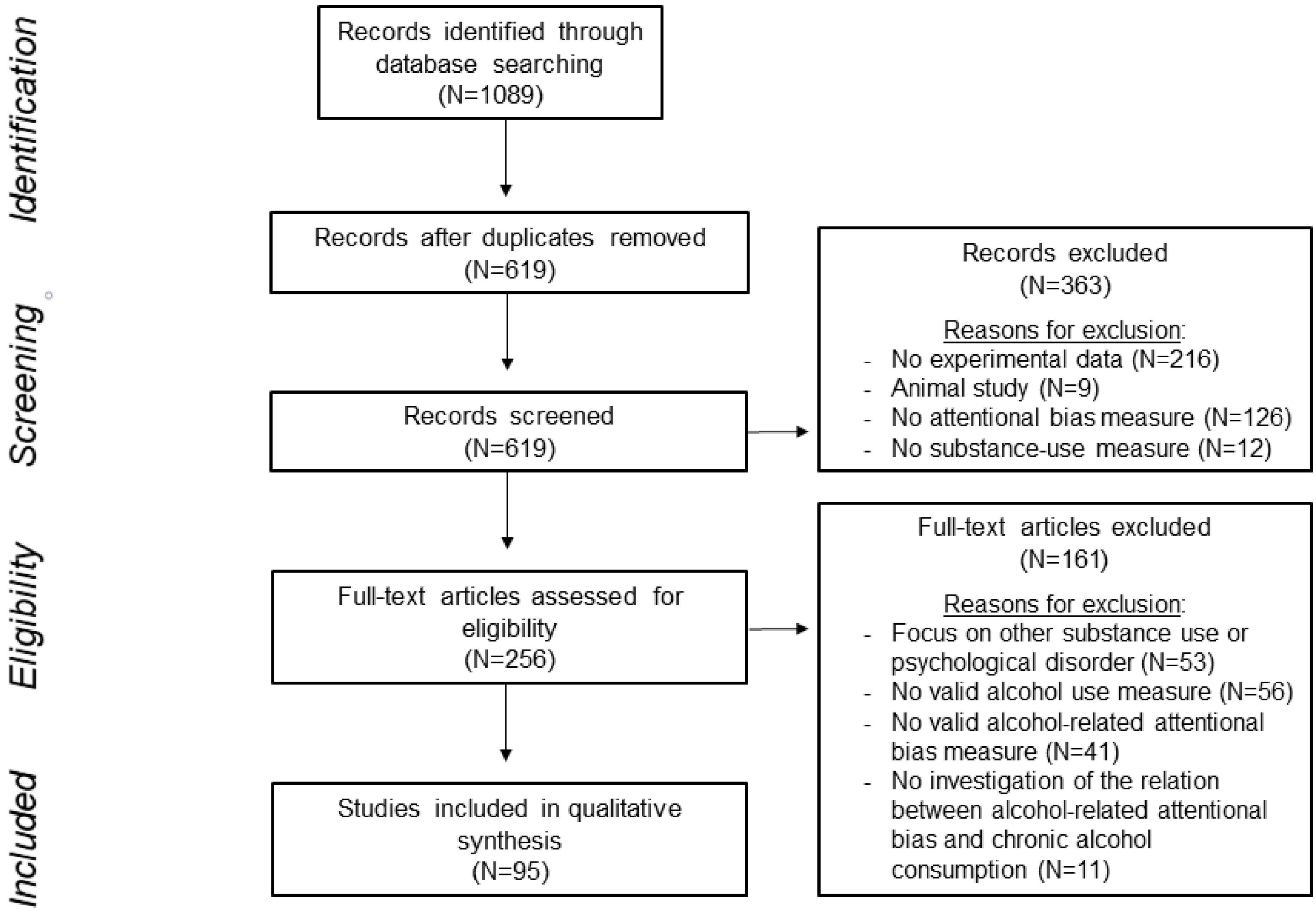
Identification
Screening
Eligibility
Included
Records identified through database searching (N=1089)
Records after duplicates removed (N=619)
Records screened (N=619)
Records excluded (N=363)
Reasons for exclusion:
- No experimental data (N=216)
- Animal study (N=9)
- No attentional bias measure (N=126)
- No substance-use measure (N=12)
Full-text articles assessed for eligibility (N=256)
Full-text articles excluded (N=161)
Reasons for exclusion:
- Focus on other substance use or psychological disorder (N=53)
- No valid alcohol use measure (N=56)
- No valid alcohol-related attentional bias measure (N=41)
- No investigation of the relation between alcohol-related attentional bias and chronic alcohol consumption (N=11)
Studies included in qualitative synthesis (N=95)

Table 1. Overview of experimental paradigms frequently used to assess alcohol AB and the number of included studies using this task.

Paradigm	Description
Visual probe task (N=38)	The task requires the participant to process a probe, following a cue, as quickly and correctly as possible. First, two pictures (cues), one representing an alcohol-related stimulus (e.g. alcoholic beverage bottle) and one a neutral stimulus (e.g. non-alcoholic beverage bottle), are displayed on the left and right side of a computer screen, respectively. Second, they are replaced by a probe appearing at the location previously occupied by one of the pictures. The participant has to process the probe (e.g., to determine the upwards or downwards direction of an arrow constituting the probe). Faster responses to probes appearing at the location previously occupied by the alcohol-related cue (compared with the neutral cue) reflect AB toward alcohol-related stimuli.
Alcohol Stroop task (N=28)	The task requires the participant to name as quickly as possible the color of alcohol-related and neutral matched words presented in different font colors. Slower responses to alcohol-related words compared with neutral ones index alcohol-related AB, assuming that the increased automatic allocation of attentional resources to the semantic processing of alcohol-related words slows down color naming for these words.
Free viewing task (N=11)	The task requires the participant to freely explore the presented stimuli, either depicting a grid of pictures or complex scenes with alcoholic and non-alcoholic cues. This task is usually combined with eye-tracking measures to analyse eye movements during the exploration.
Flicker induced-blindness paradigm (N=4)	The task requires the participant to detect a brief change in sub-parts of complex stimuli, either depicting real world scenes or a grid of alcohol-related and neutral pictures. Alcohol AB are indexed by a faster or more frequent detection of changes concerning alcohol-related stimuli.
Gaze contingency paradigm (N=3)	The task requires the participant to stare a fixation target and refrain from producing a saccade towards the neutral or alcohol-related distractors appearing in other parts of the screen. The dependent measure is the comparison of "break frequency" rates (i.e., the number of times a participant looks at the peripheral stimulus) related to neutral and alcohol-related stimuli. The task specifically measures the ability to inhibit the orientation of attentional resources towards peripherally appearing alcohol-related stimuli.
Odd-One-Out task (N=3)	The task requires the participant to indicate whether images in a matrix are from the same category of images (i.e., alcoholic drinks, non-alcohol drinks or other objects) or whether there is an odd-one-out (i.e., target image). Engagement index is calculated by subtracting the mean reaction time for *the alcohol target in neutral distractors trials* from the mean reaction time for the *neutral target in neutral distractors trials*. Disengagement index is calculated by subtracting the mean reaction time for the *neutral target in neutral distractors trials* from the mean reaction time for the *neutral target in alcohol distractors trials*. Positive scores respectively reflect attentional engagement with alcohol cues and difficulty to disengage attention from alcohol cues.
Attentional blink paradigm (N=2)	The task requires the participant to report two targets presented in a rapid serial visual presentation stream, with a various time lag between them. The identification of the first target is supposed to temporarily reduce attentional resources, causing the attentional system to blink, such that subsequent stimuli cannot be fully encoded until attention recovers. This deficit in the identification of the second target generally appears at short lags (<500ms). The absence of this attentional blink for alcohol-related second target

	suggests an increased efficiency to process these cues at early levels, indexing the presence of an alcohol AB.
Cued visual probe task (N=2)	A cued version of the visual probe task with priming cues predicting the location of alcohol-related or neutral stimuli.
Rapid serial visual presentation task (N=1)	The task requires the participant to detect either an alcohol or a non-alcohol target in a stream of 9 rapidly presented objects, and ignore alcohol or non-alcohol distractors presented in task-irrelevant parafoveal locations. A detection sensitivity index is computed based on the proportion of hits and false alarms recorded for alcohol or non-alcohol targets, with the presence of alcohol or non-alcohol peripheral distractors.
Spatial cueing task (N=1)	The task requires the participant to direct his/her attention towards alcohol cues (approach-alcohol block) or non-alcohol cues (avoid-alcohol block), which are randomly presented to the left or right side of a fixation cross. On 25% of all trials, a probe (i.e. an abstract arrow pointing up or down) appears after the stimulus. The probe is located at the attended position on 80% of the trials (valid cue trials), and on the opposite side for the remaining 20% of trials (invalid cue trials). The participant has to indicate the orientation of the arrow. Faster responses to probes appearing at the location previously occupied by the alcohol-related cue (compared with the non-alcohol cue) in valid and invalid trials reflect AB toward alcohol-related stimuli.
Alcohol-change detection task (N=1)	The task requires the participant to detect whether a change has occurred in a grid comprising four images. Five type of trials are presented with equal frequency: alcohol-alcohol (i.e. all images originally alcohol-related, one changing into different alcohol-related image), alcohol-neutral (i.e. all images originally alcohol-related, one changing into a neutral image), neutral-alcohol (i.e. all images originally neutral, one changing into an alcohol-related image), neutral-neutral (i.e. all images originally neutral, one changing into a neutral image) and no-change (i.e. no change occurring) trials. The participant responds by clicking the right-hand button when a change occurred, and on the left-hand button when no change was perceived. Sensitivity to change (indexing alcohol-related AB) was measured via a d-prime based on hit and miss rate.
Visual search task (N=1)	The task requires the participant to detect in a matrix a target image of the search category named before the beginning of the task. The matrix is composed of 15 images from the same category (alcoholic or non-alcoholic drinks) and one different image (target stimulus). AB index is calculated by subtracting the mean reaction time for *alcohol target trials* from the mean reaction time for *alcohol distractors trials*. Higher positive scores reflect stronger AB for alcohol.
Selective-attention/action-tendency task (N=1)	The task requires the participant to identify a first probe and then keep or shift its attentional focus (selective-attention assessment trials) or hand (action-tendency assessment trials) on the location of the first probe to identify a second probe and report whether their orientation was matched. An alcoholic or non-alcoholic beverage image appears between the presentation of the two probes. AB is indexed by facilitated response times on trials requiring shifting towards the alcohol relative to non-alcohol stimuli (engagement trials), or by impaired response times on trials that require shifting away from the alcohol relative to non-alcohol stimuli (disengagement trials).
Visual conjunction search task (N=1)	The task requires the participant to detect whether a left-hanging alcoholic or non-alcoholic target is present or absent within arrays of alcoholic and non-alcoholic distractors. The participant responds by clicking on the target location with the computer mouse when the target is present, and clicking anywhere within the black background surrounding the array when the target is absent. The dependent variable is the reaction time for correct responses, with quicker reaction time for alcoholic targets indexing alcohol-related AB.
Dual task paradigm (N=1)	The task requires the participant to perform an odd/even decision task with a centrally presented number while also performing a peripherally presented lexical decision task

with alcohol-related or neutral words. The participant is then asked to recall the words presented in the peripheral task.

Authors (year)	Population				Exposures			Comparator		Design						Outcomes		
	Sample (N)	*Age [M(sd)]*	*Gender (% males)*	*Exclusion criteria*	*Diagnosis / Characteristics*	*Alcohol consumption measure*	*Comorbidities*	*Control group*	*Matching variables*	*Processes measured*	*Task*	*Questionnaire*	*Stimuli in AB task*	*Methodology*	*AB Measure*	*Alcohol AB results*	*Limitations reported*	*Key AB conclusions*
Albery et al. (2015)	43	NR	NR	NR	Social drinkers with high/low exposure to bar and pub	AUDIT	NR	Between-subject design: High exposure (N=21) Low exposure (N=22) Median split on 2 questions of AUDIT: High consumption (N=21) Low consumption (N=22)	None	Alcohol AB	Modified Stroop task	STAI	25 alcohol-related words 25 neutral words	Behavioral	Reaction time	Alcohol interference for high consumption group, regardless their alcohol exposure, and for low consumption group with high exposure Repeated exposure of alcohol words did not influence the interference scores for either groups	Small sample size	Attentional bias is observed in heavy drinkers, but depends on alcohol exposure in light drinkers
Baker et al. (2014)	110	32.54 (8.01)	37.27%	Age < 25 or > 60 Current or past substance use disorder Psychiatric disorder Positive breath alcohol level	Heavy drinkers [>14 (women) or >21 (men) doses/week]	AUDIT TLFB AAAQ	NR	Between-subject design: Alcohol-appetitive (N=38) Alcohol-aversive (N=36) Control (N=36)	Gender Education Employment status AUDIT AAAQ	Alcohol AB Alcohol approach and avoidance bias	Visual probe task Stimulus-response compatibility task	None	10 alcohol-related images 10 matched control images	Behavioral	Reaction time	No effect of implicit priming of motivational orientations on AB Avoidance AB for alcohol cues presented for 50 ms No AB for cues presented for 500 ms Weak positive correlation between AUDIT and AB on the 500 ms block	Invalidation of reaction time measures caused by imposition of a response window	No influence of subliminal priming of motivational orientations on automatic alcohol cognitions
Beraha et al. (2018)	143	44.7 (9.7)	68.50%	Age < 18 or > 70 Psychiatric disorder (other than depression, anxiety, bipolar disorder) Substance use disorder (other than alcohol or nicotine dependence) <0.5 % breath alcohol concentration Exclusion criteria related to baclofen	Detoxified SAUD patients (DSM-IV) [>14 (women) or >21 (men) doses/week for 1 month in the past 90 days] [2 heavy drinking days, i.e. >5 units (women) or >6 units (men) in the past 90 days]	AUDIT EuropASI TFLB OCDS	NR	Between-subject design: Baclofen (N=83) Placebo (N=60)	Age Gender Employment Marital status Alcohol consumption variables AUDIT OCDS STAI	Alcohol AB Alcohol approach and avoidance bias Alcohol-related memory associations	Negative mood induction by personalized stress imagery task Visual probe task Approach-avoidance task Brief implicit association test	STAI SAM	15 alcohol-related images 15 soft drink images 14 negative images (negative filler trials)	Behavioral	Reaction time	At baseline, AB towards alcohol at 500ms and avoidance AB for alcohol at 1500ms At t2, the baclofen group showed an avoidance AB for alcohol at 500ms No differential change regarding AB in baclofen group compared to control group	No control condition for the negative mood induction to precise its effect on AB Additional effect of baclofen to psychotherapy might have been limited, potentially reducing its effect on AB	After negative mood induction, SAUD patients showed approach AB at 500ms and avoidance AB at 1500ms for alcohol-related cues
Bollen et al. (2020)	85	21.36 (2.20) 21.07 (2.00)	47.05%	Personal or family's history of SAUD Daily alcohol consumption Neuropsychiatric disorder and substance use (except nicotine and occasional cannabis use) Uncorrected visual deficits Vegan/vegetarian diets	Binge Drinkers (binge drinking score≥22; AUDIT score≥9) Control participants (binge drinking score≤12; AUDIT score<9)	AUDIT Consumption speed Drunkenness frequency and ration Doses/week and /occasion Drinking and binge drinking occasions/week	None	Between-subject design: Binge drinkers (n=42) Control participants (n=43) Median splits on craving: High cravers Low cravers	Age Gender	Alcohol AB	Visual probe task	BDI-13 STAI UPPS-P VAS ACQ-SF-R	Alcohol-related images Matched soft drink images High and low-calorie food images	Behavioral Eye-tracking	Reaction time First fixation direction Dwell time	Longer dwell times for soft compared to alcohol in control participants but not in binge drinkers Longer dwell times for food compared to alcohol in both groups Positive correlation between craving and dwell time for alcohol Longer dwell times for alcohol compared to soft only in binge drinkers with high craving	Higher visual complexity in food stimuli No personalised stimuli No total randomization in tasks' order	AB in binge drinking occurred at the later stages of attentional processing in presence of high craving and might be generalized to other appetitive stimuli
Bollen et al. (2021)	51	49.88 (8.7) 49.52 (10.1)	50% 51.85%	Psychiatric or neurological comorbidities Polysubstance use disorder For controls: Past or present psychiatric disorder Personal or family's history of SAUD	Detoxified SAUD patients (DSM-V) following inpatient treatment Control participants (≤ 10 doses/week, ≤3 doses/day, AUDIT score<9)	AUDIT Doses/week and /day	Nicotine dependence	Between-subject design: SAUD patients (n=24) Control participants (n=27)	Age Sex	Alcohol AB	Visual probe task	BDI-13 STAI UPPS-P VAS OCDS	Alcohol-related images Matched neutral images	Behavioral Eye-tracking	Reaction time First fixation duration and direction Second fixation direction Dwell time	Shorter dwell times for alcohol cues and less second fixation towards alcohol after a first fixation on soft in SAUD patients compared to controls High reliability of dwell time and second fixation direction No difference between groups and low reliability regarding reaction time and first fixation indexes Positive correlation between dwell times for alcohol cues and craving or depression in SAUD patients, and with impulsivity in controls	Small sample size No sufficient statistical power for correlational analyses No evaluation of patient's feelings and thoughts about alcohol use at testing time	Detoxified patients with SAUD present an alcohol-related avoidance AB
Brown et al. (2018)	Exp 1a: 12 Exp 1b: 16 Exp 1c: 60 Exp 2: 43	22 (2.45) 20.44 (2.06) 21.6 (3.91) 21.37 (2.25)	71.43% 23.08% 30.43% 79.17%	No alcohol consumption in the last month Non-drinkers	Social drinkers	AUDIT AUQ	NR	None (within-subject design)	NA	Goal-driven attentional capture of alcohol	Rapid serial visual presentation paradigm	AEAS	Alcohol-related images Matched neutral images	Behavioral	Task performance (A' detection sensitivity index)	Interference only for goal congruent distractors Larger goal congruent distraction for alcohol than non-alcohol distractors No interference when alcohol images are held in working memory but goal incongruent No difference of performance between high and low AUD risk (based on AUDIT score) No correlation between task performance and alcohol consumption	Lack of variation in alcohol dependence in the sample	Involuntary alcohol attentional capture can be induced by manipulating goal-driven mechanisms
Brown et al. (2020)	39	20.56 (2.11)	25.64%	None	University students	AUDIT	NR	Between-subject design: Low hazardous drinkers (N=15) High hazardous drinkers (N=24) Median split on PSQI score: Good sleepers (N=24) Bas sleepers (N=15)	None	Alcohol AB Inhibitory control	Gaze contingency task	PSQI	Alcohol-related images Matched neutral images (office supplies)	Eye-tracking	Break frequency	Positive correlation between AB score and AUDIT Increased AB score in high (vs low) hazardous drinkers No correlation between sleeping behavior and AUDIT or AB scores No difference between good and bad sleepers in terms of AUDIT or AB scores	Unclear distinction between alcohol-related and general inhibitory control Limited to student population	High hazardous drinkers were more distracted by alcohol-related images than low ones, independently of their quality of sleep
Bruce & Jones (2004)	30	29.5 (13.7)	46.67%	Atypical alcohol consumption in the previous week Work in alcohol industry Family's history of SAUD	Social drinkers	TLFB	NR	Median split on heaviest drinking day of the previous week: Heavier drinkers (n=15) Lighter drinkers (n=15)	None	Alcohol AB	Pictorial Stroop paradigm	None	Alcohol-related images and scenes Neutral images and scenes	Behavioral	Reaction times	Higher alcohol interference in heavy drinkers compared to light drinkers No correlation between alcohol interference and alcohol consumption on the heaviest drinking day	NR	Heavy drinkers showed AB towards alcohol-related cues

