Social cognition in severe alcohol use disorder

expansion of investigated components and exploration of underlying mechanisms

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Résumé

La recherche en cognition sociale dans le trouble sévère de l'usage d'alcool (TSUA) pourrait mener à une meilleure compréhension des problèmes interpersonnels des patients. Cette thèse visait à répondre à deux limites majeures de ce champ en 1) investiguant des composantes de la cognition sociale encore non-étudiées et en 2) examinant des processus de traitements de l'information sociale plus fins qui pourraient expliquer les difficultés des patients. Nos résultats indiquent que l'étendue des difficultés de cognition sociale dans le TSUA est plus large que ce qui a été documenté précédemment, et mettent en lumière des altérations dans le traitement attentionnel et mnésique de stimuli sociaux qui pourraient sous-tendre ces difficultés. En somme, cette thèse offre une meilleure compréhension de la nature, de l'ampleur, et des potentiels mécanismes impliqués dans les difficultés de cognition sociale dans le TSUA, avec des implications pour la conceptualisation et le traitement du TSUA.

Abstract

Social cognition research in severe alcohol use disorder (SAUD) holds promise for understanding patients' interpersonal problems and more. In this thesis, we aimed at addressing current limitations of the field by 1) extending its scope toward previously uninvestigated social cognition components and 2) examining basic social information processing alterations that could constitute relevant mechanisms. Our findings suggest that social cognition difficulties associated with SAUD are broader than previously documented, and further point to precise and potentially malleable alterations in attention and memory for social information that may subtend some of these difficulties. In sum, this thesis offers a more comprehensive understanding of the range and nature of SAUD-related social cognition alterations, as well as a preliminary mechanistic model that may serve as a useful basis for future research. We discuss implications for conceptual frameworks of SAUD and clinical practice.

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List of abbreviations

We refrained from using abbreviations in the general introduction and discussion sections (except SAUD). This list concerns the abbreviations found in our review and empirical chapters.

SAUD	Severe alcohol use disorder
SC	Social cognition
HC	Healthy control participants
HAB	Hostile attributional biases
SAB	Socio-affective attentional biases
EFE	Emotional facial expression
SPK	Social perception and knowledge
FA	False alarm
R/K/G	Remember/ Know/ Guess

Foreword

Neuropsychological research and theorizing in severe alcohol use disorder (SAUD) has predominantly focused on identifying and eventually modifying the processes proximally implicated in patients' difficulties to regulate their alcohol consumption. Such a focus is understandable, given that reduced control over one's consumption behaviour is a defining characteristic of the disorder. Yet there is more to SAUD than disordered alcohol use. Like many other psychiatric conditions, it also features marked interpersonal problems.

While the presence of these interpersonal problems in SAUD has likely never been in dispute, their role in the disorder has probably been underappreciated. These interpersonal problems indeed cannot be considered mere (temporary) consequences of problematic consumption. Instead, growing evidence indicates that they may partly precede the onset of the disorder, and that they persist after consumption is interrupted, at least in the first months following abstinence. Moreover, interpersonal problems have a severe impact on patients' quality of life as and rank among the most frequently reported triggers of relapse. Hence, they are increasingly acknowledged as active contributors to the severity and maintenance of SAUD. As a consequence, there is a clear need for neuropsychological research in SAUD to extend its scope and investigate the individual-level factors participating in interpersonal problems.

Social cognition research has emerged as a highly promising field to achieve that goal. Indeed, in past years, numerous studies have pointed to SAUD-related impairments in the ability to identify others' emotions or infer their mental states that are of high relevance to understanding patients' interpersonal problems. However, social cognition research in this population also naturally faces some limitations, including a relatively narrow focus in terms of investigated components or abilities, as well as a majoritarily descriptive approach that neglects the fundamentally and clinically relevant question of underlying mechanisms. The current thesis aimed at tackling these limitations.

PART 1: THEORETICAL BACKGROUND

Chapter 1

General Introduction

Here, we will first define severe alcohol use disorder (SAUD) and mention its detrimental consequences on affected individuals and beyond. Second, we will introduce neuropsychological research in SAUD, describe its major outputs and key contribution to influential models, and highlight their relative neglect of the interpersonal domain. Third, we will present evidence supporting the importance of interpersonal dysfunctions in the maintenance of SAUD. Fourth, we will review the emerging field of social cognition as a critical extension of neuropsychological research in SAUD, and stress its relevance for explaining interpersonal problems. Finally, we will point to two limitations of the social cognition literature in SAUD that the present thesis aimed to address.

1. Severe alcohol use disorder: a major public health concern

1.1 Definition and diagnosis

According to the latest version of the widely used Diagnostic and Statistical Manual of Mental Disorders (DSM-V; American Psychiatric Association, 2013), alcohol use disorders are psychiatric conditions that can be characterized by constellations of eleven symptoms falling into four categories, including 1) *reduced control over one's alcohol consumption* (e.g., difficulty cutting down or adhering to self-imposed limitations), 2) *engagement in high-risk activities* (e.g., driving after drinking, unprotected sexual intercourse), 3) *functional consequences* (e.g., deterioration of physical and mental health, loss of important relationships, reduction of professional and leisure activities), and 4) *physiological symptoms* (e.g., increased tolerance to the effects of alcohol, withdrawal symptoms such as increased heart rate or shakiness when consumption is interrupted). Although a diagnosis is made when individuals endorse at least two symptoms, this classification system distinguishes three levels of severity (mild, moderate, severe), with individuals with more severe forms meeting more symptoms.

Our focus in the current thesis is on individuals with the most severe form (SAUD), who exhibit the most clinically impairing alcohol consumption profile (i.e., at least six of the eleven criteria), and represent the subcategory of alcohol use disorder patients that is both most difficult to treat (Adamson et al., 2009; Kiluk et al., 2018), and most likely to be encountered in specialized treatment settings (Edlund et al., 2012; Ray et al., 2017; Tuithof et al., 2016).

1.2 Prevalence and impact

Although alcohol consumption is generally declining, prevalence rates of SAUD remain consistently high. It is estimated that 2-5% of individuals are globally affected, with these rates being higher in men and higher-income countries (World Health Organization, 2018).

SAUD has devastating consequences at individual, but also interpersonal and societal levels. Perhaps most illustratively, it is the leading cause of premature death directly attributable to psychiatric disorders (Whiteford et al., 2013), and sharply increases risks of contracting liver, digestive, cardiovascular, and infectious diseases as well as several forms of cancer (Schwarzinger et al., 2017). Overall, it is estimated that SAUD is implicated in nearly three million deaths per year (GBD 2016 Alcohol and Drug Use Collaborators, 2018). Moreover, SAUD causes significant harm to others, either directly through unintentional material and physical damage (e.g., alcohol induced car accidents) or the deterioration of family and community functioning (e.g., SAUD is linked to frequent conflicts, interpersonal violence, and criminal behaviour), or indirectly by generating considerable economic costs (e.g., related to health care or reduced work productivity/ unemployment; Nutt et al., 2010). Tackling SAUD therefore constitutes one of the most critical public health imperatives (WHO, 2018).

1.3 Treatment issues

The development of prophylactic interventions at primary (e.g., policy initiatives increasing the price or legal age for drinking, and restricting vending avenues, to reduce initial exposition to alcohol) and secondary (e.g., hindering the escalation of consumption in at-risk individuals) levels represents a crucial endeavour to alleviate the global burden of SAUD by preventing its onset.
For individuals already suffering from SAUD, and for the future cases that can be expected, however, the pressing challenge lies in reducing the impact of the installed symptoms on themselves and others, and notably bringing consumption down to less harmful levels or eliminate it altogether (there are conflicting views on whether SAUD treatments should aim for total abstinence, e.g., Paquette et al., 2022). Unfortunately, SAUD is notoriously difficult to treat: most individuals in need for specialized SAUD treatment currently do not seek or receive appropriate care (Kohn et al., 2004; Mekonen et al., 2021; Venegas et al., 2021), and a large proportion of those who do receive professional help relapse (i.e., return to problematic drinking) within months (Maisto et al., 2018).

This concerning state of affairs has complex, multifactorial causes (e.g., lack of specialized infrastructure or community-based services, insufficient screening in primary care settings, societal and institutional stigmatization of SAUD, inefficient dissemination of best-practices, inadequate training of care deliverers, low-quality treatments), and naturally calls for concerted actions across all relevant levels of organization to improve the use and efficacy of care.

One avenue to reach that objective is to improve fundamental conceptualizations of SAUD. Indeed, obtaining a refined and more comprehensive understanding of the difficulties and processes that characterize and maintain the disorder may yield important insights to ameliorate patients' access to treatment, adapt existing management approaches to maximize

adherence and efficacy, and devise new and better interventions. In this thesis, we focus on the critical role of neuropsychological research in mapping the individual-level alterations that underpin patients' functional impairment profile. In the following section we illustrate the value of neuropsychological research by summarizing its main contributions so far. We emphasize its influence on currently prevailing conceptualizations of SAUD, and end by highlighting its relative neglect of an important feature of the disorder.

2. Neuropsychological research and models in severe alcohol use disorder so far

Neuropsychological research, broadly understood, aims at identifying changes in cognitive, emotional, and behavioural processes that are associated with brain alterations and mental disorders. It is particularly well suited to the study of SAUD given that, in addition to the above-mentioned adverse physical health correlates, the disorder is robustly associated with cerebral modifications. At a structural level, patients with SAUD notably show widespread reductions in grey and white matter volume that seem particularly pronounced in frontal, striatal, and insular regions (Bühler & Mann, 2011; Xiao et al., 2015; Yang et al., 2016). Functionally, increased brain activity in reaction to alcohol stimuli represents a core marker of SAUD (Schacht et al., 2013; Zeng et al., 2021). In line with these neurophysiological findings, neuropsychological studies have evidenced several alterations in patients with SAUD. These can be broadly categorized as i) general cognitive impairments and ii) biases in the processing of substance related cues.

Of note, the comprehensive meta-analysis by Stavro and colleagues (2013) indicates that SAUD-related impairments in the former category are diffuse, affecting eleven out of the twelve highly specific domains that were investigated. Here, we do not separately review all of these domains in detail. Instead, we focus on describing impairments in the broad executive, memory, and attentional domains, as these are the most extensively and robustly documented, have established clinical relevance, and are best integrated within current model. We then briefly summarize findings in the visual/perceptual and psychomotor domains, as these are also frequently reported and bear potential relevance to our later discussion.

2.1 General cognitive impairments

The term "general" is employed to signify that the impairments reviewed here are thought to reflect fundamental reductions in abilities that manifest independently of the nature of the target stimuli.

2.1.1 Executive functioning

The most extensively documented cognitive impairments in SAUD concern executive functioning, a set of higher-order abilities principally mediated by frontal brain areas that allow individuals to coordinate, and exert voluntary control over, lower-level processes and behaviour to attain goals (Miyake & Friedman, 2012). Studies have demonstrated that patients with SAUD have difficulties in all relevant executive functioning processes. These

include impairments in mental flexibility (i.e., efficiently switching between different tasks or mindsets to adapt to evolving environmental constraints; Brokate et al., 2003; Noël et al., 2012), and working memory updating (i.e., continuously refreshing working memory content without losing track of task-relevant information; Brion et al., 2017; Pitel et al., 2007). Most consistently, patients with SAUD were found to display deficits in inhibition (i.e., refraining from engaging in prepotent or habitual motor or cognitive responses when these contrast with current objectives; Brion et al., 2017; Kamarajan et al., 2005; Noël et al., 2001, 2012; Pitel et al., 2007). A meta-analysis indicates that although all executive components are impaired in SAUD, inhibitory abilities are most affected (Stephan et al., 2017). Further supporting executive, and particularly inhibitory difficulties, there is also a growing literature showing that patients show increases in the related domain of impulsivity, which can be defined as a disposition to act rashly, with disregard for long-term consequences, particularly in the face of emotion (e.g., Coskunpinar et al., 2013).

These findings are important because they offer important insights as to why patient struggle to downregulate their consumption despite being aware of the consequences. For instance, they may fail to adapt their non-drinking strategy to changing environments (e.g., being at home alone or at a bar with friends), and more directly fail to inhibit their thoughts and desires about alcohol as well as the drinking behaviour itself.

2.1.2 Memory

Another ability repeatedly found to be altered in SAUD is memory. In particular, while there is sparse evidence for semantic (memory for general facts or abstract knowledge; Fama et al., 2011; Pitel et al., 2007) and procedural (memory for non-declarative, often motor-based skills; (Fama et al., 2012) memory impairments, difficulties appear most pronounced for episodic memory, the memory of personally experienced, temporo-spatially constrained events. Within this domain, patients show reduced performance in the encoding (i.e., initial storage) and retrieval of new material (Fama et al., 2004, 2021; Le Berre et al., 2010; Noël et al., 2012; Pitel et al., 2007a), as well as in prospective memory, the ability to remember to do something in the future (Griffiths et al., 2012). Interestingly, despite executive functioning playing a role in successful episodic memory, these difficulties were found to be to be relatively independent in SAUD (Pitel et al., 2007a). Patients also recall autobiographical (real-life) episodic memories with less specificity (D'Argembeau et al., 2006; Poncin et al., 2015; Whiteley et al., 2009), an effect that transfers to patients' simulation of future events, a process analogous to episodic recall, as patients' projections involve less details about the external context and patients' inner states (D'Argembeau et al., 2006; El Haj et al., 2019; Noël et al., 2022).

Further, there is accumulating evidence that patients lack awareness of their objective memory impairments, as demonstrated by overestimations of their recall performances (Le Berre et al., 2010, 2016), or lack of agreement between their subjective evaluation of the phenomenological richness of imagined events and third-party assessments of their descriptions (Noël et al., 2022).

Each of these memory impairments also bear functional relevance. Poor encoding, recall, and/ or prospective application of information may prevent newly acquired symptom management strategies from being effectively remembered and implemented. Reduced

specificity in the recall and simulation of events can limit access to previous successes in overcoming problematic situations, prevent patients from envisioning and gauging the negative consequences of engaging in heavy drinking, or the positive consequences of refraining to do so. Finally, a reduced insight into cognitive decline may lead to minimizations of disorder severity and delay decisions to enter treatment.

2.1.3 Attention

Difficulties have also been reported in evaluations of attention. Patients were found to show poor performance at tasks requiring selective and sustained attention (e.g., maintaining attentional focus on specific elements over prolonged periods of time; Cordovil De Sousa Uva et al., 2010), divided attention (e.g., efficiently performing two tasks concurrently; Tedstone & Coyle, 2004), and attentional control (e.g., concentrating on task-relevant information while resisting salient distractors; Maurage et al., 2014). Of note, however, these tasks all recruit executive processes to some extent and lower level attentional abilities highlighted in theoretical models, including alerting (i.e., maintaining a level of vigilance to promptly react to incoming stimulations) and orienting (i.e., spatially engaging and disengaging attentional focus to sensory stimulations; Petersen & Posner, 2012), are not consistently affected in SAUD (Maurage et al., 2014). Hence, the observed attentional impairments may largely reflect difficulties in executive control, and emerge selectively for more complex tasks.