Carrigan et al. (2004)	79	33.42 (10.85)	54%	Non-drinkers Color blindness Benzodiazepine use Alcohol consumption earlier in the day of participation	Community volunteers	QFV SADD	Social anxiety	None (correlational analyses)	NA	Alcohol AB Social threat AB	Modified Stroop task	AESES DAM SIAS SPS DEQ	Alcohol-related words Social threat words Neutral words	Behavioral	Reaction times	Positive correlation between alcohol interference scores and alcohol dependence or drinking coping motives No correlation between alcohol interference scores and social anxiety or quantity-frequency of alcohol consumption Higher alcohol interference scores in participants reporting more frequent use of alcohol in anticipation of social situations	Only one measure of AB Unclear interpretation of Stroop results regarding the direction of AB	Alcohol AB is related to both severity of alcohol use and drinking to cope
Ceballos et al. (2009)	26	20.62 (2.0)	84.61%	Poor quality of eye-tracking data	Undergraduate students	QFI Age at first drink Days since last drink	NR	None (correlational analyses)	NA	Alcohol AB	Free visual exploration	None	20 alcohol-related scenes 20 matched neutral scenes	Eye-tracking	Initial fixation Dwell time Pupillary diameter	Positive correlation between quantity-frequency of alcohol consumption and initial fixation / dwell time on alcohol-related stimuli No correlation between quantity-frequency of alcohol consumption and pupil diameter during fixation of alcohol-related stimuli	Too homogeneous sample (small, mainly white males) Lack of investigation of psychological factors associated with alcohol consumption on college campuses More eye-tracking-related metrics could have been measured	Intensity of alcohol consumption is related to both controlled (dwell time) and automatic (initial fixation) attentional processes of alcohol AB
Christiansen & Bloor (2014)	48	21.48 (2.92)	29.17%	Current or past alcohol use disorder Color blindness	Undergraduate social drinkers (>0 drinking occasion/week)	AUDIT TLFB	NR	None (within-subject design)	NA	Alcohol AB	Modified Stroop task	DAQ	Soft drink words General and individualized alcohol-related words Neutral words	Behavioral	Reaction times	No difference of reaction times between versions of the task Individualised but not general alcohol Stroop bias predicts variance in alcohol involvement	Potential carry-over effects exaggerating AB in the individualised Stroop task caused by the blocked format Word lengths unmatched in the individualised Stroop task	Individualised Stroop task shows higher predictive value of alcohol consumption than the general alcohol Stroop task
Christiansen et al. (2015b)	60	20.02 (2.04)	35%	Current or past alcohol use disorder Wearing eyeglasses	Social drinkers (>0 drinking occasion/week)	AUDIT TLFB Doses/week	NR	None (within-subject design)	NA	Alcohol AB	Visual probe task	DAQ	General and individualized alcohol-related scenes Matched neutral scenes	Behavioral Eye-tracking	Reaction times Dwell time	Increased internal reliability of the visual probe task when using dwell time (compared to reaction time) and personalized stimuli Increased intensity of attentional bias at behavioral level for personalized stimuli No correlation between attentional bias and alcohol consumption or craving	Unmatched picture sets regarding presence of faces and items depicted	Eye tracking measure and personalized stimuli increase the internal reliability of the visual probe task, but AB is not correlated with consumption/craving (indexing poor construct validity)
Clarke et al. (2015)	SAUD: 62 Controls: 60 Unprimed controls: 40	45.55 (9.04) 43.2 (14.05) 32.93 (16.18)	54.8% 53.3% 45%	Colour blindness Illiteracy Brain injury Learning disability	SAUD patients (ICD-10) receiving treatment Social drinkers (controls)	KAT	NR	Between-subject designs: SAUD patients (n=62) Controls (n=59) Primed control (n=60) Unprimed control (n=40)	Age Ethnicity Gender	Alcohol AB AB towards negative cues	Modified Stroop task	None	Alcohol-related words Negative emotion words Neutral words	Behavioral	Error rates Reaction times	Fast and slow interference for alcohol words in SAUD and social drinkers No fast but slow interference for negative words in SAUD and social drinkers Positive correlation between alcohol consumption and AB in the slow process Alcohol interference only observed in the primed control group	No standardisation of testing environment No unprimed SAUD patients Lack of confounding variable measures (urinalysis, prescribed medication or illicit drugs taken, alcohol abstinence, mood levels) Unreliability of self-reported measures (KAT)	Alcohol AB (in fast and slow processes) in SAUD patients and social drinkers only when primed about the presentation of alcohol-related words Stroop effect might be due to implicit priming effect of the experimental procedure
Cox et al. (2002)	T1: 23 T1: 20 T2: 14 T2: 16	T2: 41.9 (10.6) 37.3 (10.3)	T2: 78.6% 25%	History of psychiatric disorder	SAUD patients (DSM-IV) from inpatient detoxification and treatment unit Controls (non-abusers but heavy social drinkers)	KAT	NR	Between-subject design (T1): Treatment completers (n=14) Treatment non-completers (n=9) Controls (n=20) Between-subject design (T2): SAUD patients (n=14) Controls (n=16)	Age	Alcohol AB AB towards concern-related cues	Modified Stroop task	Abridged MSQ	10 individualized alcoholic beverage brands 10 individualized concern-related words Keyboard symbols	Behavioral	Reaction times	No difference in alcohol interference between treatment completers, non-completers and controls at T1 (before treatment) Patients with unsuccessful SAUD treatment showed increased alcohol interference from T1 to T2 (4 weeks later) while patients with successful treatment and controls showed similar responding pattern	Control group revealed to be heavy social drinkers	Patients who succeed treatment showed similar pattern of AB than controls while patients with unsuccessful treatment showed an increase in alcohol AB 4 weeks after their entry in treatment
Cox et al. (2003)	80	NR	6.25%	Color blindness Alcohol consumption in the last 6 hour	Undergraduate students	KAT	NR	Between-subject design: Beer exposure Soft drink exposure Upper and lower thirds of the distribution on AAAI scores: Low consumers Heavy consumers	None	Alcohol AB	Modified Stroop task	Beverage saliency questionnaire	Alcohol-related words/brands Soft drink words/brands Cleaning-related words/brands 'XXXXX'	Behavioral	Reaction times	AAAI scores and alcohol cue exposure predicted alcohol interference scores in heavy consumers but not in low consumers	NR	Alcohol AB occurred in heavy drinkers with prior exposure to alcoholic beverage
den Uyl et al. (2018)	83	48.60 (0.94)	72.29%	Neurological disorder tDCS exclusion criteria	SAUD patients following inpatient treatment	AUDIT	Smokers (60)	Between-subject design: Real-ABM active-tDCS (n=21) Control-ABM active-tDCS (n=20) Real-ABM sham-tDCS (n=20) Control-ABM sham-tDCS (n=22)	NR	Alcohol AB Approach and avoidance associations	Visual probe task Implicit Association Task ABM task	BDI PACS SCL-90-R	Alcohol-related images Matched soft drink images Neutral images	Behavioral	Reaction times	At baseline, no correlation between AB score and alcohol problems or craving The overall AB went from a slight avoidance to more neutral at post-assessment regardless of the intervention During AB modification training, stronger avoidance alcohol AB only in real-ABM active-tDCS group (when 4 sessions combined) No effect of AB modification training on relapse	Unreliability of the visual probe task High drop-out at follow-up Low sample	No beneficial effect of tDCS or AB modification on alcohol AB or implicit association
DePalma et al. (2017)	94	21.4 (3.9)	28.72	Age<18	Binge drinkers (QFIs>0 and >0 binge drinking episode in the past 6 months) Non binge drinkers (QFIs>0 and 0 binge drinking episode in the past 6 months)	AUDIT BDQ QFI	NR	Between-subject design: Binge drinkers (word task) (n=22) Non binge drinkers (word task) (n=33) Binge drinkers (image task) (n=25) Non binge drinkers (image task) (n=14)	NR	Alcohol AB	Attentional blink paradigm	DAQ qFH	Alcohol-related words and images Soft drink-related words and images Neutral words and images	Behavioral	Accuracy	Non-binge drinkers showed an early attentional blink, however reduced for alcohol compared to control images Delayed attentional blink for non-alcohol targets in binge drinkers No evidence for alcohol attentional blink in binge drinkers Higher AUDIT scores and family history of SAUD are related with reduced alcohol attentional blink only in binge drinkers	Lack of male participants and ethnicity heterogeneity Generic alcohol-related cues Tasks recruitment with time discrepancies (no randomisation) No investigation of acute effects of binge drinking episodes on AB	Binge drinkers showed no alcohol attentional blink, suggesting a more efficient processing of alcohol-related cues at early levels of encoding and indexing the presence of an alcohol AB
Duka et al. (2002)	36 6 43	38.6 (2.1) 35.7 (2.5)	58.33% 50% 53.49%	Age<25 or >65 Not abstinence at testing time For social drinkers:	SAUD patients (DSM-IV or ICD-10) following inpatient treatment for minimum 2 weeks	AUQ SADQ Alcohol-related information	Depression (n=2) Illicit substance use disorder (n=16)	Between-subject design: LO-med (<2 medically supervised	Age Gender Verbal IQ	Alcohol AB Additional cognitive functions	Modified Stroop tasks Impulsivity and Vigilance task	AEQ DAQ NART	Alcohol-related words Positive emotional words	Behavioral	Error rates Reaction times	SAUD patients (LO-med and HI-med) made more errors in Stroop with alcohol-related words than controls	No severe dependence in the recruited patients Undergoing an intensive program of psychotherapy	Both group of patients showed alcohol AB, independently of the number of detoxifications

		37.3 (2.0)		Mental, neurological or chronic disorder Under drug treatment	Social drinkers			detoxifications) (n=36) HI-med (>2 medically supervised detoxifications) (n=6) Social drinker controls (n=43)			Maze tasks	POMS STAI TCI	Negative emotional withdrawal-related words			No difference in terms of reaction times	that might change cognitive processes	
Duka & Townshend (2004)	48	20.7 (0.7) 21.9 (0.9) 21.6 (0.6)	50	Age<18 or >35 Too high (62) or low (<10) weekly alcohol consumption Psychiatric or neurological disorder History of drug or alcohol abuse Altered metabolism of alcohol	Social drinkers	AEQ AUQ	NR	Between-subject design (alcohol preload): Placebo (n=16) Alcohol 0.3g/kg (n=16) Alcohol 0.6g/kg (n=16)	Gender Age Doses/week AUQ score Alcohol expectancies	Alcohol AB	Visual probe task Modified Stroop Task	DAQ POMS	Alcohol-related images or words Matched neutral (stationery) images or words	Behavioral	Reaction times Error rates	For the visual probe task: Faster reaction times for congruent cue trials for all participants. Alcohol AB only in 0.3g/kg group. Negative correlation between alcohol AB and AUQ only in 0.6g/kg group. For the Stroop task: The 0.6g/kg group made more errors than other groups. Positive correlation between alcohol AB scores in both tasks only in 0.6g/kg group	NR	Alcohol administration in small doses can prime alcohol AB while high doses would induce a state of satiation and decrease the salience of alcohol-related stimuli Pre-load of high doses increase the errors made on the Stroop task
Elton et al. (2021)	34	26.3	100	Past neurological or psychiatric diagnoses Contraindications for fMRI or amino acid depletion Current psychoactive drug use History of substance use disorder Moderate drinkers: Current or past AUD	Moderate social drinkers (<14 doses/week, <10 lifetime binge episodes and none last year) Binge drinkers (≥14 doses/week, ≥12 binge episodes in the last year)	AUQ CAUPQ	NR	Within-subject design: P/T depletion Placebo	Age Education Familial SAUD	Alcohol AB Reward AB	Visual probe task Modified attentional blink task Reward task	None	Alcohol-related pictures Neutral pictures	Behavioral Resting-state fMRI	Reaction time Accuracy fMRI data	Visual probe task: Greater alcohol AB in individuals reporting greater current binge drinking P/T depletion reduced alcohol AB, this effect being moderated by current binge drinking Attentional blink task: P/T depletion reduced alcohol AB, this effect being moderated by adolescent binge drinking and mediated by decreased in functional activity between FIC and striatum, and between ACC and amygdala	No direct measure of dopamine levels Only male sample Behavioural tasks performed after the resting-state scan	P/T depletion reduced alcohol AB, particularly in individuals reporting higher levels of past or current binge drinking
Emery & Simons (2015)	100	19.85 (1.45)	39%	NR	College students (>0 dose in the past 90 days)	DDQ	NR	Between-subject design (mood induction): Negative (n=33) Positive (n=34) Neutral (n=33)	NR	Alcohol AB	Visual probe task	PANAS DMQ-R	Alcohol-related pictures Matched neutral pictures	Behavioral	Reaction times	Poor split-half and test-retest reliability of the visual probe task Alcohol AB was predicted by alcohol consumption for men but not women Mood induction and drinking motives did not predict alcohol AB	Poor reliability of the visual probe task	Higher alcohol AB in men could be caused by higher alcohol consumption in this group or by gender differences in neural processes Lack of findings regarding mood induction might be due to the low reliability of the visual probe task
Fadardi & Cox (2006)	134	43.80 (7.95) 24.13 (9.35)	72% 37%	Patients: neurological impairment, comorbid psychopathology Controls: nondrinkers, >6 doses the night before	SAUD patients from inpatient treatment Social drinkers (SMAST score<2)	AUQ SMAST	None	Between-subject design: SAUD patients (n=47) Social drinkers (n=87)	None	Alcohol AB Inhibition and cognitive flexibility	Classic and modified Stroop task SILS	None	28 alcohol-related words 28 neutral words	Behavioral	Reaction times	SAUD patients showed higher classic and alcohol interference scores than social drinkers Negative correlation between SILS score and classic and alcohol interference scores Positive correlation between classic and alcohol interference scores Larger alcohol interference scores in SAUD patients even after controlling for SILS and classic interference	Findings could not be generalized to other measures of alcohol AB (e.g., visual probe task, flicker paradigm) Age and education not statistically controlled through covariance analysis (for collinearity issue)	Alcohol AB in SAUD patients are not an artefact of their general cognitive impairment
Fadardi & Cox (2008)	87	Males: 22.19 (6.99) Females: 24.13 (9.35)	36.78%	Nondrinkers Alcohol consumption the night before	Social drinkers (SMAST score<2)	AUQ SMAST	NR	None (regression analyses)	NA	Alcohol AB Inhibition and cognitive flexibility Memory for alcohol-related cues	Classic and modified Stroop task SILS Post-Stroop memory task	PCI Emotional-valence ratings	28 alcohol-related words 28 neutral words	Behavioral	Reaction times	Alcohol AB and maladaptive motivation both positively predicted alcohol consumption Alcohol AB did not mediate the effects of maladaptive motivation on alcohol consumption	Alcohol AB and motivational explained only 11.5% of variance Assessment of motivational structure was indirect and based on distal reasons for drinking	Alcohol AB predicted alcohol consumption independently of maladaptive motivational structure
Fadardi & Cox (2009)	200	30.35 (12.42) 22.82 (3.91) 40.75 (15.86)	14% 28% 87%	Age<18 Alcohol consumption in the last 6h	Social drinkers [<14 (women) or <21 (men) doses/week] Hazardous drinkers [15-35 (women) or 22-50 (men) doses/week] Harmful drinkers [>35 (women) or >50 (men) doses/week]	TAAD SIP	NR	Between-subject design: Social drinkers (n=40) Hazardous drinkers (n=68) Harmful drinkers (n=92)	NR	Alcohol and concern-related AB Cognitive flexibility AB modification	Classic and modified Stroop tasks AACTP	CSSRI PANAS PCI RTCQ SCQ SRI DRIE	Alcohol-related words Matched neutral words Individualized alcoholic and non-alcoholic beverage images	Behavioral	Reaction times	Harmful and hazardous drinkers showed higher alcohol interference than social drinkers Alcohol consumption was predicted by alcohol interference scores after controlling for age, gender, affects and classic interference AB training decreased alcohol and classic but not concern-related interference scores in hazardous and harmful drinkers AB training decreased alcohol consumption in harmful drinkers and increased motivation to in hazardous and harmful drinkers	No randomized control trials with a control group to evaluate AACTP intervention	Alcohol AB is associated with the amount of alcohol consumption AB training helps reducing alcohol AB and increases motivation to reduce drinking in hazardous and harmful drinkers
Fernie et al. (2012)	55	21.2 (2.8)	49%	Alcohol dependence Illness increasing alcohol sensitivity Drugs interacting with alcohol consumption Age<18 or >30 No drinking occasion (>5 drinks) in the last 14 days Aversion or allergy for presented stimuli Pregnancy, breastfeeding	Heavy drinkers [>21 (men) or >14 (women) doses/week] Moderate drinkers [<22 (men) or <15 (women) doses/week]	AUDIT TLFB	NR	Between-subject design: Heavy drinkers (n=26) Moderate drinkers (n=26) Within-subject design: 0.4g/kg alcohol Placebo	Age Gender	Alcohol AB Cognitive measures	Visual probe task Bogus taste test Approach-avoidance task Controlled oral words association task Cued go/no-go task Delay discounting task	DAQ-brief AAAQ BIS-11 SIS TRI	10 alcohol-related scenes 10 matched neutral scenes (stationery objects)	Behavioral Eye-tracking	Reaction times Dwell time	No behavioral AB in moderate and heavy drinkers Higher dwell time for alcohol-related cues in heavy drinkers after both alcohol and placebo administration Higher dwell time for alcohol-related cues in moderate drinkers only after alcohol administration No correlation between alcohol AB and alcohol consumption during the taste test after administration	Participants were not required to abstain for >1 day and thus might have been recently intoxicated or under hangover No measures of initial orienting of attention	Alcohol AB, as indexed by eye-tracking measures, was increased after alcohol administration in moderate drinkers whereas heavy drinkers showed an alcohol AB independently of intoxication level
Field et al. (2004)	40	23.40 (5.30)	60%	NR	Light social drinkers (≤10 doses/week) Heavy social drinkers (≥20 doses/week)	AUQ	NR	Between-subject design: Light drinkers (n=19) Heavy drinkers (n=21)	Age Gender	Alcohol AB	Visual probe task Picture rating task Relevance rating task	Alcohol urge questionnaire DAQ	Alcohol-related scenes Matched neutral scenes	Behavioral	Reaction times	Heavy drinkers showed greater AB scores than light drinkers when stimuli are presented for longer durations (500 and 2000ms) but not for shorter ones (200ms) AB scores at 2000 ms was positively correlated with craving, AUQ and doses/week	NR	Heavy drinkers showed alcohol AB in the maintenance but not initial orienting of attention

Field et al. (2005)	50	20.10 (2.0)	34%	Medical advice to reduce alcohol consumption	Social drinkers (drink beer at least occasionally)	AUQ	NR	Between-subject design (tertile split on DAQ score): High craving group (n=17) Low craving group (n=17)	Age AUQ score Gender Time since last alcohol consumption Doses/week	Alcohol AB Alcohol approach tendencies	Visual probe task Stimulus-response compatibility task Progressive ratio operant task	DAQ Craving rating Picture rating	Alcohol-related scenes Matched neutral scenes	Behavioral	Reaction times	Higher AB scores in high cravers compared to low cravers AB scores positively correlated with evaluative bias and initial craving but not with alcohol seeking-behavior or alcohol consumption variables	No distinction between drug-wanting and drug-liking in craving assessment Lack of specificity regarding stimuli in the different measures of the study No gender equity No counterbalanced order of the tasks	Alcohol AB is associated with subjective alcohol craving in social drinkers but not with alcohol consumption
Field et al. (2007)	90	16.83 (0.40)	92.22%	Colour-blindness Non-drinker	Adolescents drinkers (≥1 dose in the last 6 months)	AAIS AUDIT	NR	Between-subject design (tertile split on weekly alcohol consumption): Heavy drinkers (n=34) Light drinkers (n=32)	Age Gender	Alcohol AB Decision making	Modified Stroop task Delay discounting task	DAQ	Alcohol-related words Music-related words Neutral words	Behavioral	Reaction times	Heavy drinkers were significantly slower at naming alcohol-related cues than neutral words No difference in terms of reaction time in light drinkers Stroop interference scores were positively correlated with alcohol-related delay discounting scores, craving and alcohol consumption variables	Limited access and control of confounding variables (e.g. socioeconomic status, parental history of AUD)	Adolescents heavy drinkers, but not light drinkers, showed alcohol AB and impulsive decision making Alcohol AB is associated with impulsive decision making, craving and alcohol consumption
Field et al. (2011)	58	19.93 (1.48)	53%	Non-drinker <1 dose/week Not regular beer drinker Visual impairment	Social drinkers	AUDIT TLFB Doses/week	NR	Between-subject design (median split on weekly alcohol consumption): Light drinkers (n=26) Heavy drinkers (n=28)	None	Alcohol AB	Free visual exploration	AAAQ	10 alcohol-related images 10 matched control images	Eye-tracking	Dwell time	Higher dwell times for alcohol cues in heavy drinkers, independently of the level of alcohol expectancy Higher dwell time for alcohol cues in light drinkers only when alcohol expectancy is high	Groups based on post-hoc median split, reducing the representativity of light and heavy drinkers Administration of non-alcoholic beer during AB task	Heavy drinking is associated with a stable alcohol AB, which is only present when alcohol expectancies are high among light drinkers
Field et al. (2013)	54	42.71 (11.12) 42.35 (11.36)	64.28% 38.46%	SAUD patients: Psychosis or bipolar disorder diagnosis, brain injuries Social drinkers: Major mental illness, physical health problems, alcohol abuse	SAUD patients (ICD-10 diagnosis, first week of treatment) Social drinkers	AUDIT (social drinkers) SADQ (SAUD patients)	NR	Between-subject design: SAUD patients (n=28) Social drinkers (n=26) Median split on craving in SAUD patients: High cravers (n=13) Low cravers (n=12)	Age Gender Education level	Alcohol AB	Visual probe task Modified Stroop task	AUQ VAS HADS	Alcohol-related scenes and words Matched neutral scenes and words	Behavioral	Reaction times	Visual probe task: No difference of reaction times between SAUD and social drinkers Craving was positively correlated with 500ms AB scores in SAUD patients but not 200 or 2000ms High cravers>social drinkers>low cravers for alcohol AB scores Modified Stroop task: SAUD patients, but not social drinkers, were slower for alcohol-related than neutral words No correlation between Stroop interference and craving, or between overall AB scores and treatment compliance	No record of some descriptive characteristics (e.g. race/ethnicity, nicotine dependence, comorbidities, number of previous detoxifications, abstinence duration) Small sample size No use of a recognized published interview protocol for diagnosis Tasks administrated in fixed order Overall low craving in abstinent SAUD patients Control group with AUDIT score of hazardous drinking	Craving plays a crucial role in alcohol AB and treatment outcomes of abstinent SAUD
Fridrici et al. (2013)	72	46.9 (9.7) 44.0 (8.7)	67% 61%	Psychotic disorders Other substance use Severe medical condition Neurological impairment SAUD patients: Relapse during stay Control: Mental illness, alcohol abuse, psychotropic drug intake	SAUD patients (DSM-IV diagnostic, in a rehabilitation program) Healthy moderate drinkers	Form 30 Interview	SAUD patients: Depression Anxiety	Between-subject design: SAUD patients (n=39) Healthy moderate drinkers (n=33)	Age Gender Education level	Alcohol AB Verbal intelligence Visual-motor scanning and cognitive flexibility	Modified Stroop task Vocabulary test Trail Making test	Rating scales	General and individualised alcohol-related words Neutral and negative words	Behavioral	Reaction times	Slower reaction times for SAUD patients than control, except for specific alcohol words Similar reaction times for all word categories in SAUD patients Slower reaction times for specific alcohol words compared to other categories in control	Limited procedure of generating personally relevant alcohol words Omission of a community-drawn group, meeting SAUD criteria but not seeking treatment Comorbidities and medication in half of SAUD patients Combination of vocal and manual responses	Controls, but not SAUD patients, showed alcohol AB for individualized stimuli No impact of individualized Stroop task on alcohol AB in SAUD patients
Fridrici et al. (2014)	84	45.9 (7.3) 46.6 (9.4) 44.4 (8.6)	78.57% 53.57% 64.29%	Other substance use Severe medical condition Neurological impairment SAUD patients: Relapse during stay, mental disorders Control: Psychiatric diagnosis, medical illness, medication with CNS side-effects	SAUD patients (DSM-IV) without comorbidity SAUD patients (DSM-IV) with major depression Healthy moderate drinkers	EuropASI Form 30 Interview	Major depression	Between-subject design: SAUD patients without comorbidity (n=28) SAUD patients with major depression (n=28) Healthy controls (n=28)	Age Gender Education level	Alcohol AB Alcohol memory bias Verbal intelligence Visual-motor scanning and cognitive flexibility	Modified Stroop task Directed forgetting paradigm Vocabulary test Trail Making test	AASE ADS-k BIS-11 STAI OCDS	Alcohol-related words Neutral and negative words	Behavioral	Reaction times	Slower reaction times for all word categories in all SAUD patients compared to controls Slower reaction times for alcohol-related words compared to negative words in all participants	Recruitment limited to SAUD patients that have completed a day-clinic rehabilitation program No inclusion of key variables such as alcohol priming or expectancy	Alcohol AB is not specific to SAUD patients with and without depression but also present in healthy controls
Garland (2011)	58	39.8 (9.3)	81%	<18 years old Resident of the treatment facility for <18 months	SAUD patients (resided in a residential treatment facility, DSM-IV)	AUDIT MINI	NR	None (correlation and regression analyses)	NA	Alcohol AB	Spatial cueing task	FFMQ PACS SCQ PSS-10	Alcohol-related images Matched neutral images	Behavioral	Reaction times	AB score did not differ from zero in SAUD patients Positive correlation between alcohol AB and doses/day Trait mindfulness negatively correlated with alcohol AB Doses/day and mindfulness as predictors of alcohol AB	Omission of other important factors for alcohol AB Measure of trait mindfulness might be coextensive with such factors (e.g. readiness to change, distractibility)	Alcohol AB in SAUD patients is associated positively with previous alcohol consumption and negatively with trait mindfulness
Gladwin et al. (2013)	35	21	20%	AUDIT score=0	Social drinkers	AUDIT	NR	None (correlation analyses)	NA	Alcohol AB	Spatial cueing task	None	4 Alcoholic beverage pictures 4 Matched soft-drinks pictures	Behavioral fMRI	Reaction times Accuracy fMRI data	Participants were faster to shift attention to invalid location following alcoholic versus non-alcoholic cues Medial parietal region activated when attention had to be directed towards alcohol AUDIT score was negatively correlated with activation of the medial parietal region	Limited generalization of their findings to clinical population Differential contribution of gender as there was more male in heavier drinkers Limited behavioural data due to fMRI procedure Hazardous drinking only based on AUDIT No assessment of craving	Medial parietal activation might reflect attentional disengagement from alcohol stimuli features that might interfere with task performance Reduced activity of this region in heavier drinkers, indexing a weaker tendency to disengage from distracting alcohol cues
Gladwin (2017)	56	20.1 (4.8)	8.93%	NR	Students	AUDIT-C	NR	None (correlation analyses)	NA	Alcohol AB	Classical and cued visual probe task	None	Alcoholic beverage pictures Matched soft-drinks	Behavioral	Reaction times Accuracy	Strong association between AUDIT-C scores and both AB variability measures At long cue-stimulus interval, participants with higher AUDIT scores tend to answer too late to probes appearing at the location of cues predicting soft drinks	Sample limited to students, (not clinical population) Briefness of the task No measures of awareness of cue-stimulus type contingencies Online study, limiting the supervision of participants	Alcohol AB variability is strongly associated with riskier alcohol consumption