These results nevertheless carry critical implications, as they suggest that patients may struggle to stay focused for extended periods of time (e.g., during long treatment sessions), experience difficulties while carrying out important tasks simultaneously (e.g., doing groceries while taking care of a child), and fail to resist salient distractors in critical situations (e.g., ignoring a ringing phone while driving).

2.1.4 Vision and psychomotricity

In addition to more traditionally considered cognitive alterations, patients may also show impairments in their visual and motor abilities. A recent review pertaining to the former domain points to evidence that patients show subtle differences at tasks assessing low-level processing of visual properties such as colour, motion, and speed, as well as the ability to perceive peripherally presented stimuli or to copy complex visual figures (Creupelandt et al., 2021). Moreover, recent studies revealed alterations in the processing of spatial and temporal frequencies (Creupelandt et al., 2022a, 2022b). However, the authors caution that the literature is currently too disparate to draw definitive conclusions, and that the processes underlying these alterations or the extent to which they can account for functional impairments is currently unclear (Creupelandt et al., 2021).

Regarding psychomotor impairments, SAUD is notably thought to be associated with a generalized slowing in executing movements (Oscar-Berman et al., 2014). Studies looking at more precise abilities have noted the presence of specific lower limb difficulties reflected in postural, gait, and balance instability (Ritz et al., 2016; Sullivan et al., 2000), but others also documented upper-limb alterations such as reduced grip strength (Sullivan et al., 2005). More recent work in older individuals has shown broader impairments also encompassing

reduced fine motor skills (e.g., manipulating small objects to build something), coordination of upper and lower limbs and imitation (Carvalho et al., 2021).

2.2 Biased processing of substance related cues

In addition to general cognitive impairments, a broad literature indicates that SAUD is associated with specific alterations when processing signals that are evocative of alcohol. According to incentive sensitization theory (Berridge & Robinson, 2016; Robinson & Berridge, 1993), addictive substances have the ability to enduringly sensitize (i.e., increase over repetitions) activity in the mesolimbic system, responsible for imbuing stimuli with motivational value. The more this system responds to given stimuli, the more individuals become motivated, incentivized, to pursue them. Since substance-related cues (e.g., the sight/ taste of one's preferred beverage, the context of typical consumption) inevitably co-occur with actual consumption, they acquire, via classical conditioning, the ability to elicit activity in this system and to become motivationally salient by themselves. This motivational salience in turn favours preferential processing of substance cues, which increases activity in the mesolimbic system, creating a vicious circle. In line with this view, several lines of evidence show that patients with SAUD allocate greater cognitive and behavioural resources to substance cues.

More specifically, studies using different paradigms found patients to attend more to alcohol vs. non-alcohol cues (e.g., Fadardi & Cox, 2006; Field et al., 2013; Müller-Oehring et al., 2019; Sharma et al., 2001). However, a systematic review on the topic cautions that such attentional biases are not consistently observed and hence may not represent a stable characteristic of SAUD (Bollen et al., 2022). Instead, a recent study directly assessing attention via eye-tracking indicates that the presence of attentional biases toward alcohol cues in patients depends on the initial presence of craving, defined as an impetuous desire to consume alcohol, and may thus rather represent a marker of transitory motivational states (Bollen et al., 2023).

There is also evidence that patients with SAUD show superior memory for alcohol related cues and for contexts that surround them (Franken et al., 2003; Goldfarb et al., 2020; Klein et al., 2013; but see Fridrici et al., 2014). Finally, SAUD was found to relate to approach biases to alcohol. This was evidenced at both conceptual (patients associate alcohol vs. non-alcohol words more strongly with approach words; Wiers et al., 2017), and motor (they are faster to pull joysticks toward them then to push them away when faced when alcohol vs. non-alcohol stimuli; Ernst et al., 2014; Wiers et al., 2014) levels, although there again, there are conflicting results (Barkby et al., 2012; Spruyt et al., 2013). Altogether, these findings suggest that beyond the general cognitive impairments that might compromise patients' ability to strategically overcome their addiction and engender functional difficulties, patients may also be spontaneously drawn to allocate their diminished resources to the very stimuli they are supposed (and willing) to avoid.

2.3 Dual process models: SAUD as an imbalance between drive and control

The neuropsychological findings reviewed above have contributed to the emergence and substantiation of the influential dual-process models of SAUD (e.g., Noël et al., 2010; Stacy & Wiers, 2010; Wiers et al., 2007). The central tenet of these models is that SAUD development and maintenance is caused by an imbalance between two systems. On the one hand, an over-reactive appetitive system is thought to increase individuals' urge to consume alcohol by increasing the perceptual salience of substance cues and hence favouring their spontaneous processing and approach (i.e., biased processing of substance-related cues). On the other hand, an under-reactive reflective system (i.e., general cognitive impairments) is thought to prevent individuals from overcoming drives to consume by limiting the efficiency of processes involved in deliberate, reasoned decision-making and self-regulation. In other words, substance related cues are proposed to attract individuals with SAUD by capturing cognitive and behavioural resources while impairments in higher order cognitive abilities would prevent them from appropriately weighing the pros and cons of consumption (e.g., by recalling states of distress associated with withdrawal or the negative consequences of drinking) and from inhibiting the act of drinking.

These models build on and surpass previous propositions based on single explanatory processes (e.g., Robinson & Berridge, 1993) and offer a compelling integration of the bulk of major neuropsychological findings while specifying how broad subcomponents participate in the persistence of the disorder. Another strength of these models is that they are well reflected at the neurological level, with neuro-imaging data notably demonstrating consistent over-activations of reward and salience systems in patients confronted with substance-related cues, as well as under-activations of higher-order cognitive systems in tasks requiring inhibitory control and decision-making (Zilverstand et al., 2018). The validity and clinical relevance of dual-process approaches is moreover supported by evidence that both its neuropsychological constituents (i.e., general cognitive impairments and biased processing of substance related cues) predict relapse or treatment adherence (Rolland et al., 2019). Moreover, interventions directly targeting substance related biases (Manning et al., 2021, 2022; Rinck et al., 2018) were found to have a beneficial effect on drinking outcomes and relapse rate. Similarly, interventions on general cognitive impairments have shown promise (e.g., Rupp et al., 2012) although they have yet to overcome several methodological limitations (low sample sizes, low replicability) to convincingly demonstrate clinical utility (Caballeria et al., 2020; Nardo et al., 2022).

It must be emphasised however, that the consistency and size of the predictive relationship between the elements of dual process models and clinical outcomes (Christensen et al., 2023; Christiansen et al., 2015b; Wilcox et al., 2014), as well as the size of treatment effects (e.g., Boffo et al., 2019), are modest. As an illustration, one of the largest trials using substance bias modification to date resulted in an 11.9% increase in abstinence rate at two weeks, 13% at 3 months, and 4% at one-year post-discharge in the active vs. control condition, with over 80% of patients in the active condition having relapsed after one year (Manning et al., 2021, 2022). Hence, while the available evidence clearly supports the validity of the processes revealed by neuropsychological research, and incorporated in the dual process models that guide current scientific thinking and treatment development, as critical variables contributing to the maintenance of SAUD, it also indicates that these variables are far from telling the

whole story. Put differently, it appears that the described framework fails to account for facets of SAUD that are critical to its perpetuation.

In this context, it is important to stress that extensions of dual-process models have recently began to emerge, notably to accommodate neuroscientific (e.g., Koob & Volkow, 2016; Naqvi & Bechara, 2009; Zilverstand et al., 2018) findings and theoretical developments. These extensions primarily concern the inclusion of interoceptive (Flaudias et al., 2019; Noël et al., 2013), as well as negative emotionality (Boness et al., 2021; Kwako et al., 2016) factors, as additional processes in conceptualizations of SAUD. These processes may help better explain important consumption-related phenomena such as craving, by acknowledging a role for body-signals integration, and drinking as a way to down-regulate distress, and thus hold considerable promise for improving predictions and treatment of the disorder.

Nonetheless, dual-process models and their extensions alike, along with neuropsychological research more generally, can be criticized for their relative neglect of the interpersonal domain (Heilig et al., 2016). Indeed, it is increasingly clear that SAUD is more than a consumption disorder: it features marked interpersonal problems that play an active role in its maintenance. We elaborate this point in the next section.

3. SAUD as an interpersonal disorder

3.1 Description of interpersonal dysfunctions in SAUD

Patients with SAUD show extensive relationship difficulties that cut across all relevant social spheres. A review guided by the International Classification of Functioning, Disability, and Health (WHO, 2001) evidenced diffuse interpersonal dysfunctions compromising patients' relationships with family members (other than spouses), intimate partners, friends, health professionals, and colleagues (Levola et al., 2014). These interpersonal dysfunctions further manifest in several ways. SAUD is notably associated with elevated rates of verbal and physical aggression, with affected individuals being more often implicated as both perpetrators and victims of assaults (Gautier et al., 2023; Levola et al., 2014). Patients with SAUD also report higher numbers of separations and greater likelihoods of life-long absence of significant or committed intimate relationships (Levola et al., 2014), indicating a greater difficulty to engage in and sustain meaningful interactions. Relatedly, SAUD is characterized by a reduced participation in community activities as well as decreases in the size and diversity of social networks (i.e., networks of frequently contacted people; Chou et al., 2011; Mowbray et al., 2014).

A recent large-scale study used the Inventory of Interpersonal Problems (Horowitz et al., 1988), a validated assessment of tendencies to adopt problematic behaviours across six domains (difficulties being assertive, sociable, submissive, and intimate, and tendencies to be too controlling and to feel excessively responsible/ guilty) in patients with SAUD and controls (Maurage et al., 2017). Using cluster analyses, the authors revealed distinct profiles of interpersonal impairments in patients, with subgroups differing in the magnitude and/ or nature of dysfunctions. However, their results also importantly showed that 75% of patients were categorized in clusters with significantly higher scores (i.e., more problems) than demographically matched control groups on *all* investigated interpersonal problem domains. These findings further underscore the breadth of interpersonal dysfunctions in SAUD, but

also crucially highlight that these are highly prevalent (although not systematic, as is interestingly also the case for executive impairments; Schmid et al., 2021), with the notable caveat that they are based on self-report measures. Finally, in addition to the literature documenting overt or objectifiable interpersonal problems, several reports also indicate that SAUD is associated with perceptions of poor social support (Birkeland et al., 2021) and loneliness (Akerlind & Hörnquist, 1992).

In summary, there is ample evidence supporting interpersonal dysfunction as a frequent and far reaching (i.e., spanning multiple domains and social spheres) feature of SAUD.

3.2 Status of interpersonal dysfunctions in SAUD

The diagnostic criteria from the DSM-V (APA, 2013) explicitly referring to interpersonal problems ("Continued alcohol use despite having persistent or recurrent social or interpersonal problems caused or exacerbated by the effects of alcohol."; "Important social, occupational, or recreational activities are given up or reduced because of alcohol use.") suggest that these are mostly a direct result of the effects of alcohol. From this perspective, it would appear unwarranted to dedicate specific research and treatment resources to the management of interpersonal problems since they would be expected to fade after consumption is interrupted (e.g., following detoxification). We do not dispute the fact that alcohol may itself cause or accentuate interpersonal dysfunctions. However, we reject the idea that interpersonal problems are *only* mere secondary consequences of excessive consumption episodes.

Studies investigating risk factors for the later development of SAUD consistently highlight conduct problems and aggression as potent predictors of disorder onset (Dubow et al., 2008; Edwards et al., 2016; Kendler et al., 2011). Additional robust predictors include having parent(s) with SAUD and a history of childhood abuse (Afifi et al., 2012; Edwards et al., 2016; Fenton et al., 2013; Kendler et al., 2011; Kosty et al., 2020; Lieb et al., 2002; Mellentin et al., 2016). Of note, both parental history of SAUD and experience of childhood abuse relate to interpersonal problems in individuals without SAUD (DiLillo, 2001; Domenico & Windle, 1993; Paradis & Boucher, 2010; Schmid et al., 2023). Hence, interpersonal dysfunctions in SAUD are likely to partly precede the onset of the disorder. Furthermore, there is evidence that problems in the social sphere persist, or at least do not return to 'normal' levels, even after prolonged periods of abstinence (Foster et al., 2000; Hibbert & Best, 2011).

Thus, current data are consistent with the view that interpersonal dysfunctions are relatively stable features of patients with SAUD themselves, (features that may predate SAUD onset and/ or emerge as a consequence of chronic excessive consumption) that may of course be modulated by, but do not exclusively manifest in the context of, the pharmacological effects of alcohol. This alone justifies tackling interpersonal problems as an independent and separate component of SAUD, as a means to improve quality of life and functioning capacity, which are increasingly regarded as key treatment goals besides drinking reduction (Carlon et al., 2022), in patients themselves, and to reduce the outward impact of the disorder on others.

3.3 Role of interpersonal dysfunctions in SAUD

Interpersonal factors also critically influence the maintenance of SAUD. Larger supportive social networks relate to increased motivation to reduce drinking as well as greater likelihood of treatment seeking whereas larger negative (promoting continued alcohol use or minimizing problems) social networks have the opposite effect (George & Tucker, 1996; Hunter-Reel et al., 2010; Rapp et al., 2006). Thus, difficulties asserting and distancing oneself from harmful circles, and difficulties forming and maintaining healthier relationships, can impede decisions to change one's consumption. Interpersonal dysfunctions can also threaten the intervention process itself, once initiated, by affecting the quality of the therapeutic alliance, which is a key determinant of SAUD treatment drop-out (Brorson et al., 2013). Finally, consistent with theoretical proposals emphasizing the importance of social processes in SAUD relapse (Hunter-Reel et al., 2009), studies showed that interpersonal factors including conflicts and desire for connection are among the most frequently mentioned relapse triggers (Kabisa et al., 2021; Mau et al., 2019; Shafiei et al., 2014; Zywiak et al., 2003) whereas social support and positive changes in social network characteristics conversely predict better treatment outcomes and long-term recovery (Sliedrecht et al., 2019; Strickland & Acuff, 2023).

As a sum, evidence shows that interpersonal dysfunctions actively interfere with 1) patients' motivation and readiness to change and seek help; 2) treatment completion and efficacy; 3) the long-term consolidation of symptom improvements. Interpersonal problems can therefore not be considered as mere downstream consequences of heavy consumption episodes, or epiphenomena of the disorder. Instead, and as confirmed by a recent large-scale modelling study encompassing a hundred measures, social functioning variables are better viewed as playing a causal role in SAUD (Rawls et al., 2021). Accordingly, there is growing consensus on the need to improve current models to better understand, account for, and ultimately alleviate interpersonal problems in SAUD (Heilig et al., 2016; Verdejo-Garcia et al., 2023), not only to improve patients' quality of life and functioning, but also to improve consumption-related clinical outcomes (see Figure 1). In particular, an essential step for the development of patient-centered interventions is to identify the individual-level factors that underly them. Social cognition research in SAUD, the main focus of the current thesis, holds considerable promise in that regard. In the next section, we review the main results of this literature and point to areas of improvement that serve as the basis for this work.