Gladwin et al. (2020)	Exp 1: 47 Exp 2: 70 Exp 3: 94 Exp 4: 76	42.04 (11.20) 36.89 (10.50) 35.87 (9.14) 39.66 (9.83)	65.96% 52.86% 63.83% 47.37%	NR	Adults	AUDIT	NR	None (correlation analyses)	NA	Anticipatory alcohol AB	Cued visual probe task	None	Alcoholic beverage pictures Soft-drinks pictures	Behavioral	Reaction times	Overall alcohol AB No correlation between AUDIT and alcohol AB scores	Convenience sample Online data collection	Risky drinking behaviour is not associated with anticipatory alcohol AB measures
Groefsema et al. (2016)	192	20.73 (1.72)	51.6%	Age<18 or >25 <1 dose/week	Social drinkers (≥1 dose/week)	AUDIT Ecological momentary assessment (alcohol use and drinking company) Doses/week	NR	None (correlation and regression analyses)	NA	Alcohol AB Alcohol approach bias	Visual probe task Stimulus-response compatibility task	None	Social and non-social alcohol-related pictures Social and non-social soft drink pictures	Behavioral	Reaction times	No correlation between AB, weekly alcohol use and AUDIT at baseline Slower reaction times for social pictures, independently of stimuli type Women showed greater alcohol AB than men Social alcohol AB positively associated with alcohol use and number of friends of opposite gender	No trigger of challenging situations amplifying alcohol AB (e.g. stress, priming) Low variance and reliability of AB measures Brands included in pictures Study design hampering to analyse causal relationship between AB and drinking behavior	Alcohol AB for social pictures are related to alcohol use in the presence of various friends of the opposite gender
Gunn et al. (2021)	37	20.22 (2.2)	51.35%	Smokers Consumers of >400mg caffeine per day Pregnant or breastfeeding Current or past personal/family history of alcohol or drug dependency Diagnosed sleep disorder	Adult drinkers [>6 (women) or >8 (men) units per heavy drinking day]	AUDIT eBAC	NR	Within-subject design: Hangover condition No-hangover condition	NA	Alcohol AB Response inhibition	Visual probe task Go/No-Go task	BIS-11 RT-18 STAI mAHSS GSQS KSS AUQ VAS RSME	Alcohol-related images Neutral images	Behavioral	Reaction times	No difference in terms of reaction time in the visual probe task between conditions AB scores did not differ from 0 in either condition AB scores did not correlate with AUDIT or hangover severity	Problems with recording eye-tracking data hampering the use of reliable AB measures	Student drinkers did not present any alcohol-related AB Hangover is associated with impaired response inhibition but did not influence alcohol-related AB
Hallgren & McCrady (2013)	84	21.1 (4.4)	30%	Age<18 No binge episode in the last 30 days	Undergraduate student binge drinkers (≥1 binge drinking episode in the last 30 days)	RAPI TLFB	NR	Between-subject designs: High-intensity drinkers (n=41) Low-intensity drinkers (n=43) High-frequency drinkers Low-frequency drinkers Problem drinkers Non-problem drinkers	NR	Alcohol AB	Modified Stroop task	None	Alcohol-related words Matched neutral words	Behavioral	Reaction times	Participants were slower for alcohol words presented sequentially rather than neutral ones No difference in reaction times between high- and low-frequency drinkers or between problem and non-problem drinkers High-intensity drinkers were slower for trials where alcohol words preceded neutral words than trials where neutral words preceded any word type	No measure of some biasing variables (emotional state, comorbid substance use) Alcohol-related words containing beverages of different levels of alcohol by volume Words normed in a British sample but used in an American sample No longitudinal assessment of drinking behavior	College drinkers with a recent binge drinking episode showed an alcohol AB, not related to drinking frequency or drinking-related problems Drinking intensity was related to delayed alcohol Stroop interferences
Heitmann et al. (2020)	169	20.55 (2.80)	18.3%	None	Undergraduate students	MATE-Q RAPI	NR	None (within-subject design)	NA	Alcohol AB	Visual Search Task (VST) Odd-One-Out Task (OOOT)	OCDS	Alcohol-related pictures Soft drink pictures	Behavioral	Reaction times Accuracy	Alcohol AB index of VST was positively (weakly) correlated with drinking frequency but not with quantity, craving or alcohol use problems Disengagement AB index of OOOT was positively (weakly) correlated with drinking frequency and quantity but not for craving or alcohol use problems Engagement AB index of OOOT is associated with drinking frequency in males only	Non-clinical sample (noise, unstable AB, low alcohol use problems) Convenience sample with low percentage of males Discrepancy in wording MATE-Q Calculation of AB indices based on different contrast category Need for more trials in the OOOT and individualized stimuli	Low reliability of the VST and OOOT Disengagement processes of alcohol AB are associated with alcohol consumption in students
Heitmann et al. (2021)	245	20.3 (2.08)	46%	Non-drinkers	Low student drinkers (1-7 doses/week) High student drinkers (≥14 doses/week)	MATE-Q RAPI-18	NR	Between-subject designs: Self-identified high drinkers (n=84) Self-identified low drinkers (n=157) Reported high drinkers (n=129) Reported low drinkers (n=112) OOOT in laboratory context (n=127) OOOT-adapt in bar context (n=114)	NR	Alcohol AB	Odd-One-Out task (OOOT) Adapted Odd-One-Out task (OOOT-adapt)	OCDS	Alcohol-related pictures Neutral pictures (soft drink or office supplies and flowers)	Behavioral	Reaction times	High drinkers (either reported or self-identified) showed greater attentional engagement towards alcohol than low drinkers in the OOOT-adapt No difference between groups regarding OOOT or regarding disengagement AB in OOOT-adapt	No disentangle between the context and/or the adaptations of the task More distractions in the bar than the laboratory context Internal consistency of the tasks under the threshold for good reliability One vs. multiple alcohol-related stimuli to assess engagement vs. disengagement AB	High drinkers engaged faster with alcohol-related cues than low drinkers The OOOT-adapt showed higher reliability to index AB in alcohol use behavior
Heitmann & de Jong (2021)	AUD: 66 Controls: 66 CUD: 28 Controls: 28	49.86 (12.34) 48.67 (13.49) 31.21 (7.32) 32.82 (8.71)	60.3% 55.6% 75.0% 64.3%	Controls: No history or need for treatment for SAUD or CUD	SAUD patients CUD patients Healthy controls	MATE-Q	NR	Between-subject designs: SAUD patients (n=53) Controls (n=60) CUD patients (n=17) Controls (n=26)	Age Gender	Alcohol AB	Odd-One-Out task (OOOT)	None	Alcohol-related pictures Cannabis-related pictures Neutral pictures (e.g., soft drink, flowers)	Behavioral	Reaction times	SAUD patients did not differ from controls regarding distraction and detection AB indexes for alcohol-related cues	Reduced sensitivity of AB indexes due to high number of incorrect responses Online assessment at home reducing control and increasing distraction No control of other biasing variables between clinical and control groups No measure of other substance use Low internal consistency of the OOOT	SAUD patients were not characterized by speeded detection of alcohol-related cues or increased distraction from these cues
Hobson et al. (2013)	58	24.54 (7.00)	41.37%	Non-drinkers	Students	SADQ TLFB	NR	Between-subject designs: Light drinkers (n=29) Heavy drinkers (n=29) Low cravers (n=29) High cravers (n=29)	Age	Alcohol AB	Flicker change blindness paradigm	DAQ	Alcohol-related pictures and real world scenes Matched neutral pictures and real world scenes	Behavioral Eye tracking	Changes detection Latency/orientation of first saccade Number of fixations Dwell Time	Heavy drinkers detected a higher proportion of alcohol changes in real world scenes than light drinkers High cravers detected a higher proportion of alcohol changes and showed faster saccades towards alcohol in real scenes than low cravers	Task demands limiting the ability to maintain attention on the target stimulus Structure of grid encouraging strategic scanning	Eye-tracking measures showed an initial orientation towards alcohol in real scenes for individuals with high craving, but unrelated to alcohol consumption Maintained attention was not related to craving or alcohol consumption
Janssen et al. (2015)	378	14.9 (1.28)	35.2%	None	Adolescents	TLFB	NR	None (longitudinal study design)	NA	Alcohol approach bias Alcohol AB Implicit attitudes Impulsivity	Stimulus Response Compatibility Task Alcohol approach-avoidance task Visual Probe Task Modified Stroop Task	SURPS	Alcohol-related pictures or words Water-related pictures and neutral (office supplies) words	Behavioral	Reaction times Scores (DDT)	No correlation between weekly alcohol use at each time point and alcohol AB at T1 Alcohol AB (measured by the VPT) predicted weekly alcohol use at each time point except T1 Baseline alcohol use did not predict alcohol AB at T4	No investigation of significant relations in a full cross-lagged structural equation model caused by the numerous measures of cognitive biases Low reliability of the tasks	Alcohol AB did not predict the initialization of alcohol use but predicted quantity of drinking at later time points in adolescents

											Brief Implicit Attitude Test Delay Discounting Task					No correlation between alcohol AB and impulsivity	Small sample sizes at later time points limiting the possibility to examine all predictive relations in a single model	
Jones et al. (2002)	92	NR	NR	None	Undergraduate volunteers	TLFB	NR	Between-subject design: Normal laterality/ alcohol-related change detected (n=24) Normal/alcohol neutral change detected (n=20) Reversed laterality/alcohol-related (n=29) Reversed/alcohol neutral (n=19)	None	Alcohol AB	Flicker change blindness paradigm	None	Alcohol-related scene with alcohol-related and neutral changes	Behavioral	Change detection	Participants detecting the alcohol-related change had higher consumption (heaviest drinking day in the last week) than those detecting the neutral change	NR	Alcohol AB is associated with higher alcohol consumption in the last week
Jones et al. (2003)	100	23.4 (3.4)	NR	None	Students	TLFB	NR	Between-subject design: Normal laterality/ alcohol-related change (n=25) Normal/neutral change (n=25) Reversed laterality/alcohol-related (n=25) Reversed/neutral change (n=25) Subgroups generated per group from lightest (n=10) and heaviest drinkers (n=10)	Gender	Alcohol AB	Flicker change blindness paradigm	None	Alcohol-related scene with an alcohol-related or neutral change	Behavioral	Number of flickers to change-detection	Heaviest drinkers detected the alcohol-related change faster than lightest drinkers or than neutral change Lightest drinkers detected the neutral change faster than heaviest drinkers or than alcohol-related change	NR	Alcohol AB in social drinkers appears to be related to alcohol consumption
Jones et al. (2006)	72	34 31	66.67%	None	SAUD patients (DSM-IV) from treatment centre (n=36) Social drinkers (n=36)	Social drinkers: TLFB	None	Between-subject design based on: Population (SAUD patients, social drinkers) Nature of change (alcohol-related, neutral) Laterality of stimulus (normal, reversed)	Age Gender	Alcohol AB	Flicker change blindness paradigm	None	Alcohol-related scene with an alcohol-related or neutral change	Behavioral	Change-detection latency	SAUD patients, but not social drinkers, were faster when detecting the alcohol-related change rather than the neutral change Negative correlation between change-detection latency for alcohol-related change and number of previous treatment in SAUD patients	Small variation in alcohol consumption in the social drinkers sample Use of a single alcohol-related and neutral change-to-be-detected, limiting its generalization to other stimuli	Graded continuity of alcohol AB along the consumption continuum
Jones et al. (2012)	29	21.16 (3.33)	45.17%	Alcohol-related disorders Consumption of beer and chocolate <1/week Age <18 or >30 Medical advice to reduce alcohol consumption	Social drinkers	AUDIT TLFB Doses/week	NR	None (within-subject design)	NA	Alcohol and chocolate AB	Free visual exploration	Chocolate use and craving	Alcohol-related images Chocolate-related images Matched neutral images	Eye tracking	Dwell time	Overall longer dwell times for alcohol and chocolate than neutral cues Increased AB score in social drinkers (higher dwell time) when reward expectancy is high, independently of the expected reward (present for alcohol and chocolate rewards)	Manipulation of expectancy conducted on a trial-by-trial basis, potentially leading to an overlap in reward expectations No actual consumption of the rewards Preference for one of the rewards was not evaluated No investigation of alcohol AB in the 50% probability condition	Reward expectancy increases AB, this effect being independent of the expected reward (alcohol/chocolate)
Jones et al. (2018)	Exp 1: 67 Exp 2: 46	Exp 1: 25.08 (6.53) Exp 2: 21.35 (3.98)	Exp 1: 38.81% Exp 2: 23.91%	Substance use disorder (current or recent)	Regular drinkers (≥1 dose/week)	TLFB	NR	None (correlation analyses)	NA	Alcohol AB	Visual Probe Task	AAAQ	8 alcohol-related scenes 8 matched neutral scenes	Behavioral Eye-tracking	Reaction times Dwell time	Alcohol AB did not significantly change over time No correlation between alcohol AB and alcohol consumption or craving No difference between alcohol AB to personalized or general cues	No recruitment of a specific sample (e.g. heavy drinkers, alcohol-dependent patients)	Assessing alcohol AB using the visual probe task is unreliable due to poor psychometric properties of the test, even after following empirical recommendations
Knight et al. (2018)	50	20.08 (1.59)	24%	Taking/smoking prescribed or recreational drugs Non-drinker Colour blindness	Social drinkers	TLFB	NR	Between-subject design: Heavy social drinkers (n=25) Light social drinkers (n=25)	None	Alcohol AB	Alcohol change detection task	None	Alcohol-related pictures Neutral pictures	Behavioral	Reaction times	Heavy drinkers detected more accurately alcohol-related change in neutral-alcohol trials than light drinkers	No screening for psychiatric comorbidities	Heavy drinkers, but not light drinkers, showed a pre-existing alcohol AB
Langbridge et al. (2019)	51	22.0	39.22%	AUDIT≥20 Current psychiatric or regular recreational drug use Family history of SAUD	Binge drinkers (BD; Binge score >24) Non-binge drinkers (NBD; Binge score <16)	AUQ AUDIT	Smokers (n=3)	Between-subject design: BD with combined intervention (n=10) BD with AB training (n=10) BD with sense of control training (n=10) Untrained BD (n=11) Untrained NBD (n=10)	Gender Age	Alcohol AB Alcohol consumption Cognitive tasks	Visual probe task Bogus taste test Anagram task Concept Identification cards task	PACS TLC Summary-SCI TSSCI	Alcohol-related pictures Matched neutral pictures	Behavioral EEG	Reaction times Cued-elicited event related potentials	Binge drinkers showed higher alcohol AB scores than non-binge drinkers Alcohol AB decreased over time, regardless of the intervention EEG data showed no difference between BD and NBD at baseline, or between intervention groups Reduced alcohol consumption after combining attentional and sense of control training	Need for more neutral probes Insufficient power to detect group differences Overrepresentation of young people and students in the sample No distinction between effects of global alcohol intake and specific pattern of consumption	Binge drinkers showed higher alcohol AB than non-binge drinkers at baseline No effect of attentional training on behavioural and electrophysiological markers of alcohol AB in binge drinkers
Luehring-Jones et al. (2017)	60	21.9 (2.2)	45%	<3 doses/week Psychiatric disorder (past or current) Current consumption of illegal substances History of cardiovascular disease Pregnancy Fail at urine toxicology screening or alcohol breath test	Social drinkers	AUDIT TLFB Age at starting drinking Doses/occasion Occasions/week Binge drinking episodes	NR	Between-subject design: Attentional training (n=30) Sham training (n=30)	None	Alcohol AB Implicit alcohol attitudes Craving	Modified Stroop task Visual probe task Implicit Association Task Cue exposure task	OCDS	Alcohol-related words and pictures Neutral words and pictures	Behavioral	Reaction times	Number of drinks per occasion was correlated with alcohol Stroop interference at baseline Attentional training reduced alcohol AB scores in all tasks Attentional training indirectly reduced craving through reduction in Stroop interference scores	Small sample size (may explain pre-training variability, no exploration of moderating factors) Visual probe task with filler pictures (direct alcohol/neutral comparisons might offer stronger results)	Alcohol AB is associated with alcohol consumption in social drinkers Efficacy of AB training on alcohol AB