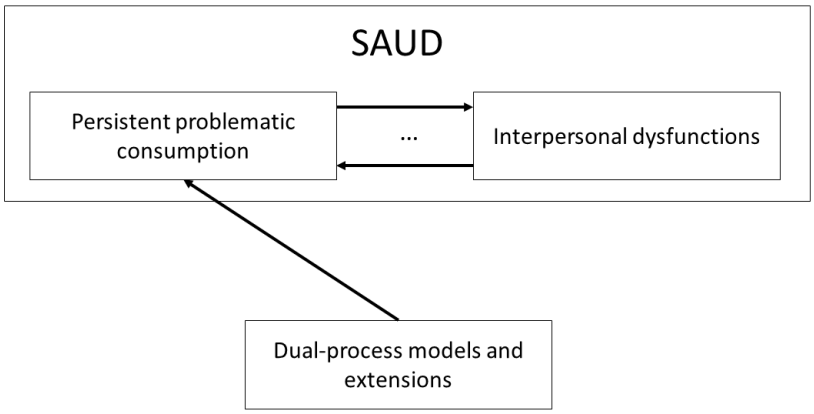

Figure 1*.Illustration of our proposal that interpersonal dysfunctions are an integral feature of the broader SAUD construct itself (hence their inclusion in the SAUD box) rather than a mere secondary and temporary consequence of heavy consumption episodes. It acknowledges that problematic consumption likely increases interpersonal problems but also stresses the contribution of the latter to the maintenance of the former. Finally, it indicates that current conceptualizations principally focus on explaining problematic consumption and neglect the interpersonal domain.*

4. Social cognition research in SAUD

In the past two decades, prompted by the need to better account for the complex nature of the disorder, neuropsychological research in SAUD has slowly departed from an exclusive focus on "cold" (e.g., memory, attention for neutral information) or substance-focused cognitive processes to also investigate social cognition. Although there is currently no clear consensus on its exact definition, it is generally accepted that social cognition is an umbrella concept designating the processes involved in the perception, interpretation, and mobilization of socially relevant information (Frith, 2008; Green et al., 2008). As such, social cognition is a domain that is specifically related to the processing of social stimuli, and that has been found to be clearly dissociable, although not independent, from more general cognitive functions (Sergi et al., 2007; Van Overwalle, 2009).

Preserved social cognition abilities are essential to successfully navigate the social world because they allow individuals to understand each other and adapt their behaviour to maintain satisfactory relationships. Conversely, social cognitive impairments relate to several difficulties in social functioning (Lemmers-Jansen et al., 2023). Further supporting this view is evidence that social cognition impairments are transdiagnostic characteristics of

psychiatric and neurological disorders marked by interpersonal dysfunctions (Cotter et al., 2018). Determining the integrity of social cognitive abilities in SAUD therefore represents a highly relevant avenue to understand interpersonal problems in this disorder from an individual-level perspective. So far, investigations have predominantly focused on emotion recognition and Theory of Mind abilities.

4.1 Emotion recognition alterations in SAUD

Emotion recognition refers to the ability to decode the emotional signals (mostly "basic" emotions such as anger, contempt, disgust, fear, joy, or sadness; Ekman & Cordaro, 2011) conveyed by characteristic stimuli. Some research has found patients to show difficulties in the recognition of emotional prosody (e.g., the emotion conveyed by voice), body movements and music excerpts (Kornreich et al., 2016; Maurage et al., 2009; Monnot et al., 2001; Uekermann et al., 2005). However, the majority of studies in SAUD have assessed this ability using facial emotion recognition paradigms requiring participants to categorize photographs of posed emotional facial expressions (e.g., Maurage et al., 2021). The most robust finding form this line of inquiry, backed up by two meta-analyses (Bora & Zorlu, 2017; Castellano et al., 2015), is that SAUD is associated with reduced facial emotion recognition accuracy, meaning that patients more often miscategorise emotional facial expressions. These meta-analyses further revealed that the magnitude of impairments varies across emotions, with particularly large effects observed for anger and disgust, smaller effects for fear sadness and surprise, and non-significant effects for happiness. In addition to difficulties in the recognition of pictures of expressions of basic emotions, a small number of studies has shown that patients' performance decrements generalize to more complex stimuli such as parts of faces expressing more subtle or mixed affective states (Maurage et al., 2011) or emotional expressions placed in context (Grynberg et al., 2017b).

Beyond well-established reductions in accuracy, additional studies indicate that patients with SAUD 1) are also slower to recognize facial expressions, even after controlling for general reductions in processing speed (Foisy et al., 2007b; Maurage et al., 2008a), 2) overestimate the intensity of the depicted (and non-depicted) emotions (Kornreich et al., 2001a; Maurage et al., 2009b; Philippot et al., 1999a), 3) require more emotional intensity for accurate judgments (D'Hondt et al., 2015; Maurage et al., 2021). Another repeatedly reported finding is that patients with SAUD tend to show specific patterns of errors: they more often incorrectly categorize expressions as signals of social threat (e.g., anger, contempt, disgust Freeman et al., 2018; Frigerio et al., 2002; Maurage et al., 2009; Philippot et al., 1999).

Of note, several studies included control tasks assessing face-based gender, age, or racial identification, at which patients performed equivalently to controls, lending support to the idea that emotion recognition impairments do not reflect more general face processing difficulties (Foisy et al., 2007b; Hoffman et al., 2019b; Maurage et al., 2008a). Likewise, Kornreich et al. (2016) provided evidence that these impairments do not only emerge in the context of tasks requiring the verbal labelling of expressions.

Finally, complementary assessments indicated that, despite exhibiting objective performance decrements, patients did not rate tasks as being more difficult than control participants, suggesting that SAUD is associated with a poor awareness of their emotion recognition impairments (Maurage et al., 2009; Philippot et al., 1999). All in all, there is a large and

consistent body of evidence indicating that patients with SAUD, *as a group*, display severe impairments in emotion recognition, and especially in the recognition of emotional facial expressions.

4.2 Theory of Mind impairments in SAUD

Theory of Mind refers to the ability to represent and infer others' complex mental states (e.g., intentions, desires, beliefs, feelings; Premack & Woodruff, 1978). It differs from emotion recognition in that it has a broader range of objects (i.e., mental states vs. emotions), and in that it involves reasoning processes that go beyond the decoding of directly perceptible, "diagnostic" stimuli (Byom & Mutlu, 2013; Tager-Flusberg & Sullivan, 2000). Again, two meta-analyses indicate that SAUD robustly relates to impairments Theory of Mind (Bora & Zorlu, 2017; Onuoha et al., 2016). Impairments in this ability have been evidenced using a variety of tasks. The most frequently employed is the *faux-pas* task (Stone et al., 1998), containing written descriptions of social vignettes in which characters unintentionally say or do something that hurts other characters. There, patients with SAUD show a reduced ability to identify instances in which a faux pas was committed and to reason about the intentions/ beliefs/ feelings of the "perpetrator" and the "victim" of the faux-pas (Cox et al., 2018; Schmid et al., 2021b; Thoma et al., 2013). Other studies showed that patients with SAUD have difficulties understanding irony (Amenta et al., 2013) or performing tasks that require taking into account other peoples' false beliefs: patients more often fail to predict that an individual X will perform actions (e.g., look for a hidden object) based on their beliefs (e.g., the object is at place A) rather than according to true states of affairs (e.g., the object has been moved from place A to place B in the absence of individual X; F. Maurage et al., 2015).

More recent work further showed that Theory of Mind difficulties in SAUD also emerge when using more ecological, video-based tasks requiring participants to identify a wide range of different mental states in people taking part in realistic social interactions (Maurage et al., 2016). Interestingly, patients in this study were specifically impaired in their ability to infer affective, not cognitive (e.g., beliefs, intentions) mental states.

Hence, results from paradigms differing in format and targeted mental states converge in supporting the view that patients with SAUD also show impairments in Theory of Mind, with emerging evidence of particularly pronounced difficulties in the inference of affective mental states.

4.3 Evolution, and functional and clinical correlates of social cognition alterations in SAUD

An early cross-sectional investigation comparing emotion recognition abilities in patients with SAUD that were recently detoxified or abstinent for at least two months, as well as healthy controls, found both patient groups to be impaired, providing initial evidence that social cognitive impairments persist after sustained (for at least two months) interruptions in alcohol consumption (Kornreich et al., 2001b). This finding was corroborated by the most recent meta-analysis (Bora & Zorlu, 2017), which found no evidence that impairments in both emotion recognition and Theory of Mind were modulated by the duration of abstinence at a study level. However, the most direct and compelling evidence for the maintenance of

social cognition impairments over abstinence derives from two longitudinal studies showing that both emotion recognition and Theory of Mind performances in recently detoxified patients either did not change following two months of abstinence or showed only small practice effects that were mirrored in the control group (Foisy et al., 2007a; Rupp et al., 2021a). Hence, social cognition impairments appear to constitute relatively enduring features of patients with SAUD that may reflect pre-morbid risk factors (as supported by studies showing social cognitive difficulties in offspring of individuals with alcohol use disorder; Khemiri et al., 2020; Schmid et al., 2023) and/ or long term consequences of chronic alcohol misuse. At the very least, the reviewed studies suggest that social cognition impairments persist in the first few months following detoxification, which constitutes the critical time-window during which most patients with SAUD relapse (Hunt et al., 1971).

Of particular interest to the current thesis, the relevance of these social cognition impairments in understanding interpersonal dysfunctions has been supported by studies showing direct associations between emotion recognition impairments and real-life interpersonal problems specifically within patients with SAUD (Hoffman et al., 2019; Kornreich et al., 2002; Maurage et al., 2009). Social cognition impairments further relate to clinical variables such as the duration of abuse and the magnitude of typical consumption (Bora & Zorlu, 2017; Cox et al., 2018). While this relation is often interpreted as reflecting the downstream effects of longer and more intense consumption on socio-affective processing, it may also indicate that social cognitive impairments contribute to the severity of SAUD, consistent with the absence of abstinence duration effects. In line with the idea that social cognition may play a role in the clinical progression of the disorder, two longitudinal studies found greater impairments in this domain at the beginning of inpatient treatment to predict premature dropout and relapse in patients with SAUD (Foisy et al., 2007a; Rupp et al., 2017). Importantly, in these studies, relapsers and abstainers did not differ in potentially confounding variables such as general cognitive functioning or psychopathological symptoms such as depression or anxiety.

In summary, the available literature indicates that SAUD is robustly associated with emotion recognition and Theory of Mind impairments that do not naturally recover over the first months of abstinence, and relate to both interpersonal problems and clinical outcomes, with longitudinal evidence implicating them in treatment drop-out and relapse. This shows that previously documented neuropsychological impairments extend to the social cognitive domain and offers novel valuable insights into individual-level factors that contribute to the marked but largely neglected interpersonal dysfunctions, as well as to the poor prognosis, that characterize SAUD.

Social cognitive impairments may thus represent viable candidates to increase the predictive power of neuropsychological models of SAUD, and interventions aimed at addressing them may improve social functioning, treatment completion, and long-term recovery rates. Yet, although promising, social cognition research in SAUD is still in its infancy, and important limitations need to be overcome to maximize its impact on the conceptualization and treatment of interpersonal problems in this disorder. In the current thesis, we focus on two important caveats that we describe below.

4.4 Perspectives for social cognition research in SAUD

4.4.1 Broadening the scope of investigated components.

One main limitation of current social cognition research in SAUD is that it has not been situated within a clear framework or taxonomy delineating relevant social cognitive components. Consequently, the field has arbitrarily focused on emotion recognition and Theory of Mind abilities, as demonstrated by the content coverage of recent meta-analyses (Bora & Zorlu, 2017; Castellano et al., 2015; Onuoha et al., 2016). This restricted focus can be explained by the popularity of these constructs and the widespread availability of their assessment procedures. However, they only constitute a subset of relevant social cognition abilities (a point we will develop in the next chapter). Moreover, while impairments in these abilities undoubtedly compromise social functioning, they are unlikely to account for the full extent of interpersonal problems associated with SAUD, which include, for instance, elevated rates of aggression and difficulties solving interpersonal issues in context-sensitive ways (Gautier et al., 2023; Maurage et al., 2017; Schmidt et al., 2016). The profile of social cognitive impairments in SAUD may thus be more complex and it is thus essential to broaden the field of investigation beyond emotion recognition and Theory of Mind. Indeed, comprehensively mapping the individual-level factors involved in interpersonal dysfunctions in SAUD is critical not only for theoretical progress, but also for the development of integrative intervention programs that are able to yield the widest possible range of improvements. In other words, in order to effectively improve social functioning, it is essential to have a relatively comprehensive sense of the range of social cognition abilities that are affected in SAUD.

In Chapter 2, we will introduce a clinically relevant framework to guide the expansion of social cognition research in SAUD, and report the findings of a systematic review conducted on the basis of this model to empirically confirm the disproportionate focus on emotion recognition and Theory of Mind, and identify potential preliminary results regarding other components.

4.4.2 Clarifying basic underlying mechanisms.

Documenting the social cognition impairments (e.g., emotion recognition, Theory of Mind) associated with SAUD is essential to understand which individual-level factors proximally relate to negative functional and clinical consequences. From an applied perspective, a clear mapping of social cognitive difficulties will inform clinicians about the range of aspects to consider during treatment to favour retention, and determine the factors that should be addressed by rehabilitation programs specifically aimed at improving social functioning in SAUD. However, the description of difficulties at the level of analysis that is typical of social cognition research provides little information regarding *how* to best tackle them. Knowing that patients with SAUD show emotion recognition or Theory of Mind impairments does not tell us how these difficulties come about. Indeed, both components are complex and multidetermined, and the specific processes giving rise to ostensibly identical impairments have been shown drastically differ between psychiatric conditions (e.g., Altschuler et al., 2021). Accordingly, in order to develop precise and efficient interventions, it is critical to clarify which basic and actionable mechanisms underlie social cognition impairments in SAUD.

In Chapter 3, we will present a model specifying relevant information processing alterations that may interfere with social cognition. This model will serve as the starting point for our empirical investigations.

Chapter 2

Model-based scoping review of investigated social cognition components in SAUD

This chapter is adapted from:

Pabst, A., Gautier, M., & Maurage, P. (2022). Tasks and investigated components in social cognition research among adults with alcohol use disorder: A critical scoping review. *Psychology of Addictive Behaviors*, *36*(8), 999.

1. Introduction

Patients with SAUD present widespread interpersonal problems that constitute major predictors of clinical outcomes (Hunter-Reel et al., 2009; Levola et al., 2014; Moos & Moos, 2006; Sliedrecht et al., 2019; Zywiak et al., 2003). The individual-level factors underpinning these problems, however, have long been understudied, thereby preventing targeted intervention developments. In the past decades, the study of social cognition, defined as the ability to perceive, interpret, and mobilize interpersonal information, has emerged as a promising avenue of research for clarifying the factors involved in AUD-related social difficulties. Indeed, recent meta-analyses concluded that AUD is associated with medium-to-large impairments in major social cognitive abilities (Bora & Zorlu, 2017; Castellano et al., 2015; Onuoha et al., 2016). Nevertheless, current social cognition research in SAUD comprises an important limitation impeding theoretical progress and practical applications: it lacks anchorage within a theoretical framework delineating relevant components.