Lusher et al. (2004)	128	40.23 (9.16) 32.80 (9.91)	84.4% 53.1%	SAUD patients: Abuse of medication or illicit substances Controls: Abuse of alcohol or any drugs	SAUD patients from outpatient treatment service Controls	SADQ	NR	Between-subject design: Alcohol group (n=64) Control group (n=64) Median split on SADQ score: Low severity (n=31) High severity (n=33) Medium split on years of SAUD: Low number (n=32) High number (n=33)	None	Alcohol AB	Modified Stroop task	POMS-SF	Alcohol-related words Matched neutral words (household-related)	Behavioral	Reaction times	Alcohol group showed longer reaction times to alcohol than neutral words when compare to controls Group as only predictor of Stroop interference score when accounting for confounding variables (age, sex, mood, education) Alcohol groups high and low on dependence severity, or on number of years of SAUD, did not differ in their reaction times to alcohol-related and neutral words	Small sample size Exploratory analyses	SAUD patients showed increased alcohol AB compared to controls Mood status, demographics or alcohol involvement did not influence alcohol AB
McAteer et al. (2015)	44	16.92 (48.34) 17.87 (7.65) 16.06 (31.56)	65.9%	Head injury Diagnosis of psychological disorders	Adolescent Heavy (AUDIT≥9), light (AUDIT 1-8) and non-drinkers (AUDIT=0)	AUDIT Age at first drink Abstinence duration	NR	Between-subject design: Heavy drinkers (n=17) Light drinkers (n=15) Abstainers (n=12)	None	Alcohol AB	Free visual exploration	AEQ-A	60 alcohol-related images 60 matched neutral images	Eye tracking	Latency/orientation of first fixation Dwell time	Higher total fixation time for alcohol stimuli among heavy drinkers compared to abstainers No group difference on the latency or orientation of initial fixation Higher fixation time for alcohol stimuli among heavy drinkers in the second (1500-2500ms) but not first (0-1249ms) half of the presentation time Total fixation time to alcohol stimuli correlated with alcohol use	Self-report assessment of alcohol consumption No analyses of the covariation between alcohol AB, alcohol use and alcohol expectancies No measure of laterality that might influence left gaze bias	Adolescent heavy drinkers showed alcohol AB underpinned by controlled rather than automatic processes Stronger alcohol AB is related with alcohol consumption in adolescence
McAteer et al. (2018)	139	Early ado: 12.63 Late ado: 17.10 Young adults: 20.19	46.04%	Head injury Psychological disorder Visual impairment	Early and late adolescents, young adults Heavy (AUDIT≥9), light (AUDIT 1-8) and non-drinkers (AUDIT=0)	AUDIT	NR	Between-subject design: Non-drinkers early adolescents (n=42) Light drinkers (n=38): late adolescents (n=14) or young adults (n=24) Heavy drinkers (n=39): late adolescents (n=16) or young adults (n=23)	NR	Alcohol AB	Free visual exploration	None	60 alcohol-related images 60 matched neutral images	Eye tracking	Orientation of two first fixations Dwell time	Heavy drinkers showed longer total fixation time for alcohol stimuli compared to light drinkers, independently of age Young adults showed higher percentage of initial fixation towards alcohol compared to mate adolescents, independently of consumption	Cross-sectional study rather than longitudinal No investigation of confounding factors like alcohol exposure or reasons for abstention in non-drinkers	Heavy drinkers showed increased alcohol AB underpinned by controlled processes compared to light drinkers Alcohol AB underpinned by automatic processes increased with age
McGivern et al. (2021)	58	15.25 (0.58)	46.55%	Age <14 or >16	Adolescent heavy drinkers (AUDIT>8) Adolescent light drinkers (AUDIT between 1 and 8) Adolescent abstainers (AUDIT=0)	AUDIT	NR	Between-subject design: Heavy drinkers (n=15) Light drinkers (n=21) Abstainers (n=22)	None	Alcohol AB	Free visual exploration	AEQ-A CSDS-SF	Alcohol-related images of words, objects and scenes Neutral images	Eye tracking	Direction/duration of initial fixation Number of fixations Dwell time	Drinkers did not direct their first fixation more frequently towards alcohol (i.e. vigilance bias) First alcohol fixations were longer in heavy drinkers than abstainers (i.e. delayed disengagement bias) Proportion of alcohol dwell time: heavy>light>abstainers (i.e. maintenance bias) More fixations towards alcohol in heavy drinkers compared to abstainers (i.e. maintenance bias) Heavy drinkers showed longer alcohol dwell times than light drinkers and abstainers in the first half of presentation and longer than only abstainers in the second half	Non-clinical sample limiting the generalisability of the results	No vigilance bias or automatic orienting in adolescents, but heavy adolescents drinkers showed both a delayed disengagement bias and a maintenance bias towards alcohol compared to abstainers
Miller & Fillmore (2010)	25	24.04 (3.80)	56%	Alcohol dependence (SMAST score >5) Infrequent alcohol consumption Recent drug use Prior treatment for AUD Conviction for driving under the influence	Regular drinkers (≥2 drinking occasion/month in the last 3 months)	TLFB S-MAST	NR	None (regression analyses)	NA	Alcohol AB	Visual probe task	None	20 complex and simple alcohol-related images 20 complex and simple matched neutral images	Behavioral Eye tracking	Reaction times Dwell time	Participants showed alcohol AB (indexed by reaction time and dwell time) when confronted with simple alcohol images No alcohol AB for complex stimuli Alcohol AB as measured by dwell time was predicted by higher intensity/frequency of consumption	NR	Regular drinkers present alcohol AB when confronted with simple (but not complex) alcohol images Alcohol AB is associated with alcohol consumption Dwell time is a better AB index than behavioral measures
Monem & Fillmore (2017)	35	24.60 (3.40)	45.71%	Under legal drinking age History of AUD Prior treatment for AUD Visual impairment	Regular drinkers (≥1 dose/week in the last 3 months)	AUDIT TLFB	NR	None (within-subject design)	NR	Alcohol AB	Free visual exploration in natural setting	None	Recreational room with 4 alcohol-drinks and 4 matched soft-drinks	Eye tracking	Dwell time	Alcohol AB only during the second session of in vivo visual exploration of real life environment (i.e. reduced dwell time due to habituation for soft images, not for alcohol) Correlation between alcohol AB and alcohol consumption (i.e., number of drinks, binge drinking days and subjective drunkenness days)	Laboratory setting Aim of the study easily guessed Not clinical population	Regular drinkers showed a sustained alcohol AB (not diminishing over time compared to soft-drinks), this AB being correlated with drinking habits
Mülller-Oehring et al. (2019)	39	50.3 (9.5) 49.6 (11)	80.95% 55%	Education <8 years History of medical, psychiatric, neurological disorders DSM-IV-TR Axis I disorders (control group)	SAUD patients (DSM-IV-TR) Controls	TLFB SCID	History of cannabis abuse/dependence (n=11) History of substance abuse/dependence (n=15) History of major depressive disorder (n=8) History of anxiety disorder (n=2)	Between-subject design: SAUD patients (n=21) Controls (n=18)	Gender Age	Alcohol AB Cognitive abilities	Modified Stroop task DRS-2 WTAR WMS-R	ACQ-R BDI BIS STAI	Alcohol-related words Cannabis-related words Colour words	Behavioral fMRI	Reaction times fMRI data	Longer reactions times for alcohol and cannabis-related words relative to neutral words in SAUD compared to controls SAUD with higher consumption of alcohol (but not cannabis) correlated with greater alcohol AB Early age at SAUD onset, late age at CUD onset and less heavy cannabis use per month contribute to strong alcohol AB Frontal and premotor deactivation to alcohol words in SAUD compared to controls, which correlated with lifetime alcohol consumption	No participant with acute cannabis use Small sample of SAUD with past cannabis use No investigation of the effects of cognitive training on alcohol AB Majority of SAUD sample with history of substance abuse	Abstinent SAUD showed alcohol AB relative to controls at behavioral (reaction times) and neural (frontal hypoactivation) levels
Murphy & Garavan (2011)	84	20.8 (3.0)	53.57%	Age <18 or >30 More than occasional use of illegal drugs	Student drinkers (≥1 dose/week)	AUDIT	NR	Between-subject design (based on AUDIT score): Problem drinkers (n=42) Non-problem drinkers (n=42)	Age Gender	Alcohol AB Impulsivity Inhibitory control	Modified Stroop task Delay discounting task Go-NoGo task	None	Alcohol-related words Music-related words Neutral words Coloured 'XXXX's	Behavioral	Reaction times	Alcohol AB positively correlated with impulsivity and impaired inhibition Alcohol AB and impulsivity were strong discriminator of problem from non-problem drinkers Alcohol AB predicted AUDIT scores in problem drinkers, but not in non-problem drinkers	Loss of statistical power in regression analyses due to dichotomous outcome measure Low specificity due to high AUDIT cut-off score	Alcohol AB can help discriminate groups of problem and non-problem drinkers and predict AUDIT scores

Nikolaou et al. (2013)	14	23.93 (1.4)	35.71%	Age <18 or >35 History of psychiatric, neurological or physical disorder Under treatment for drug or alcohol dependence Medication for psychological or physical condition Regular use of cannabis Smoking >20 cigarettes/day	Social drinkers [>2 units/week (AUQ)]	AUQ	NR	None (correlational analyses)	NA	Alcohol AB	Concurrent flanker/alcohol AB task	None	20 alcohol-related images 20 matched neutral images 20 plain grey background	Behavioral	Reaction times Response accuracy Flanker effect	In the congruent condition, longer reaction times in the presence of neutral and alcohol-related images compared to grey background In the incongruent condition, longer reaction times in the presence of alcohol-related images compared to neutral and grey backgrounds Lower accuracy in the presence of alcohol-related images only in the congruent condition Number of drinks/week positively correlated with greater alcohol interference under increased cognitive load	No examination whether interference effect might derive from increase in craving	Alcohol AB could interfere and compromise cognitive control mechanisms This interference effect is associated with alcohol consumption
Noël et al. (2006)	64	45.6 (8.2) 44.2 (10.1)	63.88% 67.85%	SAUD: Current other DSM-IV Axis I disorders History of medical illness Head injury Use of psychotropic drugs or substances Overt cognitive dysfunction Social drinkers: Non-drinkers DSM-IV Axis I disorders Drug abuse disorder Alcohol consumption >54 g/d	SAUD patients (DSM-IV, from inpatient treatment) Social drinkers	None	NR	Between-subject design: SAUD patients (n=36) Social drinkers (n=28)	Gender Age Education	Alcohol AB	Visual probe task	BDI STAI Craving VAS	Alcohol-related scenes Matched neutral scenes	Behavioral	Reaction times	SAUD patients showed alcohol AB when presented at 50ms, greater than social drinkers Social drinkers showed alcohol AB when presented at 500ms, greater than SAUD patients No difference between groups when stimuli are presented at 1250ms Positive correlation between number of prior treatments and alcohol AB score at 50ms	Craving VAS with too restricted range	SAUD patients have an initial orienting alcohol AB followed by an attentional disengagement, suggesting an approach-avoidance attentional pattern Severity of SAUD is associated with early attentional allocation for alcohol cues
Pennington et al. (2020)	99	20.77 (2.98)	35%	Non-drinkers	Social drinkers	AUDIT	NR	None (regression analyses)	NA	Alcohol AB	Visual conjunction search task	ACQ-SF-R DMQ-R-SF	4X6 grids with alcoholic and neutral appetitive images	Behavioral	Reaction times	Participants showed faster reaction times for alcoholic relative to non-alcoholic stimuli Alcohol AB scores are predicted by AUDIT and alcohol consumption but not by craving or drinking motives	No counterbalanced order between craving and AB assessment that may have reciprocal influence Sample with high proportion of students and harmful alcohol use Potential existence of other cofounding variables (e.g. socio-demographic)	Alcohol AB is associated with alcohol consumption Visual conjunction search task is a valid and reliable experimental measure of alcohol AB
Pieters et al. (2011)	Exp 1: 195 Exp 2: 82	Exp 1: 13.69 (0.89) Exp 2: NR	Exp 1: 44% Exp 2: 100%	Exp 1: None Exp 2: Female Age <18 and >28 Color blindness	Exp 1: Young adolescents beginning drinkers Exp 2: Young adult heavy drinkers (≥20 doses/week, ≥1 binge episode in the last 2 weeks)	Exp 1: Frequency of alcohol use Weekly alcohol use Exp 2: TLFB AUDIT	NR	Between-subject designs: Exp 1: OPRM1 no risk (n=151) OPRM1 risk (n=44) Exp 2: OPRM1/DRD4 no risk (n=49) OPRM1 risk (n=13) DRD4 risk (n=20)	None	Alcohol AB	Visual probe task	Exp 1: None Exp 2: Affect-grid Craving VAS	Alcoholic beverage images Soft drinks images	Behavioral Genotyping	Reaction times OPRM1 and DRD4 polymorphisms	Exp 1: Alcohol AB predicted more frequent and intense alcohol use only for adolescents with the OPRM1-C risk genotype Exp 2: Alcohol AB was positively associated with problem drinking only for heavy drinkers with the DRD4 risk genotype	Cross-sectional data preventing from causal statement regarding AB and alcohol use Selective samples preventing the generalizability of results Modest internal consistency of AB measure Not identical procedures in the two studies Potential existence of other sources of variability No direct assessment of liking and wanting	The relation between alcohol use and alcohol AB is moderated by OPRM1 risk genotype (reflecting liking and wanting) in early adolescents and by DRD4 risk genotype (reflecting wanting) in young adults
Pieters et al. (2014)	427	13.96 (0.78)	47.7%	Non-drinkers	Adolescents	Intensity of alcohol use (weekdays, weekend, at home, outside)	NR	None (regression analyses)	NA	Alcohol AB Alcohol approach bias Alcohol memory associations Working memory capacity	Visual probe task Stimulus response compatibility task Implicit association test Word association test Self-ordered pointing task	Alcohol expectancies	Alcoholic beverage images Soft drink images	Behavioral	Reaction times	No correlation between alcohol AB and other study variables Alcohol AB did not predict changes in alcohol use from T1 to T2	Implicit and explicit cognitive processes assessed once Normative sample of early adolescents with initial or irregular alcohol use Short interval assessments (<1 year) Numerous indirect measures of implicit cognitions	Positive expectancies are better predictors than implicit cognitions of increase in adolescents and young adults alcohol use Dual process model of addiction do not predict alcohol use in adolescents with normative alcohol use
Qureshi et al. (2019)	41	21.50 (6.61)	21.95%	Non-drinkers (AUDIT=0)	Regular drinkers	AUDIT	NR	Between-subject design (median split on AUDIT): Non-problem drinkers (n=23) Problem drinkers (n=18)	Gender	Alcohol AB Saccade inhibition	Gaze contingency paradigm	None	30 alcoholic appetitive images 30 non-alcoholic appetitive Images 30 matched non-appetitive images	Eye tracking	Break frequency (i.e. inability to inhibit saccade)	For centrally-located stimuli, higher break frequency among problem drinkers for non-appetitive stimuli compared to alcohol stimuli For peripheral stimuli, higher break frequency in problem drinkers for alcoholic and non-alcoholic stimuli compared to non-appetitive stimuli	Unmatched stimuli regarding valence and color No measure of baseline thirst Alcohol AB based on only one measure Groups based on median split Bayesian analysis suggesting more data is requested	Problematic drinking is associated with reduced inhibitory control on saccadic movements towards peripheral appetitive (alcohol-related and non-alcohol-related) stimuli
Ramirez et al. (2015a)	39	19.1 (0.8)	51.28%	<1 beer/week over the last month Treatment for AUD (currently or in the past month)	Underage college student drinkers	TLFB RAPI AUDIT	NR	Within-subject design: Water-cue exposure Beer-cue exposure	NA	Alcohol AB Craving	Visual probe task Cue-reactivity procedure	AUQ	10 alcoholic beverage 10 matched soft drink images	Behavioral	Reaction times	AUDIT was negatively correlated with alcohol AB during water-CR sessions Faster reaction times for alcohol stimuli only in alcohol-CR sessions Stronger alcohol AB in alcohol-CR sessions than water-CR sessions Craving did not predict alcohol AB	No assessment of AUD status and high percentage of AUDIT scores>16 in the current sample Lack of sensitive AB measures and power to capture the relationship with craving	Stronger alcohol AB in college drinkers after in-vivo exposure to alcohol cues
Ramirez et al. (2015b)	80	19.1 (0.8)	42.5%	<1 beer/week over the last month Treatment for AUD (currently or in the past month)	Underage college student drinkers	TLFB RAPI AUDIT	NR	Between-subject design: Short alcohol-cue exposure (n=40) Long alcohol-cue exposure (n=40) Subgroups based on gender: Men (n=17) Women (n=23)	Gender Age Ethnicity TLFB RAPI AUDIT	Alcohol AB Craving	Visual probe task Cue-reactivity procedure	AUQ	10 alcoholic beverage 10 matched soft drink images	Behavioral	Reaction times	No correlation between alcohol AB at baseline and craving or alcohol consumption Increases in alcohol AB from T1 to T2 in both exposure groups Changes in craving positively predicted changes in alcohol AB for women in long alcohol-cue exposure	Modest rates of alcohol consumption that might be related to unreliable alcohol AB at baseline Limited power for sex differences analyses	Both short and long alcohol-cue exposure increased craving and alcohol AB Craving changes are predictive of AB changes in women when longer exposed to alcohol cues
Rettie et al. (2018)	81	44.83 (9.92) 44.11 (13.38)	NR	Severe psychotic disorder or neurological impairment Illicit drug use Color blindness Controls: History of SAUD	SAUD patients (discharged of treatment unit in the next 3 days) Staff members of treatment unit	TFLB SIP	NR	Between-subject design: SAUD (n=45) Controls (n=36) Subgroups of SAUD based on relapse: Relapsed (n=15) Successful (n=20)	Age Age at first drink	Alcohol AB	Modified Stroop task	RCQ DERS HADS	Alcohol-related words Neutral words Positive and negative change-related words	Behavioral	Reaction times	No difference of groups regarding alcohol AB interference scores Successful SAUD patients showed lower alcohol interference scores than relapsed SAUD patients	Indirect measures of AB	AB to positive change-related words is a better predictor of relapse and TFLB score than alcohol AB