This led to a narrow investigation scope, with previous meta-analyses focusing exclusively on emotion recognition and/or Theory of Mind (Bora & Zorlu, 2017; Castellano et al., 2015; Onuoha et al., 2016), even though these only constitute a subset of social cognition components. The prominent four-component model (Green et al., 2008; Pinkham, 2014, see Figure 2), initially developed in schizophrenia, but now serving as a basis for social cognition research in psychiatric populations transdiagnostically (e.g., Plana et al., 2014; Tauro et al., 2022) indeed highlights social perception & knowledge and attributional biases as additional core and clinically relevant components.

Social perception & knowledge refers to the identification and use of information about social contexts and subtle interpersonal relationships (social perception), as well as knowledge of social rules or expectations that underlie social situations (social knowledge). Attributional biases can be defined as tendencies to endorse certain types of causal explanations for social events more than others (Green et al., 2008; Pinkham, 2014). Both components show consistent links with social functioning (Couture et al., 2006; Fett et al., 2011; Klein Tuente

et al., 2019) and might thus play a key role in interpersonal problems in SAUD. The restricted focus of previous studies in SAUD on emotion recognition and Theory of Mind therefore presents a significant obstacle to gaining a comprehensive understanding of patients' social cognition profile, and hampers integrative intervention development perspectives.

In light of this key limitation, we conducted the first model-based systematic review of social cognition studies in SAUD, identifying and quantifying the current level of evidence related to each component, and offering a first summary of findings related to previously unreviewed components (i.e., social perception & knowledge, attributional biases). Another objective of this review was to systematically chart and critically appraise the tasks used to assess the more classically investigated emotion recognition and Theory of Mind components. However, in this chapter, we do not elaborate on this aspect.

We used a scoping review approach, which is the method of choice for quantifying available research and mapping it onto specific practices (e.g. employed tasks) and investigated concepts (e.g., social cognition components; Munn et al., 2018; Peters et al., 2020). We additionally included a narrative review of social perception & knowledge and attributional biases findings to provide readers with the current state of knowledge regarding the association between SAUD and these components.

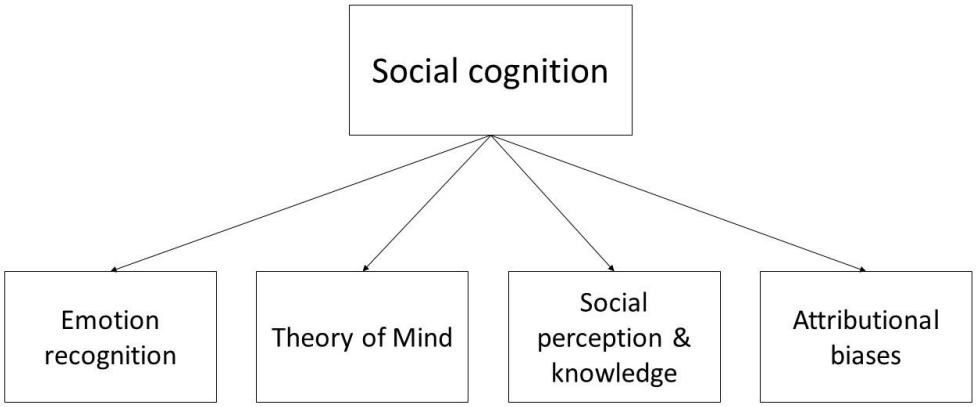

Figure 2. *Illustration of the four-component model of social cognition*

2. Method

We followed published methodological guidance (Peters et al., 2020) and adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR; Tricco et al., 2018) guidelines. This review was not pre-registered.

2.1 Inclusion criteria

We included original quantitative reports that compared a group of human adults with a formal DSM or ICD (regardless of version) diagnosis of alcohol-related disorder (e.g., alcohol-use disorder, alcohol dependence, alcoholism), hereafter referred to as SAUD for clarity, to a group of adult healthy controls (HC; i.e., individuals without SAUD or another diagnosis of psychiatric disorder), or published norms, on a behavioral measure of social cognition. Reports in which SAUD was only considered as a comorbidity to another primary psychiatric or neurological disorder, or in which individuals with SAUD were mixed with participants presenting other diagnoses were not included.

Reports had to investigate at least one of the four social cognition components defined above (i.e., emotion recognition, Theory of Mind, social perception & knowledge, or attributional biases). We focused on behavioural assessments requiring participants to produce explicit online judgments. Consequently, self-report scales evaluating (*self-*)*perceived* social cognition ability or frequency of use, and paradigms only assessing physiological responses (e.g., brain activation, eye movements, electrodermal activity) or response times to social stimuli did not qualify as social cognition measures in the current review. When reports comprised both behavioural social cognition assessment and self-reports, physiological measures, and/or reaction times, we only considered the former.

2.2 Search strategy

We conducted the search on three databases (Scopus, PubMed, PsycInfo) on the 18th of December 2020, and again on the 16th of November 2021 (see below). We identified records through a title-abstract-keywords search of a combination of terms referring to alcohol-related disorder ("alcoholism" OR "alcohol dependence" OR "alcohol dependent" OR "alcohol use disorder" OR "alcoholic*") and both specific sub-facets of social cognition and social cognition more generally ("social cognition" OR "emotion recognition" OR "emotion decoding" OR "theory of mind" OR "mentalizing" OR "perspective taking" OR "empathy" OR "affect sharing" OR "experience sharing" OR "attribution bias" OR "attributional bias" OR "social attribution*" OR "hostile bias" OR "hostility bias" OR "social perception" OR "nonverbal sensitivity" OR "relation perception" OR "relationship perception" OR "relational perception" OR "status perception" OR "social schema" OR "social knowledge" OR "social rules" OR "social expectations" OR "social reasoning" OR "social conventions"). We applied no restriction to publication date or record type (although only peer-reviewed articles could be accessed or met inclusion criteria), but we limited our search to records written in English, French, or German. The first search yielded a total of 2237 records (Scopus = 1950, PubMed = 114, PsycInfo = 173).

2.3 Screening and selection

We employed a three-step screening and selection procedure. First, we removed duplicates (n = 210). Second, we checked titles and abstracts individually for the presence of one of the following features: no original data (e.g., reviews, commentaries, editorials), animal study,

non-adult samples, no SAUD group, and no social cognition measure. We performed this step using Rayyan (Ouzzani et al., 2016) and two members of the review team (who were blind to the decision of the other member) consulted each record. We excluded records receiving two rejection decisions at this stage (n = 1886). Finally, the first author appraised the remaining article's full texts based on the same criteria, and excluded an additional 80 records (no original data = 1, no SAUD vs HC group comparison or focus on SAUD as a comorbidity = 57, no social cognition measure = 22). We were not able to retrieve the full-texts of 3 records that were therefore excluded. We resolved uncertainties at the full-text appraisal stage through discussion between authors. In addition to the remaining 58 records, we included 12 records known by the first author or identified in reference lists.

We conducted a search update on the 16th of November 2021, using the exact same procedure. This update led to the inclusion of 4 additional records (total = 72).

2.4 Data charting

We first assigned each record one or several labels corresponding to the social cognition components (emotion recognition, Theory of Mind, social perception & knowledge, attributional biases) under investigation based on title, study objectives, or description of the underlying construct assessed by the tasks. For each social cognition component, we extracted the tasks used and counted the number of studies using them. In the current chapter, we focus on the tasks used to assess social perception and knowledge and attributional biases and describe them in the narrative review.

3. Results

Of the 72 included records, 58 investigated emotion recognition, 14 investigated Theory of Mind, 2 investigated social perception & knowledge, and 1 investigated attributional biases (some assessed more than one social cognition component and hence the total exceeds 72). Of note, these numbers exclude two studies that will be presented in the empirical section of the current thesis, and thus reflect the state of knowledge *before* we investigated social perception and knowledge and attributional biases in SAUD.

3.1 Narrative review of individual social perception & knowledge, and attributional biases studies

3.1.1 Social perception and knowledge

Khemiri et al. (2012) assessed social knowledge in 20 patients with SAUD and 20 heathy controls using the Moral Behavior Inventory (Mendez et al., 2005), which comprises 15 items describing morally questionable behaviors (e.g., "Taking the last seat of a crowded bus", "Not offering to help after an accident"). For each item, participants rated how wrong each behavior was on a 4-point rating scale ranging from "not wrong" to "severely wrong". The authors found no group differences when comparing mean ratings, suggesting preserved knowledge of social and moral norms in SAUD.

Kornreich et al. (2011) used the Wason Selection Task (Wason, 1966) to investigate the ability to reason about social rules in 25 patients with SAUD and 25 HC. Participants read descriptions of "If P, then Q" social contract rules (e.g., "If you borrow a car (P), then you must fill up the tank with gas (Q)") but also descriptive and precautionary rules, and were then presented with four cards with information on P and a Q on each side, each card corresponding to one of 4 logical combinations (P-not Q, P-Q, not P-Q, not P-not Q). Participants had to indicate which cards they needed to turn to determine if the rule had been violated (the logical answer being to select P and not Q cards). Patients with SAUD performed worse than HC on social contract rules (but also on descriptive and precautionary rules), indicating a difficulty to logically mobilize social knowledge to detect breaches in social contracts.

3.1.2 Attributional biases

Moss & Whiteman (1985) tested 35 patients with SAUD an 37 HC using the Paired Hands Test (PHT; Barnett & Zucker, 1975), a task presenting participants with pictures of two hands performing ambiguous interactions. Participants had to choose among multiple positive and hostile descriptors which one best represented what is happening in the picture (e.g., "showing love", "slapping someone"). Patients with SAUD did not differ from HC in the number of positive/ negative descriptors chosen, suggesting an absence of hostile attributional biases in SAUD.

4. Discussion

This review highlights a marked disproportion in the number of studies assessing each social cognition component in SAUD, with emotion recognition by far the most investigated component, followed by Theory of Mind. Social perception & knowledge and attributional biases have only received anecdotal scientific attention, with no study specifically assessing social perception. Consequently, half of the relevant components remain insufficiently studied in SAUD. Social perception & knowledge and attributional biases have established interpersonal and functional correlates (Couture et al., 2006; Fett et al., 2011; Klein Tuente et al., 2019) and bear obvious relevance to SAUD, which is notably associated with elevated aggression and difficulties adopting context sensitive social behavior (Puhalla et al., 2020; Schmidt et al., 2016). It is hence necessary to extend social cognition research in SAUD toward these components to enrich our conceptualization of individual-level factors underlying social difficulties, and to develop flexible modular treatments targeting each component. A more systematic reference to the presented four-components model (Green et al., 2008; Green & Horan, 2010; Pinkham, 2014) in SAUD constitutes a first step toward raising researchers' awareness regarding the multidimensionality of social cognition and addressing this important gap in the literature by going beyond emotion recognition and Theory of Mind paradigms.

The very few studies assessing social knowledge and attributional biases in SAUD provide an interesting preliminary basis for future investigations. Results concerning social knowledge suggest that the ability to evaluate the social and moral acceptability of behaviors

seems preserved in SAUD (Khemiri et al., 2012). It is unknown, however, whether this extends to an intact ability to identify tacit social rules in complex social scenes, which arguably represents a decisive skill for adaptive everyday functioning. The results of (Kornreich et al., 2011) point to difficulties in at least some aspects of social knowledge in SAUD, namely the ability to reason about social rules, which may hamper the detection of situations where such rules are violated, by others or patients themselves, and consequently lead to problematic social interactions.

Regarding attributional biases, the study by Moss & Whiteman (1985) suggests no increased tendency to describe ambiguous interactions as hostile in patients with SAUD. However, pictures of interacting hands may be too abstract for biases to emerge. Moreover, the mere artificial presentation of positive interpretation options may dampen spontaneous negative ones, potentially masking hostile attributional biases that would be observed in more ecological situations.

In summary, the studies above offer a preliminary picture of social perception & knowledge and attributional biases in SAUD and suggest that at least some aspects of these components are impaired, while others might be preserved. The scarcity and methodological limitations of the currently available literature, however, highlight the need for additional studies before any conclusion can be drawn. Investigating social perception abilities is a priority since they have not yet been assessed in SAUD. Regarding social knowledge, an important perspective is to go beyond the rather simple acceptability rating task and to determine patients' ability to extract social rules in complex ecological situations. Future attributional biases studies, in turn, should consider using more evocative material such as realistic descriptions of ambiguous social situations. Additionally, other (non-hostile) attributional biases, such as internalizing/externalizing (i.e., attributing positive/negative social events to internal/external causes), or personalizing attributional biases (i.e., attributing negative social events to others rather than circumstances), could also be explored.

On a more general note, it should be highlighted that the vast majority of studies included in the current review relied on relatively small sample sizes with higher proportions of men than women with SAUD. Increased consideration for statistical power, as well as sample diversity and representativeness with respect to gender, but also other aspects such as biological sex and ethnicity, hence constitute other important avenues for improving the field.

Some limitations must be acknowledged. First, this review was not preregistered. Second, our choice to focus on explicit behavioural production tasks led to the exclusion of several paradigms solely assessing reaction times, physiological correlates, or self-reports. Although we argue that these paradigms do not directly tap into participants' online perception, interpretation, or mobilization of social information, and hence fall outside the scope of this review, they provide valuable complementary information into the efficiency of social cognition, underlying strategies and mechanisms, as well as metacognitive insights, underlining the need to consider them in future studies. Finally, our search focused on titles, abstracts, and keywords, instead of full-texts, due to an extremely high number of occurrences of our search words in irrelevant records. Although we cannot exclude that this may have led to the exclusion of relevant reports, this probability is lessened by the facts that we included a broad range of search terms, and checked the reference list of each included paper.

5. Conclusion

Research on social cognition in SAUD constitutes a major step forward in our understanding of the individual-level factors underlying the variety of difficulties, and notably interpersonal ones, that aggravate and maintain the disorder. This review, while acknowledging the crucial progresses made on this topic during the last two decades, highlights important limitations in the current body of literature, which restrict its theoretical and clinical impact. We notably demonstrate that two of the four social cognition components (social perception & knowledge and attributional biases) of dominant models have been insufficiently studied, preventing general conclusions regarding social cognition impairments in SAUD. By providing a first summary of preliminary social perception & knowledge and attributional biases results, and emphasizing their relevance for SAUD, we stress the need for an expansion of social cognition research to include these two components.

Chapter 3

Initiating the exploration of basic mechanisms of social cognition impairments in SAUD

This chapter is partly based on:

Pabst, A., Heeren, A., & Maurage, P. (2020). Socio-affective processing biases in severe alcohol use disorders: Experimental and therapeutic perspectives. *Addictive Behaviors*, , *106*, 106382.

1. A cognitive working model of social cognition

As mentioned in Chapter 1, besides expanding social cognition research in SAUD to determine the range of difficulties exhibited by patients, it is also critical, from a fundamental and clinical point of view, to clarify the basic mechanisms giving rise to these impairments.

One influential hypothesis has been that social cognition difficulties in SAUD result from cognitive impairments related to damages in the frontal lobes, and notably executive functions (Uekermann & Daum, 2008). This proposal aligns with fundamental arguments that accurate social judgments often solicit control processes such as the inhibition of one's own mental states at the benefit of understanding others', or the continuous and flexible monitoring of different sources of information (Stone & Gerrans, 2006). Supporting this view, some studies have evidenced associations between emotion recognition/ Theory of Mind and executive functioning in SAUD (Quaglino et al., 2015; Schmid et al., 2021b; Trick et al., 2014). However, there is also compelling evidence that social cognition impairments are observed in patients with SAUD with normal executive functioning or at tasks that impose only minimal demands on executive control (Maurage et al., 2015; Schmid et al., 2021b).

A second proposal has been that social cognition difficulties might arise from lower-level visual impairments compromising the basic perceptual processing of social signals (Creupelandt et al., 2019; D'Hondt et al., 2014). General visual deficits would however be expected to affect judgments of visual stimuli globally, yet available findings suggest that SAUD is linked with preserved performance in non-emotional facial processing, for instance (Foisy et al., 2007b; Maurage et al., 2008a). It may then be that patients have specific visual difficulties for socio-affective material. However, direct tests of this proposal have been largely inconclusive (Creupelandt et al., 2022a, 2022b), with the exception of highly specific differences in the modulation of patients' high-spatial frequency processing following emotional face presentations. In addition, visual socio-affective processing difficulties cannot fully account for reduced performance at tasks where visual information does not provide critical information, such as the faux-pas task (Stone et al., 1998).

All in all, while it is clear that the above-mentioned processes may play a decisive role in some aspects of SAUD-related social cognition alterations, it is also clear that additional mechanisms, operating in between basic visual processing and cognitive control, need to considered. In the absence of formal theoretical proposals regarding what these mechanisms might be in SAUD, we used a general conceptualization describing, at a coarse level, the broad classes of information and corresponding cognitive operations supporting social cognition across all relevant components, as a working model to organize our investigations (see Figure 3, full black lines). This simplified formulation derives from several integrative cognitive frameworks putting emphasis on distinct specific processes (e.g., Achim et al., 2013, 2020; Adolphs, 2009; Cassel et al., 2019; Crick & Dodge, 1994), but all sharing the view that social cognition judgments are shaped by both 1) sensory input from the social environment (e.g., facial movements, gaze direction, actions, situational background), as well as 2) top-down information (e.g., past experiences, schemas about the social world, knowledge about given persons or situations, current mental states).

Accordingly, the model suggests that social cognition judgments will be determined by the nature of the cues that are extracted from the directly perceptible environment, and on their integration with relevant information from "within" observers. For instance, how we judge whether someone we know is genuinely satisfied with the Christmas gift they just received, will depend on the sensory evidence we gather (e.g., what is the gift, are they smiling?) as well as from the general (e.g., do people usually overtly express discontent when receiving a Christmas gift?) and specific (e.g., does the person I know like Christmas or the person they are receiving the gift from?) knowledge we resort to. Likewise, identifying the social rules in effect in a given situation requires careful scrutiny of the environmental setting (e.g., is this inside or outside, how are people behaving, how do they talk to each other, how are they dressed?) as well as access to previous experiences and knowledge (e.g., I am dressed like that at work so this is likely an office, people do not talk that way if they are friends at a casual event, in a professional environment one is expected to use formal language).

Of note, while the weight or importance of sensory and top-down input is thought to vary depending on the nature of the social cognitive judgments, even abilities often viewed as more basic, such as emotion recognition, mobilize both sources of information. Indeed, while it was long considered that basic emotions can be universally "read out" from particular sets of perceptible facial configurations, recent theory and evidence indicates that efficient emotion recognition involves conceptual knowledge and, for instance, higher order reasoning processes about the probable causes of the emotional state (Barrett et al., 2019a; Dricu & Frühholz, 2020).

In our schematic illustration in Figure 3, the larger arrow pointing from the first to the second box illustrates the more systematic influence of extracted sensory information on the later interpretation of social stimuli (e.g., missing the fact that someone made a friendly smile after having made an offensive comment will inevitably reduce the likelihood that this comment is interpreted as a joke) whereas the second, smaller arrow illustrates that top-down information may also influence what is extracted from the environment (e.g., expectations of being rejected can modify the focus of attention; Berenson et al., 2009).

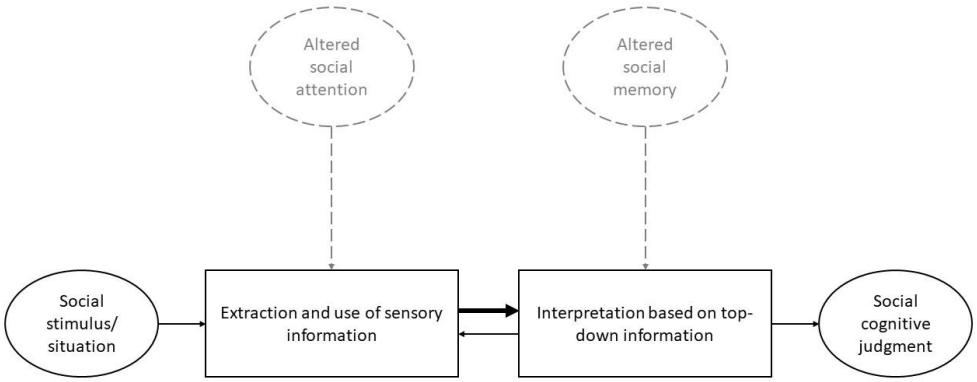

Figure 3. *Illustration of the cognitive working model of social cognition, and of the social information processing mechanisms we will investigate.*

2. Reduced social attention and memory as potential mechanisms in SAUD

The general model described above suggests that any mechanism altering the amount or type of sensory cues extracted from the environment, and/ or of the top-down information that is mobilized at the interpretation stage may ultimately affect social cognition judgments.

In this thesis, we will focus on alterations in attention and memory for social information, which represent particularly relevant sources of social cognition impairments (Achim et al., 2013, 2020; Crick & Dodge, 1994; see Figure 3, dotted grey lines). Indeed, as illustrated in a previous example, inattention to important sensory input would disrupt social cognition early in the information processing stream and cause later interpretations to be based on partial/ incomplete data. Similarly, alterations in the storing and recall of social information (i.e., the identity or previous actions of current interaction counterparts, previous social experiences) may compromise the development of accurate social schemas and/ or limit/ influence the endogenous information that will taint the interpretation of social situations.

Our emphasis on these domains is further justified by the fact that, as developed in the general introduction, attentional and memory impairments have been widely established in patients with SAUD using tasks comprising neutral material (Stavro et al., 2013), and indirect preliminary evidence suggests these may extend to the social domain. For instance, SAUD has been associated with structural and functional alterations in brain regions involved in the attentional processing of informative facial cues (e.g., attending to the eyes), as well as for the encoding and retrieval of social material (Adolphs et al., 2005; Harvey et al., 2007; Kennedy & Adolphs, 2010; Le Berre et al., 2013; Makris et al., 2008; Marinkovic et al., 2009; Meyer et al., 2019; O'Daly et al., 2012; Salloum et al., 2007; Trick et al., 2014; Wolf

et al., 2014). SAUD has also been related to modifications in event-related potentials indexing attentional processing during facial emotion recognition tasks (Maurage et al., 2008b). Moreover, on the basis of correlations between the two processes, it has been suggested that patients rely on episodic memory during social cognitive tasks and that impairments in the former may impact the latter (Nandrino et al., 2014).

Finally, our choice to focus on these processes was also motivated by clinical considerations. Indeed, there is evidence that social attentional (Lazarov et al., 2017; Spilka et al., 2019; Wolf et al., 2014), and various aspects of memory impairments (Belmans et al., 2023; Raes et al., 2009) can be successfully modulated. Alterations in these domains may thus be more easily amenable to change than others and offer relatively short-term concrete therapeutic prospects.

Alterations in attentional and memory processing of social information thus represent heuristic and viable candidate mechanisms participating in social cognition impairments in SAUD, and we therefore sought to investigate their presence and characterize their nature in the current thesis.

3. Biases in social information processing as potential mechanisms in SAUD

In addition to reductions in attention and memory for relevant social information, we also considered the possibility that patients with SAUD could show biased processing of socially threatening information. Indeed, several lines of evidence support this possibility.

First, as briefly alluded to in the general introduction, patients with SAUD show particularly pronounced difficulties in the processing of socially threatening stimuli, with the most recent meta-analysis emphasizing that disgust and anger are the emotions for which patients show the largest accuracy decrements (Bora & Zorlu, 2017).

Second, SAUD is associated with an overestimation of the presence and intensity of socially threatening emotions. Philippot et al. (1999) evidenced a tendency to perceive negative emotions in happy faces and to misattribute anger and contempt (which the authors interpreted as signals of interpersonal conflict) to faces actually displaying other emotions. Frigerio, Burt, Montagne, Murray, and Perrett (2002) further showed that patients with SAUD more frequently misrecognized sad faces as angry or disgusted. Foisy et al. (2007) also found both a tendency to misperceive anger and disgust as sadness and to report disgust in sad faces. Later, Maurage and colleagues (2009) showed that patients overestimate the intensity of facial stimuli presenting anger, and confirmed that they also detect anger in stimuli actually presenting sadness, fear, and even neutral emotions. More recently, Freeman et al. (2018) and Creupelandt et al. (2020) further supported previous findings by revealing specific error patterns in SAUD when categorizing emotional facial expressions, with patients more often perceiving anger and disgust in other negative and neutral emotions. Altogether, these behavioural studies using different tasks and measures support the view that patients with SAUD exhibit, beyond the mere reduced performance in emotion decoding, biases towards the over-estimation of socio-affective information signalling social threat.

Third, patients with SAUD have modified brain activations related to social threat. Congruent with the proposal of altered social threat processing, patients with SAUD display increased dorsal anterior cingulate cortex activation compared to healthy controls when processing angry faces (Park et al., 2015). Moreover, they show higher insula and dorsal anterior cingulate activations when confronted with social threat, namely during social exclusion (Maurage et al., 2012). Interestingly, higher dorsal anterior cingulate activation to specific stimuli (smoking cues) is related to attentional biases towards the same specific stimuli in smokers (Luijten et al., 2011). Additionally, the dorsal anterior cingulate and insula are involved in the attribution of salience to and the detection and appraisal of social threat (Heilig et al., 2016; Kawamoto et al., 2015). Therefore, this pattern of neural activation may reflect a heightened sensitivity to stimuli signalling social threat in SAUD, which might underlie the biased processing of these stimuli.

Hence, there is both behavioural and neurophysiological evidence pointing to biases toward the processing of social threat in patients with SAUD. Although we do not suggest that such biases selectively pertain to attention and memory, we propose that biases in these domains might certainly contribute to the higher-order social cognition impairments in SAUD. A selective attentional processing of negative versus positive social information might lead to undue assessments of ambiguous social situations as being threatening, and greater memory for negative information might favor negative social expectations and beliefs about specific others or the social world more generally, and/ or increase the availability of past negative social experiences, in turn increasing the probability of negative social cognitive judgments.

Thus, we investigated both reductions and biases in attentional and memory processing as candidate mechanisms altering the extraction of relevant social information as well as their later interpretation in SAUD.

4. Objectives and general overview of the current thesis

The overarching aim of the current thesis was to further our knowledge of social cognition alterations in patients with SAUD. We formulated two different but complementary objectives based on the limitations in the literature highlighted at the end of Chapter 1.

The first was to obtain a more comprehensive understanding of the range of social cognitive components patients with SAUD exhibit difficulties in, by expanding the field beyond classically investigated emotion recognition and Theory of Mind abilities. To do so, we conducted a first line of three studies investigating the other social cognition domains listed in the four-component model described in Chapter 2, and illustrated in Figure 2.

Specifically, in Chapter 4, we performed the first comprehensive investigation of social perception and knowledge in SAUD. In Chapters 5 and 6, we conducted two studies investigating hostile attributional biases using different methodologies.

The second objective was to gain insights on potential mechanisms underlying social cognition alterations in patients with SAUD. On the basis of 1) the working model described above, and illustrated in Figure 3, 2) our proposal that SAUD relates to biases in the processing of socially threatening information, 3) previous literature documenting general

impairments in these domains, and 4) clinical considerations, we conducted a second line of three studies investigating attentional and memory processing of social information.

Specifically, in Chapter 7, we investigated whether SAUD was associated with reduced attention toward informative social information, namely facial features considered important for the recognition of emotional expressions. In Chapter 8, we tested whether patients with SAUD showed attentional biases toward threatening (anger, disgust) as well as non-threatening negative (sad) and positive (happy) facial expressions. Finally, in Chapter 9, we examined whether patients with SAUD show difficulties and/ or biases in the encoding of novel positive and negative socio-affective information, as well as in the ease of access to already established positive and negative memories.

PART 2:
FIRST LINE OF EMPIRICAL STUDIES - EXPANSION OF INVESTIGATED COMPONENTS

Chapter 4

Social perception and knowledge impairments in severe alcohol use disorder: group and individual level findings

This chapter is adapted from:

Pabst, A., Peyroux, E., Gautier, M., de Timary, P., & Maurage, P. (2021). Social perception and knowledge impairments in severe alcohol use disorder: Group and individual-level findings. *Drug and alcohol dependence*, *227*, 109009.

1. Introduction

Severe alcohol use disorder (SAUD) is associated with impairments in social cognition (the ability to perceive and interpret social information; Bora & Zorlu, 2017; Le Berre, 2019). These impairments predict interpersonal problems (Hoffman et al., 2019; Kornreich et al., 2002) and poorer treatment adherence and efficacy (Foisy et al., 2007b; Rupp et al., 2017). Social cognition therefore represents a high-priority research domain that may help conceptualize and address functional and clinical issues in SAUD.

However, social cognition studies in SAUD currently overemphasize specific components. Indeed, authoritative taxonomies (Green et al., 2008; Green & Horan, 2010) outline four social cognition facets: emotion processing, Theory of Mind, attributional bias, and social perception and knowledge (SPK). Nevertheless, investigations in SAUD have been restricted to the first two (Bora & Zorlu, 2017; Le Berre, 2019). Only one study explored attributional biases (revealing more hostile intentions attributions among patients with SAUD; Pabst et al., 2020b), and none directly explored SPK.

SPK designates the ability to interpret social situations (social perception) and to identify latent social rules, conventions or expectations (social knowledge; Green et al., 2008; Green & Horan, 2010). Unlike other social cognition components focusing on individual characteristics (e.g., emotions, beliefs, intentions), SPK relates to the situation as a whole. It requires context processing (e.g., location, time), identifying interpersonal relationships (e.g., statuses, roles, intimacy), and accessing social settings-specific semantic knowledge, to infer the meaning and likely unfolding of a social situation. SPK is related to social functioning, especially social problem solving (Couture et al., 2006), in healthy and psychiatric populations (Addington et al., 2006; Cusi et al., 2012; Fett et al., 2011; Schmidt et al., 2011; Schroeder, 1995). SPK impairments may thus contribute to social problem solving anomalies and, more globally, to the profound social disruptions observed in SAUD (Levola et al., 2014; Nutt et al., 2010; Schmidt et al., 2016).

Preliminary evidence suggested preserved social knowledge in SAUD (Khemiri et al., 2012). However, this was based on ratings of "how wrong" a series of morally questionable actions were, which measure the ability to morally evaluate specific behaviours rather than to extract implicit rules from complex social scenes. Conversely, support for SPK impairments in SAUD notably derives from social skills (i.e., behaving appropriately in social settings) and irony detection difficulties (Amenta et al., 2013), both requiring to integrate social cues within their broader context (social perception) and knowledge of what is typically expected (social knowledge). However, no study directly assessed perception and knowledge of social situations in SAUD, precluding firm statements regarding their integrity.