Roy-Charland et al. (2017)	Exp 1: 78 Exp 2: 76	Exp 1: 22.9 (6.41) Exp 2: 20.6 (4.92)	Exp 1: 75.64% Exp 2: 88.16%	None	Undergraduate students	KAT	NR	None (correlational analyses)	NA	Alcohol AB	Free visual exploration Memorization task	None	Alcohol-related complex visual scenes Matched neutral complex visual scenes	Eye tracking	Time to first fixation Number of saccades Dwell time	None of the AB measures correlated with alcohol consumption during free visual exploration of complex scenes Number of saccades towards alcohol correlated with alcohol consumption only when receiving instructions to memorize scenes	Lack of methological controls in study 1 Non clinical sample mostly composed of women Heterogeneity caused by no inclusion/exclusion criteria	Dynamic eye tracking indexes (i.e. number of saccades in and out alcohol-related zones) of alcohol AB are associated with alcohol consumption in complex scenes when motivated to attend to them
Ryan et al. (2002)	65	43.12 (9.49) 39.64 (8.35)	NR	Controls: Current psychotropic medication Neuromedical or psychiatric diagnoses History of AUD	SAUD patients (diagnosed for ≥5 years) from inpatient treatment Staff members of treatment unit	SADQ Quantity and frequency of alcohol consumption	NR	Between-subject design: Problem drinkers (n=32) Controls (n=33)	Education	Alcohol AB	Modified Stroop task	HADS	Alcohol problem-related words Matched neutral words	Behavioral	Reaction times	No group differences regarding alcohol interference scores, with both groups showing alcohol AB Duration of drinking and SADQ scores positively predicted alcohol interference scores Quantity of units per drinking occasion negatively predicted alcohol interference scores	Convenience sample Self-reported measure of alcohol use Stroop task is not the most sophisticate and valid measure of AB Regression analyses on a small sample No inclusion of emotionally non-alcoholic stimuli	Alcohol AB are demonstrated in both SAUD patients and expert controls Alcohol consumption variables predicted alcohol AB
Sharbanee et al. (2013)	48	17.78 (0.74) 18.76 (4.78)	50% 37%	Non-drinkers	Undergraduate dysregulated drinkers (≥14 drinks/week, BRTC score≥4) Undergraduate light drinkers (≤4 drinks/week, BRTC score≤3)	ACQ AUDIT	NR	Between-subject design: Dysregulated drinkers (n=24) Light drinkers (n=24)	Age Gender	Alcohol AB Alcohol approach bias Working memory	Selective-Attention/Action-Tendency Task Operation-span task	BRTC SOCRATES	Alcoholic beverage images Soft drink images Non-representational images	Behavioral	Reaction times	Dysregulated drinkers showed greater alcohol AB in disengagement trials than light drinkers Groups did not differ regarding engagement AB scores Disengagement AB predicted variance of drinking-group status independently from approach biases Working memory did not bring substantial contribution to these predictions	Findings limited to dysregulated and uncontrolled drinking	Alcohol AB, as indexed by a difficulty to disengage from alcohol cues, predict dysregulated drinking independently from approach biases
Sharma et al. (2001)	60	NR	75% 15% 0%	None	SAUD patients (from in-treatment local community alcohol service) Undergraduate high drinkers (AUDIT≥8) Undergraduate low drinkers (AUDIT score<8)	AUDIT	NR	Between-subject design: Problem drinkers (n=20) Heavy drinkers (n=20) Low drinkers (n=20)	None	Alcohol AB	Modified Stroop task	STAI	25 alcohol-related words 25 matched neutral words	Behavioral	Reaction times Errors	Longer reaction times for alcohol-related words compared to neutral ones in problem and high drinkers but not in low drinkers Alcohol AB interference correlated with AUDIT score when analyses performed on all participants but not when performed on each subgroup	NR	Alcohol AB in both problem and heavy drinkers Alcohol AB might be better predicted by other variables than AUDIT scores
Sinclair et al. (2016)	113	44.4 (11.2)	63%	NR	SAUD patients (from community alcohol service)	MINI	Anxiety disorder (n=113) Depression spectrum (n=111) Hypomania spectrum (n=111) Other substance use disorder (n=109)	Between-subject design: Abstinent (n=70) Still drinking (n=43)	Severity of social or generalized anxiety Number of comorbid conditions	Alcohol AB AB towards depression- and anxiety-related stimuli	Visual probe task	HADS LSAS	Alcohol-related words Depression- and anxiety-related words Matched neutral words	Behavioral	Reaction times	Overall alcohol AB in SAUD patients Significant alcohol AB scores observed in patients currently drinking but not in abstinent patients when divided according to drinking status No correlation between alcohol AB and years of drinking, number of comorbidities, severity of anxiety or depression, length of abstinence	Low reliability of the task Cross-sectional sample	Alcohol AB is only present in SAUD patients that are still drinking, thus showing a robust association with drinking status
Soleymani et al. (2020)	100	22.97 (3.82)	26%	Corrected eyesight	Students	AUDIT RAPI TLFB	NR	None (correlational analyses)	NA	Alcohol AB	Free-viewing eye-tracking task	MATE 2.1	Matrices with 8 alcohol-related images and 8 soft drink images	Eye tracking	AOI dwell time AOI location First fixation latency	In session 1, alcohol dwell times and first fixations positively correlated with AUDIT, RAPI, craving but not with alcohol use in the past 7 days Shorter alcohol first fixation latency was associated with stronger craving while shorter first fixation latency on soft drinks was associated with higher AUDIT, RAPI and craving In session 2, alcohol dwell time positively correlated only with craving and first alcohol fixations was only associated with AUDIT	Habituation or carry-over effects or boring or fatigue during session 2 Low reliability of first fixation index Non-clinical mainly female sample Lack of ecological validity (tested throughout the day, in lab-context) Craving and alcohol use only of the last 7 days	Individuals with stronger craving and alcohol problems were associated with alcohol AB measures (i.e. dwell time, location of first fixation)
Spanakis et al. (2018)	120	23.10 (8.42)	49.17%	SAUD diagnosis (history or current) Pregnancy or breastfeeding Color-blindness	Social beer drinkers (≥1 dose/week)	AUDIT TLFB	NR	Between-subject design: Computer condition (n=60) Smartphone condition (n=60)	NR	Alcohol AB	Modified Stroop task (smartphone app)	NR	11 alcohol-related and 11 matched neutral words 11 beer-related and 11 soft drink images	Behavioral	Reaction times	Slower responses to alcohol-related words compared to neutral words in the basic Stroop but no difference with images in the upgraded Stroop Alcohol AB in both tasks did not predict alcohol consumption regardless of condition (computer or smartphone)	Appetitive nature of control pictures No randomized procedure of testing Only beer-drinker participants Pictorial and personalized stimuli confounded Smartphone and naturalistic environment confounded No evaluation of the environmental factors Larger reaction times potentially caused by methodological settings	Better psychometric reliability of Stroop task in ecological settings No association between alcohol AB and alcohol consumption, suggesting poor predictive validity of the task
Suffoletto et al. (2019)	296	22.0 (2.0)	30.4%	Age<18 or >25 Medically unstable Drugs or alcohol impairment History or seeking for treatment for alcohol or drug use Current treatment for psychiatric disorders	Young adults from emergency department with at-risk alcohol consumption (AUDIT-C≥3/4 for women/men, ≥1 binge drinking episode in the last month)	AUDIT-C TLFB Event-level drinking quantity	NR	None (correlational analyses)	NA	Alcohol AB Alcohol approach bias	Modified Stroop task (smartphone app) Approach-Avoidance Task (smartphone app)	Alcohol Ladder Desire to get drunk Drinking plans	10 alcohol-related words 10 neutral (clothing) words	Behavioral	Reaction times	No correlation between alcohol AB or approach bias and AUDIT-C score or drinks per drinking day Alcohol AB and approach bias were not predictors of a binge drinking event	Self-recall of prior day drinking quantity No record of the onset of drinking time Participants exposed to different text message interventions Potentially outdated alcohol-related words Over-sensitivity of the app to finger movements Measure of alcohol consumption only twice/week	Alcohol AB and approach bias were not related to baseline or subsequent alcohol consumption variables among young adult risky drinkers

																	No measure of potential internal/external confounding factors	
Tibboel et al. (2010)	36	NR	NR	None	Heavy drinkers [>14 (women) or >21 (men) doses/week] Light drinkers (>5 doses/week)	AUDIT Weekly alcohol use RAPI	NR	Between-subject design: Heavy drinkers (n=14) Light drinkers (n=18)	None	Alcohol AB	Attentional blink paradigm	DAQ	6 alcohol-related words 6 soft drink-related words 16 neutral words Neutral distracters	Behavioral	Correct responses	Heavy drinkers, but not light drinkers, showed smaller attentional blink effect for alcohol-related than soft drink words Alcohol attentional blink correlated with AUDIT and RAPI but not DAQ	Low internal consistency and split-half reliability Small sample size Near-ceiling performance	When attentional resources are depleted, alcohol-related stimuli are better encoded than soft drink in heavy drinkers, reflecting an alcohol AB at the level of encoding
Townshend & Duka (2001)	32	21.5	37.5%	Occasional drinkers: Not in contact with alcohol-related cues on regular basis Strong anti-alcohol beliefs	Heavy (>25 doses/week) and occasional social drinkers	Heavy drinkers: AUQ	Smokers (n=9)	Between-subject design: Heavy drinkers (n=16) Occasional drinkers (n=16)	Gender	Alcohol AB Higher-order executive function	Visual probe task CANTAB tasks	AEQ TCI Occasional drinkers: Non-drinking questionaire	20 alcohol-related images and words 20 matched neutral images and words (stationery)	Behavioral	Reaction times	Heavy drinkers showed greater alcohol AB scores than occasional drinkers in the picture task Groups did not differ in the word task	NR	Increased alcohol AB in heavy social drinkers compared to occasional ones
Townshend & Duka (2007)	74	41.5 (1.8) 41.8 (1.7)	44.59%	Social drinkers: History of alcohol or drug abuse	SAUD (DSM-IV, ICD-10) patients seeking for inpatient treatment Social drinkers	AUQ SADQ	Illicit drug use (n=10)	Between-subject design: SAUD patients (n=35) Social drinkers (n=39)	Age Gender Verbal IQ	Alcohol AB	Visual probe task	NART AEQ DAQ POMS STAI	20 alcohol-related images 20 matched neutral images (stationery) 20 pairs filler images	Behavioral	Reaction times	SAUD patients showed slower reaction times for alcohol-related cues than social drinkers Significant negative AB score in SAUD patients	NR	SAUD patients, but not social drinkers, showed avoidance AB for alcohol-related stimuli
Van Den Wildenberg et al. (2006)	48	20.4 (3.5)	100%	Age <18 or >45 Regular drug use (except alcohol and cigarettes) Medical conditions Use of medication incompatible with alcohol consumption Personal or family history of psychiatric disorders Dyslexia, color blindness	Heavy drinkers (mean of 15 doses/week, ≥1 binge episode in the past 2 weeks)	AUDIT RAPI TLFB	NR	None (correlational analyses)	NA	Implicit alcohol-related cognitions Alcohol AB Heart rate	Implicit Association Test Modified Stroop task	VAS expectancy questionnaire VAS craving POMS	Alcohol-related words Matched neutral words Color words	Behavioral	Reaction times	Alcohol Stroop interference positively correlated with approach associations on the IAT but was unrelated to alcohol use and problems	Small sample Sample only composed of heavy drinkers Lack of participants with a family history of AUD No baseline measure of heart rate	Alcohol implicit associations and alcohol AB are not related to individual differences in ethanol-induced cardiac changes
Van Duijvenbode et al. (2012)	57	39.6 (12.2)	82.45%	None	Abstinent drinkers from forensic psychiatric treatment	AUDIT SumID-Q	Intellectual disability	Between-subject designs: Average IQ (n=32) Borderline IQ (n=16) Mild IQ (n=9) Light drinkers (n=19) Moderate drinkers (n=16) Heavy drinkers (n=22)	Age Gender Abstinence duration	IQ Approach-avoidance biases Alcohol AB	WAIS-III Approach avoidance task Visual probe task Picture rating task	ACQ-SF-R VAS Craving	Alcoholic beverage images Matched soft drink images	Behavioral Eye tracking (n=30)	Picture ratings Latency of first fixation Number of fixations Dwell time	Groups did not differ in terms of alcohol AB indexed by eye-tracking or behavioral measures Alcohol AB scores correlated with pleasantness ratings of alcohol pictures No correlation between alcohol AB and AUDIT scores	Small sample size No valid cut-off scores for AUDIT Long term abstinence reducing the pertinence of AUDIT administration No counterbalanced order between tasks and craving assessment	Abstinent individuals did not present alcohol AB, independently of their past consumption or mental disabilities
Van Duijvenbode et al. (2016)	130	33.9 (12.3)	67.69%	Age<18 IQ<50 Withdrawal symptoms or active psychotic or manic state Abstaining patients with history of AUD	Light drinkers (AUDIT<8) Problematic drinkers (AUDIT≥8)	AUDIT SumID-Q	Substance use disorders (n=40) Autism spectrum disorder (n=14) ADHD (n=11) Personality disorders (n=19)	Between-subject design: Average IQ, light drinkers (n=28) Average IQ, problematic drinkers (n=25) MBID light drinkers (n=33) MBID problematic drinkers (n=44)	Age Cultural background	IQ Approach-avoidance biases Alcohol AB	WAIS-III Approach avoidance task Visual probe task	VAS Craving	Alcoholic beverage images Matched soft drink images	Behavioral	Reaction times	Reaction times did not differ between groups and/or type of stimuli Alcohol AB scores did not differ from zero in any group Alcohol AB scores positively correlated with AUDIT scores AUDIT scores and weekly alcohol consumption predicted alcohol AB	Sample with various comorbidities and medications AUDIT and SumID-Q scores might be influenced by IQ levels Unclear psychometric validity of visual probe task and approach avoidance task	No alcohol AB was found in problematic drinkers with or without MBID Alcohol AB nevertheless appear related to alcohol consumption
Van Duijvenbode et al. (2017a)	133	42.5 (11.6)	70.70%	Age<18 IQ<50 Withdrawal symptoms or active psychotic or manic state	Light drinkers (AUDIT<8) Problematic drinkers (AUDIT≥8)	AUDIT SumID-Q	Substance use disorders (n=57) Mood disorders (n=9) Anxiety (n=7) ADHD (n=7) Personality disorder (n=15) Intellectual disability	Between-subject design: Light drinkers without MBID (n=27) Problematic drinkers without MBID (n=33) Light drinkers with MBID (n=40) Problematic drinkers with MBID (n=33)	Age Craving Cultural background	IQ Alcohol AB	WAIS-III Visual probe task	VAS Craving	Alcoholic beverage images Matched soft drink images	Behavioral Eye tracking (n=94)	Reaction times Latency/orientation of first fixation Dwell time	Reaction times and eye-tracking indexes did not differ between groups and/or type of stimuli Both light and problematic drinkers showed a significant alcohol AB as indexed by dwell time and direction (but not latency) of first fixation Weekly alcohol consumption correlated with dwell time AB score Craving correlated with first fixation latency	Questionable use of self-reported alcohol measures in individuals with MBID Low psychometric qualities of reaction time-based AB measures	Alcohol AB are indexed by eye tracking (but not behavioral measures) but are independent of alcohol consumption or intellectual disabilities
Van Duijvenbode et al. (2017b)	112	30.9 (12.3)	54.46%	Age<18 IQ<50 Withdrawal symptoms or active psychotic or manic state History of AUD with current abstinence longer than 1.5 months	Light drinkers (AUDIT<8) Problematic drinkers (AUDIT≥8)	AUDIT SumID-Q	Substance use disorders (n=31) Autism spectrum disorder (n=14) ADHD (n=7)	Between-subject design: Light drinkers without MBID (n=31) Problematic drinkers without MBID (n=30) Light drinkers with MBID (n=24) Problematic drinkers with MBID (n=27)	Age Cultural background	IQ Alcohol AB Executive control (working memory, inhibitory control)	WAIS-III Visual probe task Corsi block-tapping task Go/No-go task	RCQ	Alcoholic beverage images Matched soft drink images	Behavioral	Reaction times	Groups did not differ regarding reaction times for alcohol-related stimuli compared to neutral ones No significant alcohol AB scores in any group Executive control, readiness to change and alcohol-related problems did not correlate or predict alcohol AB scores	Questionable use of self-reported alcohol measures in individuals with MBID Limited assessment of executive control not encompassing all executive functions Low psychometric qualities of reaction time-based AB measures	No alcohol AB in problematic drinkers with or without MBID Executive control and readiness to change do not moderate the relationship between alcohol AB and alcohol-use problems
Van Hemel-Ruiter et al. (2015)	86	14.86 (1.37)	43%	NR	Adolescents	Substance use questionnaire	NR	None (correlational and regression analyses)	NA	Alcohol AB Executive control	Visual probe task Attention Network Task	SPSRQ	Alcoholic beverage images Tobacco images Cannabis images Matched neutral images	Behavioral	Reaction times	Alcohol AB did not correlate with reward and punishment sensitivity, executive control or alcohol use Stronger reward sensitivity, stronger alcohol AB and weaker executive control predicted alcohol use The relationship between reward sensitivity and alcohol use was not mediated by alcohol AB Alcohol AB was only associated with alcohol use in adolescents with weak executive control	Participants recruited on a voluntary basis (selection bias) Participants under legal age might have lied about their alcohol consumption Low sensitivity of the visual probe task due to low number of alcohol-related pictures	Higher reward sensitivity and lower executive control are related to early adolescent alcohol use Stronger alcohol AB are related to greater alcohol use only in adolescents with weak attentional control