We therefore tested the hypothesis of impaired SPK in SAUD using a recently developed task (Peyroux et al., 2019) evaluating this ability. We also explored whether SPK was related to alcohol consumption and psychopathological symptoms in SAUD. Finally, given previously reported heterogeneity in social cognition impairments in SAUD (Maurage et al., 2015; 2021), we investigated variations of SPK impairments across patients.

2. Method and measures

2.1 Participants (Table 1)

Thirty-five patients with a DSM-5 diagnosis of SAUD in the third week of their detoxification program (Saint Luc Hospital, Brussels, Belgium) and 35 age/gender matched healthy controls (HC) participated in the study (data collected between September 2014 and June 2015). Patients had no comorbid psychiatric disorder, as assessed by the MINI (Sheehan et al., 1998) except for nicotine dependence, and had been abstinent for at least 14 days. Twenty-four patients still received low doses of benzodiazepines (mean=17.57mg/day, SD=14.87). Preliminary analyses showed no significant associations between benzodiazepine dose and primary outcome measures (all *ps*>0.43). HC had no history of psychiatric disorder except nicotine dependence. Neurological disorders, major medical problems and other substance abuse constituted exclusion criteria. The local medical school provided ethical approval and the study complied with the Declaration of Helsinki. The present data are part of a project exploring social cognition in SAUD (Maurage et al., 2016; 2021; Pabst et al., 2020b).

2.2 Social perception and knowledge

The Social Perception and knowledge test (PerSo; Peyroux et al., 2019) assessed participants' ability to interpret social situations and identify social rules depicted in 8 pictures from the material "ColorCards – Social behavior" (e.g., a librarian having a personal phone call while clients are waiting in line). For each picture, participants had to 1) list as much elements contained in the picture as possible for 90s, without restrictions, yielding a *fluency score* (sum of elements reported for each picture), serving as a control measure of general attentional/perceptual or semantic labelling difficulties; 2) comprehensively describe what is happening in the picture without cueing, providing a *non-cued interpretation score* (0-24, 1 point per correctly reported "Where"/"Who"/"What" element, see below); 3) respond to queries about a) the context in which the scene takes place; "Where?", b) the identity of the

main characters (e.g., one librarian and two clients); "Who?" and c) the nature of their interaction (e.g., the clients are upset because the employee has a personal conversation instead of doing their job); "What?", had these elements been previously omitted, producing a *cued interpretation score* (0-24, 1 point per correct answer, elements correctly reported in phase 2 were scored 1 in this phase) and 4) indicate the illustrated social rule (e.g., respect for customers), yielding a *comprehension score* (0-8, 1 point per correctly identified rule). The PerSo's ability to discriminate between patients with schizophrenia and HC (i.e., known-groups validity; Bin Kitoko et al., 2020; Peyroux et al., 2019) provides initial support for its construct validity.

2.3 Psychopathological symptoms

Beck Depression Inventory (BDI; Beck & Steer, 1987) and State-Trait Anxiety Inventory (STAI; Spielberger & Gorsuch, 1983) scores quantitatively indexed participants' depression and anxiety symptoms.

2.4 Alcohol consumption

Participants provided the average number of alcohol units (1unit=10g of ethanol) consumed per day before detoxification, the age of SAUD onset and the number of previous detoxifications.

2.5 Data analysis

Group differences in fluency and comprehension scores were tested using independent samples *t-tests* (with Welch's correction where appropriate) and interpretation scores were submitted to a 2 (group: SAUD/HC, between) x 2 (interpretation type: non-cued/cued, within) repeated measures ANOVA. We also tested whether group differences in interpretation and comprehension scores persisted after controlling for fluency scores by including this variable, together with group (dummy coded) in a general linear model.

Associations between interpretation/comprehension scores and alcohol consumption, and psychopathological symptoms within the SAUD group were explored using Pearson's correlations.

Finally, we determined the percentage of patients with SAUD presenting significant SPK impairments by comparing each patient's interpretation and comprehension scores to those of an age/gender matched group of 5 HC using Crawford's t-tests: t=[(mean patient - mean group)/(SD group $\sqrt{}$((N group + 1)/N group))] (Crawford & Garthwaite, 2005; Crawford & Howell, 1998). Patient scores significantly lower than the control group's mean (1-tailed p-value <0.05) reflected impairments. Analyzes were performed using R (R Core Team, 2019).

Table 1. Socio-demographic, psychopathological, alcohol-related and experimental measures among patients with severe alcohol use disorder (SAUD) and healthy controls (HC): Mean (SD).

	SAUD (*n* = 35)	HC (*n* = 35)
Socio-demographic measures		
Gender ratio (M/F)	21/14	15/20
Age	47.91 (10.40)	45.06 (9.91)
Education level (in years)	7.86 (1.99)	9.40 (1.88)
Psychopathological measures		
BDI[1]	10.42 (7.66)	2.37 (3.00)
STAI-A[2]	39.43 (14.87)	29.09 (7.16)
STAI-B[2]	47.26 (11.82)	36.74 (9.68)
Alcohol consumption measures		
AUDIT score		3.20 (1.73)
Number of previous detoxifications	0.71 (0.79)	
Duration of SAUD (in years)	8.20 (7.09)	
Number of alcohol units per day[3]	21.49 (10.63)	2.66 (1.98)
PerSo		
Fluency	187.46 (44.45)	231.97 (38.23)
Non-cued interpretation	21.31 (1.64)	22.40 (1.44)
Cued interpretation	23.42 (0.98)	23.77 (0.49)
Comprehension	4.89 (2.08)	6.43 (1.33)

[1] Beck Depression Inventory (Beck & Steer, 1987).
[2] State (A) / Trait (B) Anxiety Inventory (Spielberger & Gorsuch, 1983).
[3] Before detoxification for patients with SAUD (an alcohol unit corresponds to 10 gr of ethanol).

3. Results

3.1 Socio-demographic variables and psychopathological symptoms

Groups did not differ regarding age [$t(68)=1.18$, $p=0.24$] or gender [$X^2(1)=2.06$, $p=0.15$] but patients with SAUD had lower education (i.e., completed years since starting primary school) [$t(68)=3.34$, $p=0.001$]. We therefore explored associations between education and PerSo scores in the correlational analyses. Patients with SAUD also reported more depressive symptoms [$t(44.20)=5.79$, $p<0.0001$], state anxiety [$t(48.95)=3.71$ $p=0.0005$], and trait anxiety [$t(68)=4.07$, $p=0.0001$].

3.2 Social perception and knowledge (Figure 4)

Patients with SAUD had lower fluency [$t(68)=4.49$, $p<0.0001$, d=1.07] and comprehension [$t(57.89)=3.689$, $p=0.0005$, d=0.88] scores than HC. Regarding interpretation scores, the ANOVA revealed a main effect of group [$F(1,68)=8.94$, $p=0.004$, $n^2p=0.12$], with lower interpretation scores in the SAUD group, as well as a main effect of interpretation type [$F(1,68)=108.13$, $p=<0.0001$, $n^2p=0.61$], with higher interpretation scores in the cued condition, and a group x interpretation type interaction effect [$F(1,68)=4.91$, $p=0.03$, $n^2p=0.07$]. Bonferroni-corrected follow-up between-group contrasts revealed that patients with SAUD had lower interpretation scores in the non-cued [$t(68)=2.94$, $p=0.009$, d=0.70] but not in the cued condition [$t(50.05)=1.85$, $p=0.14$, d=0.44]. Group effects on non-cued interpretation ($p=0.026$) and comprehension scores ($p=0.002$) remained significant after controlling for fluency scores.

3.3 Correlational analyses

No significant correlations emerged between non-cued interpretation (all $ps>0.08$) or comprehension scores (all $ps>0.16$) and education, alcohol consumption variables or psychopathological symptoms within the SAUD group.

3.4 Single-case analyses

Crawford's t-tests revealed that 22.86% of SAUD were impaired regarding non-cued interpretation scores, whereas 34.29% were impaired regarding comprehension scores.

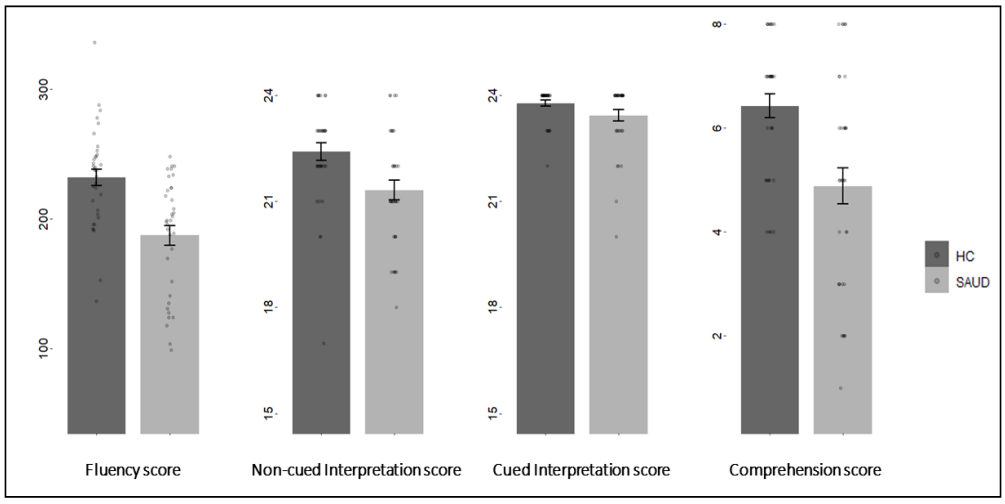

Figure 4. *Scores obtained by patients with severe alcohol use disorder (SAUD) and healthy controls (HC) for the fluency, non-cued interpretation, cued interpretation and comprehension tasks.*

4. Discussion

We assessed SPK, a central social cognition subcomponent (Green et al., 2008; Green & Horan, 2010), among patients with SAUD and matched HC, and evidenced SPK impairments in SAUD. Patients, as a group, were less able to identify relevant contextual aspects and less frequently correctly reported the main characters' identities and the nature of their interactions (social perception). They were however able to provide these elements when specifically asked to, hinting toward specific difficulties in spontaneous social perception rather than a fundamental inability. Patients were also less able to pinpoint the social rules subtending the situations (social knowledge). These impairments did not merely reflect general perceptual, attentional or semantic difficulties since SPK impairments persisted after controlling for fluency.

These findings extend the SAUD-related social cognition literature beyond emotion processing and Theory of Mind domains, and highlight SPK impairments as important processes for modelling socio-affective difficulties in SAUD. Indeed, failing to process interpersonal cues (e.g., employee-employer relationships at a dinner) or to perceive and apply social rules in specific contexts (e.g., using formal language and dressing appropriately at a job interview) may interfere with social functioning. Specifically, based on Couture et al. (2006), SPK impairments may explain SAUD-related social problem solving difficulties, characterized by the generation of socially insensitive solutions not aimed at preserving interpersonal relationships (Schmidt et al., 2016). They may also partly explain patients' inability to adapt their behaviour to social demands, generating interpersonal problems (Amenta et al., 2013; Kornreich et al., 2002). More broadly, together with evidence of hostile attributional biases (Pabst et al., 2020b), our findings substantiate the proposal that SAUD is associated with general social cognition impairments.

Correlational analyses revealed no significant relationship between SPK and alcohol consumption variables (despite a trend-level negative association between non-cued interpretation and age of SAUD onset) or psychopathological symptoms. Insufficient power for detecting small-to-moderate interindividual differences associations may explain these results, which should therefore be interpreted with caution and replicated. Alternatively, they may suggest that SPK impairments are not exclusively substance-induced and might constitute risk factors for the disorder (Mahedy et al., 2021; Rupp et al., 2021b).

Finally, single-case analyses showed that despite moderate-to-large group differences, less than 25% of patients displayed social perception impairments and one third presented social knowledge impairments. Note, however, that Crawford's tests yield conservative estimates of percentages of impaired cases (Crawford & Howell, 1998; Crawford & Garthwaite, 2006). Put differently, although most patients had reduced SPK, only a subgroup exhibited clinically significant impairments. Echoing emotion perception (Maurage et al., 2021) and Theory of Mind (Maurage et al., 2015) studies, these results imply that SPK impairments, rather than being core features of SAUD, vary substantially between individuals.

At the clinical level, considering the above-mentioned social correlates of SPK and the established role of interpersonal factors in treatment success (e.g., Sliedrecht et al., 2019; Zywiak et al., 2003), it seems warranted for social cognition rehabilitation programs in SAUD to incorporate a SPK module. Additionally, given the observed heterogeneity of impairments, evaluation and treatment of this component should be individualized. The

normalized performance of the SAUD group in the cued interpretation condition suggests that explicit instructions and training to systematically attend to “Where/Who/What” aspects may be beneficial.

Future priorities include: 1) empirically confirming the association between SPK and social functioning, and especially social problem solving; 2) longitudinally investigating the evolution of SPK over abstinence and its links with treatment adherence and relapse; 3) identifying the factors driving the variability of SPK impairments in SAUD.

In conclusion, we show that SAUD is associated with SPK impairments, with marked interindividual variability. Such impairments have been linked with disrupted social functioning in other disorders and may therefore be relevant to the conceptualization and treatment of socio-affective difficulties in SAUD.

Chapter 5

Hostile attributional biases in severe alcohol use disorder

This chapter is adapted from:

Pabst, A., Peyroux, E., Rolland, B., de Timary, P., & Maurage, P. (2020). Hostile attributional bias in severe alcohol use disorder. *Journal of psychiatric research*, *129*, 176-180.

1. Introduction

Social cognition, globally referring to processes required to perceive, interpret, and act upon social information (Green et al., 2008), has been explored in severe alcohol use disorder (SAUD) during the last two decades (e.g., Le Berre, 2019). This literature shows that patients with SAUD exhibit strong impairments in emotional facial expressions decoding and Theory of Mind (see Bora & Zorlu, 2017; Castellano et al., 2015; Onuoha et al., 2016 for recent meta-analyses). Importantly, such impairments are of high clinical relevance since they are related to real-life interpersonal problems (Kornreich et al., 2002) as well as higher rates of treatment drop-out and relapse (Rupp et al., 2017; Sliedrecht et al., 2019). Compromised social cognition may thus play a critical role in SAUD by underlying social difficulties and poor treatment outcomes, two major issues in this disorder.

The influential taxonomy proposed by Green and colleagues (2008) identified five subcomponents of social cognition warranting consideration in psychiatric populations, namely 1) emotion decoding; 2) Theory of Mind; 3) social perception; 4) social knowledge; and 5) attributional bias. In the context of SAUD, the investigation of social cognition has been largely circumscribed to the first two subcomponents, with some preliminary results regarding social perception (Maurage et al., 2012; Schmidt et al., 2016) and social knowledge (Amenta et al., 2013; Carmona-Perera et al., 2014; Khemiri et al., 2012). Conversely, attributional biases have never been explored in SAUD, thus restraining a comprehensive understanding of social cognition profiles in this disorder. Such attributional biases, and specifically the tendency to ascribe hostile intentions to others in ambiguous situations with negative outcomes (i.e., hostile attributional bias; HAB), could be particularly relevant to SAUD. Indeed, HAB are known predictors of maladaptive interpersonal functioning (Klein Tuente et al., 2019) and negative affect (Banks et al., 2018; Wang et al., 2019), which are common in SAUD and are, in turn, related to higher relapse risk (Litt et al., 2000; Zywiak et al., 2003).

The increased occurrence of HAB in SAUD would be consistent with the proposal that patients with SAUD display cognitive biases toward social threat signals (e.g., hostility cues), which might lead them to interpret ambiguous social situations as negative, ultimately reducing social functioning (Pabst et al., 2020). Indirect support for the presence of such

HAB in SAUD comes from emotion decoding studies, that showed a tendency to over-detect hostile emotions such as anger, disgust or contempt in faces actually depicting non-hostile negative (sadness) or even neutral emotions (Freeman et al., 2018; Frigerio et al., 2002; Maurage et al., 2009; Philippot et al., 1999a). Yet, these effects might stem from more fundamental deficits in emotion recognition and therefore do not constitute definite proof for HAB in SAUD. A recent study also reported negatively biased interpretations of social scenarios in polysubstance abusers (Beard et al., 2019), but the specific association between SAUD and HAB remains unexplored.

The present study addresses this issue by directly testing the presence and extent of HAB in SAUD. We used the Ambiguous Intentions Hostility Questionnaire (Combs et al., 2007a), which explicitly requires participants to provide causal explanations for people's behavior in realistic social scenarios with negative outcomes. We also explored potential associations between HAB, interpersonal problems and clinical factors in SAUD.

2. Material and Method

2.1 Participants

Thirty-five patients diagnosed with SAUD following DSM-5 criteria, who were in the third week of their detoxification stay (St Luc University Hospital, Brussels, Belgium), and thirty-five healthy controls participated in the study. Patients with SAUD had abstained from alcohol for at least 14 days, and were free of psychiatric comorbidity, as assessed by the MINI (Sheehan et al., 1998), except for nicotine dependence. Healthy controls had no history of psychiatric disorder or substance abuse, except for nicotine dependence, and had a score lower than 8 at the Alcohol Use Disorders Identification Test (Saunders et al., 1993), indicating low-risk alcohol consumption. Twenty-four patients with SAUD still received low doses of benzodiazepines (mean=17.57mg diazepam/day, SD=14.87). Major medical problems, neurological disorders and other substance abuse constituted exclusion criteria. The study was approved by the ethical board of the local medical school and was conducted in compliance with the Declaration of Helsinki. Study objectives were disclosed to the participants before participation and they all provided written informed consent. This study was part of a larger collaborative project exploring social cognition in SAUD (e.g., Maurage et al., 2016).

2.2 Measures and procedure

2.2.1 Psychopathology

Depression and anxiety symptoms were respectively assessed with the Beck Depression Inventory (Beck & Steer, 1987) and the State-Trait Anxiety Inventory (Spielberger & Gorsuch, 1983).

2.2.2 Interpersonal problems

The Inventory of Interpersonal Problems (Horowitz et al., 1988) evaluated participants' difficulties during social interactions. Respondents rated a list of 127 social behaviors, either presented as being difficult to perform or used too often, on a 4-point Likert scale (1="This problem does not apply to me at all" to 4="This problem totally applies to me"). A mean total score was computed, along with 6 subscores: difficulty being assertive / sociable / submissive / intimate, and excessive feeling of responsibility / self-control.

2.2.3 Hostile attribution biases

The Ambiguous Intentions Hostility Questionnaire (Combs et al., 2007a) constituted our experimental measure. Participants read vignettes depicting social situations with negative outcomes (e.g., "You walk past a bunch of teenagers at the mall and you hear them start laughing") and had to imagine themselves being the victims. They then provided a written statement explaining the reasons behind the other persons' behavior and rated whether the behavior was intentional (1="definitely no" to 6="definitely yes"), how angry they would be (1="not angry at all" to 5="very angry") and how much they would blame the persons (1="not at all" to 5="very much"). A composite blame score composed of these intentionality, anger and blame ratings was computed. Finally, they wrote down how they would respond to the situation. An independent research assistant coded the two written answers following the original procedures (Combs et al., 2007a), yielding a hostility score (1="not hostile at all" to 5=very hostile) for the first answer and an aggression score (1="not aggressive at all" to 5="very aggressive") for the second one, these coded scores being used in the present study. Following previous recommendations (Combs et al., 2007b), we used a short version of the Ambiguous Intentions Hostility Questionnaire composed by the 5 vignettes in which the intent of the "perpetrators" was deemed ambiguous by a sample of 200 students, as these are most sensitive to social cognition biases.

2.3 Data analytic plan

Group differences were explored using chi-squared tests for gender and independent samples t-tests (Welch's degrees of freedom correction was applied in cases of unequal variances) for all other socio-demographic, psychopathological, interpersonal problems and experimental variables. Cohen's *ds* were computed for group-differences in experimental variables. Complementary analyses explored the associations of attribution scores with psychopathological, interpersonal problems and clinical variables (number of previous detoxifications, SAUD duration and number of alcohol units consumed daily before detoxification) within the SAUD group using bivariate Pearson's correlations. Finally, we tested for the confounding effect of variables that (1) significantly differed between groups, and (2) significantly correlated with experimental measures in either group, by individually including them, along with group (dummy coded) in a multiple linear regression model predicting experimental measures. This parsimonious data-driven strategy was preferred over more common approaches simultaneously including all potential confounders in a single model because such approaches require larger sample sizes and are likely to strongly compromise the construct validity of SAUD, limiting inferences about this population (Miller & Chapman, 2001).

Table 2. Socio-demographic, psychopathological, alcohol-related and experimental measures among participants with severe alcohol use disorder (SAUD) and healthy control participants (HC): mean (SD).

	SAUD (*n* = 35)	HC (*n* = 35)
Socio-demographic measures		
Gender ratio (M/F)	21/14	15/20
Age	47.91 (10.40)	45.06 (9.91)
Education level (in years)	7.86 (1.99)	9.40 (1.88)
Psychopathological measures		
BDI[1]	10.42 (7.66)	2.37 (3.00)
STAI-A[2]	39.43 (14.87)	29.09 (7.16)
STAI-B[2]	47.26 (11.82)	36.74 (9.68)
Alcohol consumption measures		
AUDIT	/	3.20 (1.73)
Number of previous detoxifications	0.71 (0.79)	/
SAUD duration	8.20 (7.09)	/
Number of alcohol units per day	21.49 (10.63)	2.66 (1.98)
Interpersonal problems		
Total	1.56 (0.48)	1.05 (0.50)
-Assertive	1.67 (0.59)	1.41 (0.73)
-Sociable	1.63 (0.72)	1.12 (0.69)
-Submissive	1.51 (0.60)	1.01 (0.55)
-Intimate	1.36 (0.77)	0.63 (0.53)
+Responsibility	1.93 (0.83)	1.37 (0.80)
+Selfcontrol	1.24 (0.50)	0.65 (0.47)
Attributional biases		
Hostility	1.75 (0.65)	1.30 (0.30)
Agression	1.83 (0.45)	1.73 (0.18)
Blame	2.06 (0.65)	2.15 (0.37)

[1]BDI = Beck Depression Inventory (Beck and Steer, 1987).
[2]STAI = State (A) and Trait (B) Anxiety Inventory (Spielberger et al., 1983).

3. Results

3.1 Socio-demographic, psychopathological and interpersonal problems variables (Table 2)

Groups did not differ regarding age [$t(68)=1.18$, p=0.24] or gender [$X^2(1)=2.06$, p=0.15], but patients with SAUD presented lower education level (i.e., education years since starting primary school) [$t(68)=3.34$, p=0.001]. We therefore explored the association between education and experimental measures in the complementary analyses. Patients with SAUD also had higher depression [$t(44.20)=5.79$, p<0.0001], state anxiety [$t(48.95)=3.71$ p=0.0005], trait anxiety [$t(68)=4.07$, p=0.0001] and interpersonal problems (all ts>2.90, all ps<.005) scores (total score and every subscore, except difficulty being assertive [$t(68)=1.66$, p=0.10]).

3.2 Experimental measures

Patients with SAUD attributed more hostile intentions in ambiguous scenarios than healthy controls [$t(47.74)=3.76$, p=0.0005, d=0.90]. No group differences were observed regarding aggression [$t(44.83)=1.25$, p=0.22, d=0.30] or blame [$t(53.94)=-0.77$, p=0.44, d=-0.18] scores (Figure 5). Therefore, complementary analyses were conducted on hostility scores only.

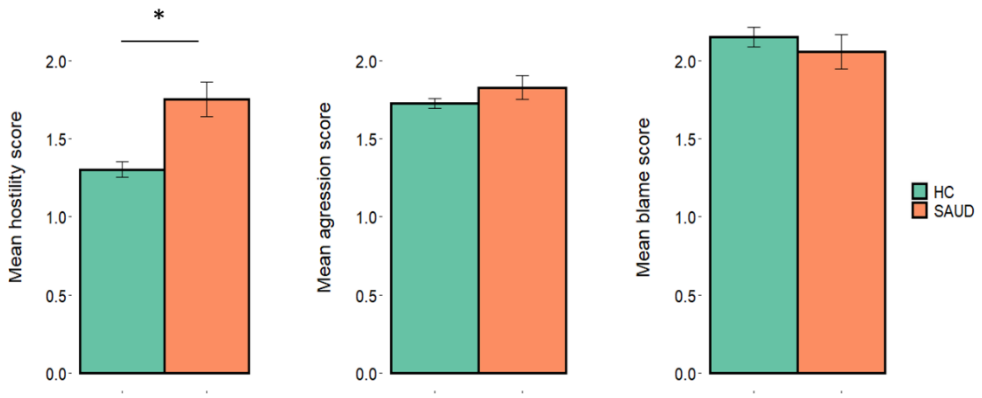

***Figure 5**. Mean hostility, aggression and blame scores in patients with severe alcohol use disorder (SAUD) and healthy control participants (HC).*

3.3 Complementary analyses (Table 3)

Table 3. Correlations between hostility scores and education, psychopathological, alcohol consumption and interpersonal problems measures in patients with severe alcohol-use disorders (SAUD) and healthy controls (HC).

	SAUD (*n* = 35)		HC (*n* = 35)	
	r	*p*	*r*	*p*
Socio-demographic measure				
Education level (in years)	-0.44	0.008**	-0.34	0.046*
Psychopathological measures				
BDI[1]	0.25	0.14	0.20	0.25
STAI-A[2]	0.34	0.04*	0.29	0.10
STAI-B[2]	0.25	0.14	0.25	0.14
Alcohol consumption measures				
Number of previous detoxifications	0.22	0.21	/	
SAUD duration	0.14	0.44	/	
Number of alcohol units per day[2]	0.13	0.47	/	
Interpersonal problems				
Total	0.16	0.34	0.17	0.32
-Assertive	0.02	0.90	0.16	0.35
-Sociable	0.12	0.50	0.09	0.57
-Submissive	0.29	0.09	-0.14	0.40
-Intimate	-0.23	0.18	0.24	0.17
+Responsibility	0.49	0.003**	0.25	0.15
+Selfcontrol	0.23	0.18	0.22	0.20

*p<0.05, **p<0.01.
[1]BDI = Beck Depression Inventory (Beck and Steer, 1987).
[2]STAI = State (A) and Trait (B) Anxiety Inventory (Spielberger et al., 1983).

3.3.1 Education

There was a negative correlation between education and hostility scores in SAUD [r(33)=-.44, p<.009]. The group effect on hostility scores remained significant after controlling for education (p=0.016).

3.3.2 Psychopathological variables

State anxiety was correlated with hostility scores in SAUD [r(33)=0.34, p=0.044]. No other correlation reached significance (all ps>0.14). The group effect on hostility scores remained significant after controlling for state anxiety (p=0.018).

3.3.3 Clinical variables

No significant correlations were found between alcohol consumption factors and hostility scores (all ps>.21).

3.3.4 Interpersonal problems

In SAUD, hostility scores were correlated with the excessive feelings of responsibility subscore [r(33)=0.49, p=0.003]. There was also a trend-level association between hostility scores and the "difficulty being submissive" subscore [r(33)=0.29, p=0.09]. No other correlation reached significance (all ps>0.17). The group effect on hostility scores remained significant after controlling for excessive feeling of responsibility (p=0.01).

4. Discussion

We assessed the presence and extent of HAB in SAUD, and showed that patients with SAUD attribute more hostile intentions to others in ambiguous social situations. This constitutes a direct evidence of HAB in SAUD and extends the growing literature on social cognition in SAUD to the previously unexplored attributional bias subcomponent. These findings also complement previous emotion recognition studies suggesting an over-detection of social threat in SAUD, and reinforce the proposal that patients with SAUD process ambiguous social situations in a threatening/hostile way (Pabst et al., 2020b). Furthermore, the positive association between state anxiety and HAB suggests that patients with SAUD may be especially prone to display HAB in stressful situations.

The results regarding associations of HAB with interpersonal problems are mixed. On the one hand, HAB was correlated, although only at a trend level, with the difficulty being submissive subscore, such that patients with higher HAB scored higher on items such as "I get angry too easily", "I get irritated or annoyed too easily" or "I quarrel too often with people". This is consistent with established links between HAB, anger and aggression (Klein Tuente et al., 2019; Wang et al., 2019), and suggests that HAB may be an important mechanism in SAUD-related interpersonal conflicts. On the other hand, despite attributing more hostility to others, patients with SAUD did not report attributing more blame or reacting more aggressively than healthy controls. Social desirability and/or difficulty accessing present anger feelings in patients with SAUD (Park et al., 2016) may explain these findings. Alternatively, perceiving hostility in others may lead some patients to think that they have wronged them, generating feelings of guilt rather than anger. This is supported by the positive association found between hostility scores and the excessive feeling of responsibility subscore, encompassing items such as "I feel too guilty for what I have done" or "Disappointing others preoccupies me a lot", and aligns with studies showing higher guilt-proneness in SAUD (Grynberg et al., 2017a). As guilt is associated with psychological distress and attempts to "repair" the damage caused (Tangney et al., 2006), the joint presence of HAB and guilt may heighten the frequency of negative affect and awkward interpersonal situations, ultimately fostering relapse (Sliedrecht et al., 2019; Zywiak et al., 2003). More work is needed to clarify the association between HAB and specific subcomponents of interpersonal problems in SAUD. Moreover, future studies should explore the link between HAB and SAUD patient's sensitivity to social exclusion (Maurage et al., 2012). Indeed, HAB may lead to the overestimation of rejection cues and hamper their effective regulation. Finally, an interesting avenue would be to explore the relations between HAB and other affected social cognitive components in SAUD, as authors have proposed that HAB may reflect reduced Theory of Mind skills (Runions & Keating, 2007) and as some evidence

suggests that psychiatric populations known to display HAB for social vignettes also misidentify emotional facial expressions (Smeijers et al., 2017).