Van Hemel-Ruiter et al. (2016)	133	19.7 (2.83) 19.0 (2.37)	68% 69%	Age<12 or >25 SUD patients: Gambling disorder Under treatment for problematic gaming Controls: Substance use disorder	Patients with SUD (diagnosis of alcohol, cannabis, amphetamine or GHB use disorder) Controls	AUDIT-C SDS	NR	Between-subject design: SUD patients (n=72) Controls (n=61) Subgroups of patients (based on primary diagnosis): Alcohol (n=10) Cannabis (n=49) Amphetamine (n=10) GHB (n=3) Within-subject design (SUD patients): Baseline (n=72) 6 months follow-up (n=38)	Age Educational level Gender	Substance AB Executive control	Visual probe task Attention Network Task	DUDIT	Substance-related (alcohol, cannabis, amphetamine, GHB) images Matched neutral pictures	Behavioral	Reaction times	SUD patients, but not controls, globally shower faster reaction times for pictures displaying their primary substance of abuse compared to neutral pictures Patients with primary diagnosis of SAUD did not show a significant alcohol AB scores and did not differ from controls Substance AB scores at 1250ms correlated with severity of SUD Executive control did not moderate the relationship between substance AB and SUD severity Baseline AB did not differ from follow-up Change in SUD severity from baseline to follow-up was not predict by change in AB or executive control	High dropout rate Questionable psychometric qualities of visual probe task Patients differed on therapy frequency Relevance of AB may vary with substance Fixed order tasks	Substance AB is related with the severity of SUD, independently of executive control No specific-alcohol AB in patients presenting a primary diagnosis of SAUD
Vollstadt-Klein et al. (2009)	34	42.06 (10.13) 35.94 (9.23)	64.71%	Social drinkers: Axis 1 psychiatric disorders Illegal drugs use Alcohol abuse Binge drinking Lifetime AUD	Recently detoxified SAUD (DSM-IV) patients Light social drinkers [<20 (female) or 40 (male) g/day in the last 2 months]	Doses/week	NR	Between-subject design: SAUD patients (n=17) Light social drinkers (n=17) Median split on abstinence duration: Shorter (n=9) Longer (n=8)	Age Gender	Alcohol AB	Visual probe task	None	20 Alcohol-related scenes 20 matched neutral scenes (office supplies) 20 neutral fillers	Behavioral	Reaction times	Both light social drinkers and SAUD patients showed an alcohol AB when presented for 50ms No reaction times differences between light social drinkers and SAUD patients, independently of time presentation (50 or 500ms) In SAUD patients, alcohol AB at 50ms positively correlated with weekly alcohol consumption while alcohol AB at 500ms negatively correlated with duration of abstinence Significant and negative alcohol AB scores at 500ms only in patients with longer duration of abstinence	NR	Similar AB patterns in light social drinkers and SAUD patients abstinent for longer than 2 weeks: initial orienting (at 50ms) towards alcohol-related cues followed by disengagement AB (at 500ms)
Waters & Green (2003)	49	NR	100%	None	Abstinent SAUD patients Controls	SADQ	NR	Between-subject design: SAUD patients (n=25) Controls (n=24)	Gender	Alcohol AB Schematic processing of alcohol-related cues	Dual task paradigm: Odd/even number decision task + Peripheral lexical decision task Incidental recall task	GHQ-28	Alcohol-related words Matched neutral words	Behavioral	Error rates Reaction times	SAUD patients (but not controls) were slower to perform the central odd/even decision task when exposed to peripheral alcohol-related words compared to neutral words This finding did not reach significance when entering alcohol dependency as covariate SAUD patients (but not controls) were slower to perform lexical decisions concerning alcohol-related words compared to neutral words	Psychometric validity of lexical decision task as part of dual task paradigm Blocked presentation of stimulus material SAUD with higher scores of depression and anxiety (confounding variables) No craving measures	SAUD patients showed an automatic AB rather than an enhanced schematic processing of alcohol-related cues
Weafer & Fillmore (2012)	50	23.9 (2.6)	60%	Head trauma Psychiatric disorder Substance abuse disorder	Adult beer drinkers	TLFB	NR	Between-subject design: Alcohol go condition (n=25) Neutral go condition (n=25)	Gender Age Impulsivity Alcohol consumption	Alcohol AB Behavioral control	Scene Inspection Paradigm Attentional Bias-Behavioral Activation task	BIS	Beer-related and matched neutral scenes Beer-related and neutral images	Eye tracking Behavioral	AOIs dwell time Inhibitory failures Reaction times	Dwell time positively correlated with number of binge days and total drinks consumed, but not number of drinking days in the last 90 days Longer alcohol dwell times are associated with faster reaction times for alcohol go condition but not with more inhibitory failures	Between-group design not accounting for individual differences regarding inhibitory control at baseline	Alcohol AB is related to alcohol consumption in adult beer drinkers Individual differences in alcohol AB predicted response activation, but not response inhibition, following alcohol images
Weafer & Fillmore (2013)	39	23.4 (2.6)	55%	Head trauma Psychiatric disorder Substance use disorder	Heavy drinkers [>9 doses/week, >0 binge episode/week, >4 (men) or >3 (women) doses on one occasion] Moderate drinkers (<5 doses/week)	TLFB B-MAST	NR	Between-subject design: Heavy drinkers (n=20) Moderate drinkers (n=19)	Gender BMI	Ad lib alcohol consumption Alcohol AB	Taste-rating test Visual probe task	VAS Craving	10 alcoholic beverages images 10 matched soft drink images	Eye tracking	Dwell time	Heavy drinkers showed greater alcohol AB than moderate drinkers following placebo Acute alcohol intoxication linearly decreases alcohol AB in heavy drinkers Alcohol AB under placebo predicted greater ad lib consumption and correlated with the intensity and frequency of alcohol consumption	Lack of a sober control condition to control alcohol expectancy No investigation of alcohol AB across the blood alcohol curve Potential impairing effects of alcohol intoxication on ocular and attentional functioning	Greater alcohol AB in heavy drinkers compared to moderate drinkers under placebo Dose-dependent decrease of alcohol AB in heavy drinkers following alcohol intoxication
Wiers et al. (2016)	45	43.83 (7.12) 41.33 (8.57)	100%	Axis I psychiatric disorders (other than alcohol and nicotine use disorder)	SAUD patients from inpatient treatment Controls (AUDIT≤8)	SAUD patients: LTDH MINI Controls: AUDIT	NR	Between-subject design: SAUD patients (n=30) Controls (n=15)	Gender Age Education IQ	IQ Alcohol-approach association Alcohol approach bias Alcohol AB	Matrix Reasoning (WAIS-III) Implicit Association test Approach Avoidance task Visual Probe task	DAQ	Alcoholic beverage images Soft drinks images	Behavioral	Reaction times	Greater (but still negative) alcohol-approach associations in SAUD patients compared to controls Groups did not differ regarding alcohol approach biases and AB Alcohol approach biases and AB were correlated in SAUD patients but did not correlate with craving or alcohol consumption	Small and only male sample LTDH scores missing for controls group Same stimuli for Approach Avoidance task and Visual Probe task leading to method bias	Stronger alcohol-approach associations but not alcohol attentional or approach biases in SAUD patients Attentional and approach biases are underlined by similar mechanisms, unlike alcohol-approach associations
Wilcockson & Pothos (2015)	86	20.88 (4.52)	36.04%	None	Undergraduate students	Doses/week	NR	None (correlational analyses)	NA	Alcohol AB	Awareness task Gaze contingency paradigm	None	16 alcohol-related images 16 matched neutral images	Eye tracking	Break frequency	Slightly higher break frequency (i.e. inability to inhibit saccade towards peripheral stimulus) for alcohol-related stimuli Higher alcohol consumption was associated with greater break frequency for alcohol-related stimuli than for neutral ones, particularly in males	No measure of SAUD	Heavy drinking is associated with decreased inhibitory control of saccadic movements and increased AB towards alcohol-related stimuli
Wilcockson et al. (2019)	19	22.24 (4.63)	36.84%	NR	Heavy drinkers (range from 10 to 55 doses/week)	Doses/week	NR	Within-subject design: Use intention No use intention	NA	Alcohol AB	Free visual exploration	DAQ Intention to use Alcohol outcome expectancy	18 alcohol-related images 18 matched neutral images	Eye tracking	Dwell time	Longer dwell times for alcohol-related stimuli compared to neutral ones in heavy drinkers, regardless of use intention Alcohol AB correlated with alcohol consumption when use was intended and with negative alcohol expectancy when use was not intended	No direct comparison between MDMA and alcohol users because of unstandardized measures No distinction between actual intention and availability of the substance	Heavy drinking is associated with a stable alcohol AB, independent of craving, positive alcohol expectancies and consumption intention
Willem et al. (2013)	94	18.0 (1.1)	52.1%	Non-drinkers	Adolescents and young adults	AUDIT (in the past 3 months)	NR	None (regression analyses)	NA	Approach bias Alcohol AB	Approach/ avoidance stimulus-response compatibility task Visual probe task	ATQ	Alcohol-related scenes Matched neutral scenes	Behavioral	Reaction times	AUDIT correlated with approach bias and attentional control but not with alcohol AB Being a man and stronger approach biases (but not AB) predicted AUDIT Lower alcohol use only for adolescents with low alcohol AB and high attentional control	Cross-sectional design (no direction effect inference) Self-reported measures of alcohol use, attentional and inhibitory control Low internal consistencies of attentional and inhibitory control scales	Stronger approach bias correlated with higher alcohol use but only for males Relationship between low alcohol AB and low alcohol use is moderated by high attentional control

																	Visual probe task containing substance-related stimuli No randomized task order	

Legend: AAAI, Annual Absolute Alcohol Intake; AAAQ, Approach and Avoidance of Alcohol Questionnaire; AAIS, Adolescent Alcohol Involvement Scale; AASE, Alcohol Abstinence Self-Efficacy Scale; AB, attentional biases; ABM, Attentional Bias Modification; ACC, Anterior Cingulate Cortex; ACQ, Alcohol Consumption Questionnaire; ACQ-R, Alcohol Craving Questionnaire; ACQ-SF-R, Alcohol Craving Questionnaire Short Form Revised; ADHD, Attention-Deficit Hyperactivity Disorder; ADS-k, General Depression Scale; AEAS, Anticipated Effects of Alcohol Scale; AEQ, Alcohol Expectancy Questionnaire; AEQ-A, Alcohol Expectancy Questionnaire – Adolescent; AESES, Alcohol Expectancies for Social Evaluative Situations scale; AOI, Area Of Interest; ATQ, Adult Temperament Questionnaire; AUDIT, Alcohol Use Disorders Identification Test; AUDIT-C, Alcohol Use Disorder Identification Test-Concise; AUQ, Alcohol Urge Questionnaire; AUQ, Alcohol Use Questionnaire; BDI, Beck Depression Inventory; BDQ, Binge Drinking Questionnaire; BIS, Barratt Impulsiveness Scale; B-MAST, Brief Michigan Alcohol Screening Test; BMI, Body Mass Index; BRTC, Brief Readiness to Change Algorithm; CANTAB, Cambridge Neuropsychological Test Automated Battery; CAUPQ, Carolina Alcohol Use Patterns Questionnaire; CSSRI, Client Socio-Demographic and Service Receipt Inventory; DAQ, Desire for Alcohol Questionnaire; DAM, Drinking for Anxiety Management scale; DDQ, Daily Drinking Questionnaire; DEQ, Drinking Expectancy Questionnaire; DERS, Difficulties in Emotion Regulation Scale; DMQ-R-SF, Drinking Motives Questionnaire Short Form; DRIE, the Drinking-Related Internal-External Locus of Control Scale; DRS-2, Dementia Rating Scale; DSM-V, Diagnostic and Statistical Manual of Mental Disorders – Fifth edition, DUDIT, Drug Use Disorder Identification Test; EEG, electroencephalograhy; ERP, event-related potential; EuropASI, European Addiction Severity Index; FFMQ, Five Facet Mindfulness Questionnaire; FIC, Fronto-Insular Cortex; fMRI, functional Magnetic Resonance Imaging; GHQ-28, General Health Questionnaire; GSQS, Groningen Sleep Quality Scale; HADS, Hospital Anxiety and Depression Scale; ICD-10, International Classification of Diseases Tenth Revision; IQ, Intellectual Quotient; KAT, Khavari Alcohol Test; KSS, Karolinska Sleepiness Scale; LSAS, Liebowitz Social Anxiety Scale; LTDH, Life Time Drinking History scale; mAHSS, modified Alcohol Hangover Severity Scale; MAST, Michigan Alcohol Screening Test; MATE 2.1, Measurements in the Addictions for Triage and Evaluation; MATE-Q, Measurements in the Addictions for Triage and Evaluation; MBID, Mild to Borderline Intellectual Disability, MINI, the Mini International Neuropsychiatric Interview; MSQ, Motivational Structure Questionnaire; NA, not applicable; NART, National Adult Reading Test; NR, Not Reported; OCDS, Obsessive Compulsive Drinking Scale; PACS, Penn Alcohol Craving Scale; PANAS, Positive and Negative Affect Schedule; PCI, Personal Concerns Inventory; POMS, Profile of Mood States; POMS-SF, Profile Of Mood States-Short Form; PSQI, Pittsburgh Sleep Quality Index; PSS-10, Perceived Stress Scale; QFI, Quantity Frequency Index; qFH, quantitative Family History; QFV, Quantity Frequency Variability Index; RAPI, Rutgers Alcohol Problem Index; RCQ, Readiness to Change Questionnaire; RSME, Rating Scale of Mental Effort; RT-18, Risk-Taking Questionnaire; SADD, Short Alcohol Dependence Data questionnaire; SADQ, Severity of Alcohol Dependence Questionnaire; SAM, Self-Assessment Manikin; SAUD, severe alcohol use disorder; SCID, Structured Clinical Interview for DSM-IV; SCL-90-R, Symptom Checklist 90-R; SCQ, Situational Confidence Questionnaire; SDS, Severity of Dependence Scale; SIAS, Social Interaction Anxiety Scale; SILS, Shipley Institute of Living Scale; SIP, Short Inventory of Problems; SIS, Subjective Intoxication Scales; SMAST, Short-Michigan Alcoholism Screening Test; SOCRATES, the Stage Of Change Readiness And Treatment Eagerness Scale; SPS, Social Phobia Scale; SPSRQ, Sensitivity of Punishment and Sensitivity of Reward Questionnaire; SRI, Self-Rating at Intake; STAI, State-Trait Anxiety Inventory; SUD, Substance Use Disorder; SumID-Q, Substance Use and Misuse in Intellectual Disability Questionnaire; Summary-SCI, Summary of the Shapiro Control Inventory; SURPS, Substance Use Risk Profile Scale; TAAD, The Typical and Atypical Alcohol Diary; TCI, Temperament and Character Inventory; tDCS, transcranial Direct Current Stimulation; TLC, Time-Locked Craving question; TLFB, Timeline Follow-Back; TRI, Temptation and Restraint Inventory; TSSCI, Task-Specific version of the Shapiro Control Inventory; UPPS-P, Impulsive Behavior Scale; VAS, Visual Analogue Scale; WAIS-III, Weschler Adults Intelligence Scale third edition; WTAR, Wechsler Test of Adult Reading Standard Score.

Supplementary Material:

Description of the results related to other constructs relevant to AB

1. Clinical population

1.1. Behavioral data

Influence of psychopathological variables on the relationship between AB and alcohol use. Three studies focused on the potential effects of psychopathological comorbidities on alcohol AB in SAUD patients (Fridrici et al., 2014; Müller-Oehring et al., 2019; Sinclair et al., 2016). Sinclair et al. (2016) administered a visual probe task using disorder-specific words to a large sample of outpatients with one or more comorbid conditions (e.g. depression, hypomania, anxiety, other substance use disorder). Results showed the presence of an alcohol AB – regardless of the group sample. Moreover, this AB was not correlated with the number or severity of comorbid conditions. Fridrici et al. (2014) investigated alcohol AB in detoxified outpatients with or without major depression. They used a modified Stroop task with alcohol-related, negative and neutral words. The authors did not find a more pronounced alcohol AB in patients with or without depression. Findings from these two studies suggested that psychiatric comorbidities have no influence on the magnitude of alcohol AB among patients. Finally, Müller-Oehring et al. (2019) explored the effect of cannabis use disorder on AB in detoxified SAUD patients. They asked participants to perform a modified Stroop task with alcohol, cannabis and neutral words. Surprisingly, later onset of cannabis use disorder and lighter cannabis use per month contributed to a stronger alcohol AB. These findings suggest that cannabis use could have a protective role on alcohol AB. Another study (Garland, 2011) measured the association between alcohol AB and trait mindfulness (i.e. nonreactive and nonjudgmental awareness of moment-by-moment cognition, emotion and sensation) in detoxified patients. The author found that alcohol-related AB, assessed by a spatial cueing task, was negatively associated with trait mindfulness.

Effect of medical treatment on alcohol AB. As mentioned above, Beraha et al. (2018) explored the effect of Baclofen treatment on AB in detoxified inpatients with SAUD. They were assigned in either baclofen or placebo groups. They performed a visual probe task (T1) at baseline and four weeks after the baclofen or placebo treatment (T2). A negative mood induction took place before each task. At T1, patients showed an AB towards alcohol at 500ms and an avoidance AB away from alcohol at 1500ms. At T2, patients who received the baclofen treatment showed a change in their AB after four weeks of treatment, as their avoidance AB was also found for alcohol-related stimuli presented for 500ms. These findings therefore support the benefic effects of baclofen on alcohol AB. Nevertheless, it should be noted that the effect of negative mood induction on AB could not be determined as no control condition was performed. Moreover, the combination of medication with psychotherapy might have limited the additional effects of baclofen on AB.

1.2. Eye-tracking data

Influence of psychological variables on the relationship between AB and alcohol use. Bollen et al. (2021) found a positive correlation among SAUD patients between dwell times for alcohol-related cues and depressive symptoms. They also showed that higher impulsivity was associated with stronger AB scores in controls.

2. Subclinical populations

2.1. Behavioral data

Influence of psychological/cognitive variables on the relationship between AB and alcohol use. Fadardi & Cox (2008) specifically investigated the predictive role of alcohol AB and maladaptive motivational structure on alcohol consumption in social drinkers. Results showed that alcohol Stroop interference and maladaptive motivation were both positive predictors of alcohol consumption. Alcohol AB did not however mediate the effects of motivational structure. Four studies from the same laboratory explored the variation of alcohol AB according to the intensity of alcohol-related problems and intellectual disabilities. In van

Duijvenbode et al. (2012), participants with borderline or mild intellectual quotient performed a visual probe task. Results showed no association between alcohol AB and intellectual impairments, as groups did not differ for reaction times. Groups were however composed of heterogeneous sample size (with only 9 participants in the mild IQ group). Similar findings were found in other studies from the same laboratory, recruiting participants with or without mild to borderline intellectual disability (van Duijvenbode et al., 2016, 2017a, 2017b). Emery and Simons (2015) measured the effects of positive and negative mood on alcohol AB in college drinkers, and whether these effects were moderated by drinking motives. Participants performed visual probe tasks before and after mood induction (positive, negative or neutral). Results showed that alcohol AB was neither predicted by the mood induced nor moderated by drinking motives. However, the split-half and test-retest reliability of the visual probe task was very low, which might explain the largely null findings reported. Another study investigated how social anxiety and drinking coping motives might influence alcohol AB (Carrigan et al., 2004). Participants with large range of social anxiety performed a modified Stroop task with alcohol-related, social threat and neutral words. Alcohol interference scores were associated with drinking to cope measures, but not with social anxiety. These interference scores were higher in participants reporting a frequent use of alcohol to reduce anxiety prior to social situations, underlying the link between social anxiety and alcohol consumption.

Influence of demographics and environment on the relationship between AB and alcohol use. Three studies investigated the role of gender and contextual variables on alcohol AB in subclinical populations (Albery et al., 2015; Emery & Simons, 2015; Groefsema et al., 2016). Albery et al. (2015) assessed participants levels of exposure to alcohol-related environment (high, low – whether or not working in a bar or pub). Light social drinkers showed alcohol Stroop interferences only when they were working in an alcohol-related environment. Heavy social drinkers showed alcohol interferences - regardless of their level of alcohol exposure. Alcohol AB appeared dependent on the exposure to alcohol-related environment only in light social drinkers. As described earlier, Groefsema et al. (2016) determined whether social drinkers showed cognitive biases specific to social alcohol-related stimuli and whether they were associated with alcohol use in social drinking contexts. Results showed that the alcohol AB specific to social pictures was positively correlated with alcohol use and the number of friends of opposite gender in drinking contexts. Alcohol AB in social drinkers thus appeared related to situation-specific drinking behavior. The authors also showed that women presented higher alcohol AB than men.

Influence of physiological variables on alcohol AB. Pieters et al. (2011) explored the moderating role of the OPRM1 (reflecting both liking and wanting processes) and DRD4 (reflecting wanting processes specifically) polymorphisms on the association between alcohol AB and alcohol consumption. In the first experiment, alcohol AB positively predicted alcohol frequency and intensity only in early adolescents with an OPRM1 risk profile. In the second experiment, alcohol AB was associated with problem drinking only in young adult men with DRD4 risk genotype. In early adolescence, the association between alcohol AB and alcohol consumption is related to both liking and wanting processes. This association is specifically related to wanting processes in young adult heavy drinkers. Elton et al. (2021) investigated the mediating role of the dopaminergic pathways on alcohol AB by using a dopamine precursor depletion procedure. During two sessions, participants underwent a placebo-controlled depletion procedure followed by a resting-state fMRI. They then completed two alcohol AB tasks (visual probe task and attentional blink task) and a reward task assessing AB towards reward-conditioned cues. For the visual probe task, individuals reporting greater current binge drinking showed higher alcohol AB following placebo. This AB effect was reduced when undergoing the dopamine precursor depletion procedure. For the attentional blink task, decrease of alcohol AB following depletion procedure was moderated by adolescent rather than current binge drinking. Therefore, such findings support the role of dopamine in alcohol AB, especially in individuals with greater past or present binge drinking. Finally, van den Wildenberg et al. (2006) investigated the correlation between alcohol induced heart rate acceleration (1.0mL/kg of alcohol) and implicit alcohol-related cognitions in male heavy drinkers. Results showed that alcohol Stroop interference was unrelated to ethanol-induced heart rate change. The authors concluded that alcohol implicit associations and alcohol AB were unrelated to individual variations in the sensitivity of alcohol's activating effects.

Effect of training interventions on alcohol AB. Three studies finally explored the effects of ABM training on alcohol-related AB in subclinical drinkers which were not seeking for treatment (Fadardi & Cox, 2009; Langbridge et al., 2019; Luehring-Jones et al., 2017). In Fadardi and Cox (2009), hazardous and harmful drinkers were trained to modify their alcohol AB with the Alcohol Attention-Control Training Program for two and four sessions respectively. After ABM, both hazardous and harmful drinkers showed a decrease in classic and alcohol interference scores and an increase in motivation to change after AB training. Moreover, harmful drinkers reduced alcohol consumption after AB training. The authors did not include randomized control trials with a control group, which did not allow for the evaluation of the training program. Similar findings were found in Luehring-Jones and al. (2017), who investigated the effectiveness of a single session of ABM in reducing craving and alcohol AB in young social drinkers. Participants were randomly assigned to active ABM training or sham training condition. Alcohol AB tasks (visual probe task and alcohol Stroop task), an implicit association task and a cue-induced craving task were administered at baseline and during the post-training assessment. At baseline, alcohol Stroop interference was only correlated with the number of drinks per occasion. Active ABM training reduced alcohol AB scores in visual probe and alcohol Stroop tasks, and indirectly reduced craving through a decrease in Stroop interference scores. Alcohol AB was therefore was reduced by a single session of ABM training. Nevertheless, Langbridge et al. (2019) did not observe any beneficial effect of ABM in binge drinking. In their study, binge drinkers received either ABM, sense of control training, both interventions, or no intervention. They were compared against non-binge drinkers who did not receive any intervention. After the intervention, the alcohol AB decreased over time in all participants, regardless of the intervention administered. Alcohol consumption in binge drinkers was reduced when receiving the combined interventions. While binge drinkers showed higher alcohol AB than non-binge drinkers at baseline, these findings showed the null effect of ABM on alcohol AB in binge drinking. The authors however underlined the insufficient power of their analyses to detect group differences.

2.2. Eye-tracking data

Influence of psychological variables on the relationship between AB and alcohol use. In van Duijvenbode et al. (2012), participants with long term abstinence were grouped according to intellectual impairments (none or mild to borderline). Results showed that participants did not present AB, independently of intellectual abilities. Similar findings were found in van Duijvenbode et al. (2017a), who showed that the intensity of alcohol AB did not differ according to participants' IQ. This study therefore confirmed that the intensity of intellectual disabilities did not influence alcohol AB.

Supplementary Table 1. Studies scoring using the adapted quality assessment tool for observational cohort and cross-sectional studies (NHLBI, 2014).

Authors	Date	Score for each item																			% score
		1	2	4a	4b	5a	5b	5c	5d	6	7	8	9a	9b	10	11a	11b	12	14a	14b	
Albery et al.	2015	Y	N	Y	N	Y	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	68
Baker et al.	2014	Y	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	79
Beraha et al.	2018	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	84
Bollen et al.	2020	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	89
Bollen et al.	2021	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	79
Brown et al.	2018	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	84
Brown et al.	2020	Y	Y	Y	N	N	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	58
Bruce & Jones	2004	Y	Y	Y	Y	N	N	Y	Y	Y	N	Y	Y	Y	N	Y	Y	N	N	N	63
Ceballos et al.	2009	Y	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	74
Carrigan et al.	2004	Y	Y	N	Y	Y	N	N	Y	Y	N	Y	Y	Y	N	Y	Y	N	Y	Y	68
Christiansen & Bloor	2014	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	N	68
Christiansen et al.	2015	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	74
Clarke et al.	2014	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	74
Cox et al.	2002	Y	N	Y	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	53
Cox et al.	2003	Y	N	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	68
den Uyl et al.	2018	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	N	79
DePalma et al.	2017	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	74
Duka et al.	2002	N	Y	N	Y	N	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	N	53
Duka & Townshend	2004	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	68
Elton et al.	2021	Y	Y	N	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	68
Emery & Simons	2015	Y	N	N	N	Y	N	N	Y	Y	N	Y	Y	Y	N	Y	Y	N	Y	Y	58
Fadardi & Cox	2006	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	79
Fadardi & Cox	2008	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	89
Fadardi & Cox	2009	Y	Y	N	Y	Y	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	N	68
Fernie et al.	2012	Y	Y	N	Y	Y	N	N	N	Y	Y	N	Y	Y	Y	Y	Y	N	N	Y	63
Field et al.	2004	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	N	63
Field et al.	2005	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	68
Field et al.	2007	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	74
Field et al.	2011	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	68
Field et al.	2013	Y	N	N	Y	Y	N	N	Y	Y	Y	Y	Y	N	N	Y	Y	N	N	Y	58
Fridici et al.	2013	Y	Y	N	Y	Y	N	N	N	Y	N	N	Y	Y	N	Y	Y	N	Y	Y	58
Fridici et al.	2014	Y	Y	N	Y	Y	N	N	N	Y	N	N	Y	Y	N	Y	Y	N	Y	Y	58
Garland	2011	Y	N	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	68
Gladwin et al.	2013	Y	N	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	63
Gladwin	2017	Y	N	N	N	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	53
Gladwin et al.	2020	Y	N	N	N	Y	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	N	58
Groefsema et al.	2016	Y	N	N	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	74
Gunn et al.	2021	Y	N	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	N	63

Hallgren & McCrady	2013	Y	Y	Y	Y	Y	N	N	N	Y	N	Y	Y	Y	N	Y	Y	N	N	Y	63
Heitmann et al.	2020	Y	Y	Y	N	Y	Y	Y	N	Y	N	Y	Y	Y	N	Y	Y	N	Y	Y	74
Heitmann et al.	2021a	Y	Y	Y	N	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	N	N	Y	68
Heitmann & de Jong	2021b	Y	N	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	N	Y	Y	68
Hobson et al.	2013	Y	N	N	N	Y	N	N	Y	Y	N	Y	Y	Y	N	Y	Y	N	N	N	47
Janssen et al.	2015	Y	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	68
Jones et al.	2002	Y	N	N	N	N	N	N	N	Y	N	Y	Y	Y	N	Y	Y	N	N	N	37
Jones et al.	2003	Y	N	N	N	N	N	N	N	Y	N	Y	Y	Y	N	Y	Y	N	N	N	37
Jones et al.	2006	Y	N	N	N	Y	N	N	Y	Y	N	Y	Y	N	N	Y	Y	N	N	N	42
Jones et al.	2012	Y	N	N	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	58
Jones et al.	2018	Y	Y	N	Y	Y	N	N	N	Y	N	Y	Y	Y	N	Y	Y	N	Y	N	58
Knight et al.	2018	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	68
Langbridge et al.	2019	Y	Y	N	Y	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	74
Luehring-Jones et al.	2017	Y	Y	N	Y	Y	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	74
Lusher et al.	2004	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	68
McAteer et al.	2015	Y	Y	Y	N	N	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	58
McAteer et al.	2018	Y	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	47
McGivern et al.	2021	Y	Y	Y	N	N	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	N	N	53
Miller & Fillmore	2010	Y	N	N	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	N	N	53
Monem & Fillmore	2017	Y	N	N	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	N	58
Müller-Oehring et al.	2019	Y	N	N	Y	N	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	58
Murphy & Garavan	2011	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	Y	Y	N	Y	Y	N	Y	N	68
Nikolaou et al.	2013	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	74
Noel et al.	2006	Y	Y	N	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	68
Pennington et al.	2020	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	74
Pieters et al.	2011	Y	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	68
Pieters et al.	2014	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	79
Qureshi et al.	2019	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	74
Ramirez et al.	2015a	Y	N	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	68
Ramirez et al.	2015b	Y	N	Y	Y	N	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	63
Rettie et al.	2018	Y	N	Y	N	Y	Y	N	N	Y	N	Y	Y	Y	Y	Y	Y	N	Y	N	63
Roy-Charland et al.	2017	Y	N	Y	N	Y	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	63
Ryan et al.	2002	Y	N	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	68
Sharbanee et al.	2013	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	N	79
Sharma et al.	2001	Y	N	Y	N	N	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	58
Sinclair et al.	2016	Y	N	Y	N	Y	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	68
Soleymani et al.	2020	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	89
Spanakis et al.	2018	Y	Y	N	Y	Y	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	74
Suffoletto et al.	2019	Y	N	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	63
Tibboel et al.	2010	Y	N	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	58
Townshend & Duka	2001	Y	Y	Y	N	N	N	N	N	Y	Y	Y	Y	N	N	Y	Y	N	Y	N	53
Townshend & Duka	2007	Y	Y	N	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	N	63

Van Den Wildenberg et al.	2006	Y	Y	N	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	68
Van Duijvenbode et al.	2012	Y	Y	Y	N	N	N	N	N	Y	N	Y	Y	Y	N	Y	Y	N	N	Y	53
Van Duijvenbode et al.	2016	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	79
Van Duijvenbode et al.	2017a	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	79
Van Duijvenbode et al.	2017b	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	79
Van Hemel-Ruiter et al.	2015	Y	Y	Y	N	Y	N	N	N	Y	N	Y	Y	Y	N	Y	Y	N	Y	Y	63
Van Hemel-Ruiter et al.	2016	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	74
Vollstädt-Klein et al.	2009	Y	Y	N	Y	N	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	N	58
Waters & Green	2003	Y	N	N	N	Y	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	58
Weafer & Fillmore	2012	Y	N	N	Y	Y	N	N	Y	Y	N	Y	Y	Y	N	Y	Y	N	Y	Y	63
Weafer & Fillmore	2013	Y	N	N	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	68
Wiers et al.	2017	Y	Y	N	Y	N	N	N	N	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	58
Wilcockson & Pothos	2015	Y	Y	Y	N	Y	N	N	N	Y	N	Y	Y	N	N	Y	Y	N	Y	Y	58
Wilcockson et al.	2019	Y	Y	Y	N	N	N	N	Y	Y	N	Y	Y	N	N	Y	Y	N	N	Y	53
Willem et al.	2013	Y	N	N	Y	Y	N	N	N	Y	N	Y	Y	Y	N	Y	Y	N	Y	Y	58

Legend: N, No; Y, Yes; CD, Cannot Determine

Note: Question related to each item:
(1) Was the research question or objective in this paper clearly stated?
(2) Was the study population clearly specified and defined (i.e. demographics, location)?
(4a) Were all the subjects selected or recruited from the same or similar populations?
(4b) Were inclusion and exclusion criteria for being in the study pre-specified and applied uniformly to all participants?
(5a) Was the sample size sufficiently large (higher than 20 participants per group)?
(5b) Was a sample size justification provided?
(5c) Was a power description provided?
(5d) Was a variance and effect estimates provided?
(6) For the analyses in this paper, were the exposure(s) of interest (i.e. measure of chronic alcohol-consumption) measured prior to the outcome(s) being measured?
(7) Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed (a minimum of 6 months)?
(8) For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?
(9a) Were the exposure measures (independent variables) clearly defined?
(9b) Were the exposure measures (independent variables) valid, reliable, and implemented consistently across all study participants?
(10) Was the exposure(s) assessed more than once over time?
(11a) Were the outcome measures (dependent variables, i.e. attentional bias measures) clearly defined?
(11b) Were the outcome measures (dependent variables) valid, reliable, and implemented consistently across all study participants?
(12) Were the outcome assessors blinded to the exposure status of participants?
(14a) Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?
(14b) Were key potential confounding variables identified and discussed in the limitation section of the discussion?