In conclusion, this article identifies attributional biases in SAUD through the presence of HAB, which are in turn linked with increased interpersonal problems. At a theoretical level, these findings highlight that beyond classically reported impairments of social cognitive processes (i.e., emotion perception and Theory of Mind), negative biases in the processing of socio-affective information may also play an important role in patients with SAUD, and therefore warrant further investigation. Such biases may greatly interfere with interpersonal functioning, exacerbate social stress and even partly underlie more global social cognitive deficits (Pabst et al., 2020). At the clinical level, the association with interpersonal problems indicates that targeting HAB in treatment settings could hold value in reducing relapse related to social factors (Rolland et al., 2019). Future studies should confirm the therapeutic pertinence of HAB in SAUD by investigating its relation to other clinically relevant processes such as craving and drinking refusal self-efficacy (Beard et al., 2019).

Chapter 6

Hostile attributional biases in severe alcohol use disorder: Replication, gender specificity, and mechanistic insights

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This chapter is adapted from:

Pabst, A., Gautier, M., & Maurage, P. (2024). Hostile attributional biases in severe alcohol use disorder: Replication, gender specificity and mechanistic insights. *Alcohol and Alcoholism*.

1. Introduction

Neuropsychological research in severe alcohol use disorder (SAUD) has recently gone beyond the classical exploration of "cold" cognitive abilities (e.g., memory, executive functions), to evidence robust impairments in social cognition (i.e., the perception, interpretation, and mobilization of social cues; Bora & Zorlu, 2017). This line of work is pivotal for understanding the interpersonal problems implicated in the severity and persistence of SAUD (Heilig et al., 2016; Sliedrecht et al., 2019; Zywiak et al., 2003). Moreover, recent evidence that social cognition impairments predict premature treatment drop-out and relapse, and do not spontaneously recover over the first months of abstinence, underscore their direct clinical relevance for the early steps of detoxification treatment (Rolland et al., 2019; Rupp et al., 2017, 2021a). Unfortunately, social cognition research in SAUD is currently characterized by a narrow focus on emotion recognition and Theory of Mind (i.e., the ability to infer others' mental states), unduly restricting our comprehension of the range of impairments in that domain, and limiting potential for action (Pabst et al., 2022).

Authoritative taxonomies (Green et al., 2008) emphasize attributional biases, and particularly hostile attributional biases (HAB; i.e., the tendency to endorse others' hostile intentions as the cause of ambiguous social events), as a core component of social cognition pertinent to clinical populations. Accordingly, HAB have been evidenced in several disorders, including schizophrenia, major depressive disorder, Parkinson disease, and bipolar disorder (Buck et al., 2023; Decombe et al., 2022; Lahera et al., 2015; Smith et al., 2016), demonstrating their broad transdiagnostic value. HAB further bear clear relevance to SAUD. Indeed, they represent key psychological processes in isolation, loneliness (Okruszek et al., 2021), and particularly aggression (Klein-Tuente et al., 2019), which are frequently observed in SAUD (Akerlind & Hörnquist, 1992; Chou et al., 2011; Gautier et al., 2023; Levola et al., 2014). HAB could thus hamper the recovery process in SAUD through their negative influence on interpersonal bonds, increasing conflicts and reducing social support. For example, HAB might directly increase perceived criticism (i.e., the frequency/intensity of negative

feedbacks and reproaches from the spouse, as self-reported by the patient) which has been identified as promoting relapse (Fals-Stewart et al., 2001). Indeed, HAB may both favor *actual* criticism due to its impact on relationship quality, and lead to misinterpretations of benevolent/ neutral comments as being critical. In spite of this importance, the association between HAB and SAUD remains insufficiently studied.

Pabst et al. (2020) recently provided the first and, to our knowledge, only direct evidence for HAB in SAUD. They used the Ambiguous Intentions Hostility Questionnaire (Combs et al., 2007b) which requests participants to provide open-ended statements to explain why people behaved in a certain way in written vignettes of ambiguous social situations (e.g., "You walk past a bunch of teenagers at the mall and you hear them start to laugh"). The statements were ascribed hostility scores by an external rater. The results showed that patients with SAUD had higher hostility scores than healthy controls (i.e., a higher tendency to infer that people present hostile intentions or attitudes towards them in ambiguous social situations), suggesting that SAUD is associated with HAB. HAB was further linked with state anxiety and interpersonal problems among patients.

This work constitutes a valuable starting point for exploration of HAB in SAUD to date. However, definitive conclusions should not be based on a single study. Moreover, methodological aspects in Pabst et al. (2020) limit the straightforward interpretation of their data. First, the Ambiguous Intentions Hostility Questionnaire is an explicit measure that overtly instructs participants to reflect, without time restrictions, on the causes of social situations. This makes researchers' goals transparent, thereby increasing risks of social desirability biases, and reduces the ecological validity of the task. Furthermore, a task encouraging reflective reasoning may be suboptimal to capture the spontaneousness and implicitness thought to characterize HAB (Wilkowski & Robinson, 2010). Second, the involvement of external raters adds a layer of subjectivity that may introduce further bias. Third, the design does not allow to determine whether the elevated scores in SAUD actually reflect increased HAB, a reduced tendency to endorse non-hostile attributions, or both. Indeed, recent work suggests that SAUD may be linked to reduced biases toward positive, rather than increased biases toward negative, social information (Pabst et al., 2023b). Finally, the study comprised a relatively low sample size, potentially affecting the reliability of the effects (Button et al., 2013).

Given the above-mentioned interpersonal and clinical relevance of this social cognition component in this population, and in line with accumulating calls for replication of novel findings in addiction science (e.g., Heirene, 2021; Pearson et al., 2022), our primary aim was to confirm the validity and robustness of the association between SAUD and HAB while addressing the limitations of Pabst et al. (2020). We used a different, highly validated task, the Word-Sentence Association Paradigm – Hostility (WSAP-H; Dillon et al., 2016; Pabst et al., 2023). Briefly, the WSAP-H requests participants to spontaneously rate the extent to which hostile and benign words *relate to* sentences describing ambiguous social situations. It has important advantages compared to the Ambiguous Intentions Hostility Questionnaire. It eliminates the need for external raters as scores are directly obtained from participants, hence removing noise introduced by subjectivity or evaluator bias. It also yields both benign and hostile attribution scores, offering the possibility to disentangle the source(s) of the observed group differences. While these caveats are also addressed by the Social Information Processing–Attribution and Emotional Response Questionnaire (Coccaro et al., 2009), the other most commonly used task assessing HAB, which asks participants to rate the likelihood

of four statements explicitly pertaining to the intentions of protagonists in eight ambiguous social scenes, the WSAP-H exhibits additional features that make it an ideal measure in our context. First, it is more implicit and ecological as it does not emphasize the need to reflect on the cause of the situation. Because it urges participants to respond as spontaneously and naturally as possible, as they normally would in everyday life, it reduces the impact of biases affecting explicit tasks (e.g., social desirability). Finally, although it has a larger content coverage of ambiguous situations than both other tasks, it is very short (<5 minutes) and easy to complete, avoiding any effect of fatigue or reduced cognitive abilities. Besides using this more valid task, we also increased the sample size to further strengthen the reliability of our study.

Secondarily, we explored potential gender differences. Some emotion recognition and Theory of Mind studies suggested that among individuals with SAUD, women may be more vulnerable to alterations in social cognition (Frigerio et al., 2002; Lewis et al., 2019; Onuoha et al., 2016). On the other hand, men were found to show higher levels of HAB compared to women in a population-based sample (Chen et al., 2012). However, gender differences in the relation between SAUD and HAB have not been examined. Addressing this question may inform our understanding of the stable sources of heterogeneity in social cognition impairments in SAUD, and bear critical implications for the individualized tailoring of interventions.

Finally, we investigated the consistency of previously reported associations between HAB, interpersonal problems and psychopathological symptoms in SAUD.

2. Method

2.1 Participants

Fifty-six patients with a DSM-5-confirmed diagnosis of SAUD and sixty-six age, gender, and education-matched healthy controls (HC) took part in the study. A power analysis conducted on G-Power indicated that a sample size of 51 participants per group was sufficient for our primary objective of detecting medium-sized (which we selected as a conservative estimate given the large differences observed in Pabst et al., 2020b) between-group differences and a small-to-medium within-between interaction with a power of 0.80. We recruited patients from Belgian specialized detoxification units. A trained psychiatrist screened them upon hospital admission to ensure that SAUD was their primary problem and that they did not present major comorbidities interfering with successful withdrawal treatment. Patients reported no lifetime diagnosis of comorbid psychiatric disorder besides depression, anxiety, and tobacco use disorder, and had abstained from alcohol for 8 days to 3 months at testing time. We recruited HC via social media and flyer advertisements, and by mobilizing the participant pool of our department. HC reported no lifetime diagnosis of psychiatric disorder and no first degree (parents, siblings) family history of alcohol use disorder. They further had Alcohol Use Disorder Identification Test (AUDIT; Babor et al., 2001) scores below eight, indicating low-risk consumption, and reported drinking less than ten units per week on average and never more than three units per day (1 unit = 10g of ethanol). The ethical committee of the department of psychology of UCLouvain and the biomedical ethical committee of the local University hospital approved all study procedures.

Table 4. Socio-demographic, psychopathological, interpersonal problems, and alcohol-related measures in patients with severe alcohol use disorder (SAUD) and healthy controls (HC): Mean (SD).

	SAUD (*n*=56)	HC (*n*=66)
Gender ratio (M/F)	28/28	39/27
Age	49.80 (10.00)	47.00 (11.61)
Education level (in years since starting primary school)	14.18 (2.19)	14.62 (2.72)
BDI[a]	**10.77 (6.18)[6]**	**3.05 (3.34)**
STAI[b]-State	**32.32 (10.10)**	**28.68 (6.87)**
STAI-Trait	**52.59 (9.14)[5]**	**38.51 (9.11)**
LSAS[c]	**51.16 (29.57)[6]**	**37.52 (26.75)**
Total IIP[d]	**94.62 (33.04)[1]**	**64.94 (32.82)**
Domineering	**7.20 (3.04)**	**5.43 (3.51)**
Self-centered	**8.59 (4.99)**	**5.83 (3.97)**
Cold/Distant	**9.72 (7.13)**	**5.88 (4.78)**
Socially Inhibited	**11.68 (9.24)**	**7.72 (6.99)**
Nonassertive	**14.51 (8.80)**	**10.58 (7.12)**
Overly accomodating	**14.71 (7.44)**	**11.57 (6.31)**
Self sacrificing	**17.85 (6.53)**	**12.25 (6.41)**
Intrusive	**12.25 (6.99)**	**6.20 (4.58)**
AUDIT[e]	**30.98 (5.42)[9]**	**3.18 (2.25)**
Number of abstinence days	24.93 (19.44)[2]	/
Number of previous detoxifications	1.38 (2.01)	/
Duration of SAUD (in years)	19.55 (17.08)	/
Number of alcohol units/ day[f]	17.03 (10.47)[1]	/
Number of DSM-5 SAUD symptoms	8.73 (1.72)	/

[a] Beck Depression Inventory (Beck & Steer, 1987).
[b] State/Trait Anxiety Inventory (Spielberger & Gorsuch, 1983).
[c] Liebowitz Social Anxiety Scale (Liebowitz, 1987).
[d] Inventory of Interpersonal Problems (Horowitz et al., 2003).
[e] Alcohol Use Disorder Identification Test (Babor et al., 2001).
[f] Before detoxification (an alcohol unit corresponds to 10 gr of ethanol).
Note = Bold lines indicate a significant difference between groups. Superscript numbers indicate the number of missing data.

2.2 Main measure

We used the French-validated version of the WSAP-H (Pabst et al., 2023) to assess HAB. It comprises fifteen sentences of ambiguous social situations (e.g., “A friend does not say hello”, “A shopping cart bumps into you”), each presented once alongside a benign (e.g., “Unaware”, “Accidental”) and once alongside a hostile (e.g., “Ignoring”, “Aggressive”) word. For each of the thirty trials, participants are instructed to indicate, as spontaneously as possible, how strongly the word relates to the sentence on a 1=”Not at all” to 6=”Extremely” scale. The order of the sentences was fixed, with at least 5 trials separating two occurrences of the same sentence, but whether the first occurrence was associated with a benign or a

hostile word was counterbalanced across participants. As per previous research (e.g., Dillon et al., 2016; Quan et al., 2019), we indexed HAB by averaging the ratings of the fifteen hostile items, and computed a benign attribution score by averaging the ratings of the fifteen benign items. The internal consistencies of the scores on hostile attribution items were α=0.78, ω=0.84 in HC and α=0.82, ω=0.87 in patients with SAUD. The internal consistencies of the scores on benign attribution items were α=0.72, ω=0.78 in HC and α=0.81, ω=0.86 in patients with SAUD.

2.3 Additional measures

We used the Inventory of Interpersonal Problems (IIP; Horowitz et al., 2003) to assess social interaction difficulties. This self-report questionnaire comprises sixty-four items from eight subscales [Cold/Distant (e.g., "It is hard for me to show affection to others"), Domineering (e.g., "I am too aggressive with others"), Intrusive/Needy (e.g., "It is hard for me to stay out of people's business"), Overly accommodating (e.g., "I am to easily exploited by others"), Nonassertive (e.g., "It is hard for me to assert myself to others"), Self-sacrificing (e.g., "I am excessively generous with others"), Socially inhibited (e.g., "It is hard for me to introduce myself to new people"), and Self-centered (e.g., "It is hard for me to support others in their life projects")] scored according to personal relevance on a 5-point scale from 0="Not at all" to 4="Extremely". We also used the thirteen-item Beck Depression Inventory (BDI; Beck & Steer, 1987) to assess depression symptoms, the State-Trait Anxiety Inventory (STAI; Spielberger & Gorsuch, 1983) to assess general state/ trait anxiety symptoms, and Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987) to assess social anxiety symptoms.

2.4 Statistical analyses

To determine the robustness and validity of previous results at the group level (independently of gender), we first used a 2x2 mixed ANOVA to investigate the effects of group (SAUD vs. HC, between), and attribution type (Benign vs. Hostile, within) on participants' WSAP-H scores. We then explored potential gender differences by adding gender (men vs. women, between; no participant reported a different gender) as an additional factor in a separate model 2x2x2 ANOVA. We investigated the relations between WSAP-H scores and interpersonal problems, psychopathological symptoms, and alcohol-related variables within the SAUD group as a whole, and separately by gender, using bivariate Pearson correlations. We finally investigated the potential confounding role of psychopathology symptoms variables found to differ between groups and to correlate with WSAP-H scores in any group by individually entering them as covariates (along with interactions with our factors of interests, to account for potential violations of the assumption of homogeneity of slopes) in the relevant models. We conducted all analyses on R (R Core Team, 2019) supplemented by the "afex" (Singmann et al., 2021), "emmeans" (Lenth et al., 2021), and "psych" (Revelle, 2022) packages.

3. Results

3.1 Socio-demographic, psychopathological, interpersonal problems, and alcohol-related measures (Table 4)

Groups did not differ in gender, age, or education. Patients with SAUD had higher scores on every collected psychopathological measure and every interpersonal problem subscale, and had higher AUDIT scores. Participant characteristics by gender are provided as Appendix 1. Importantly, men were on average younger than women.

3.2 WSAP-H scores as a function of group and attribution type (Figure 6)

We found a significant main effect of group [$F(1,120)=10.87$, $p=0.001$, $\eta^2_p=0.08$], with higher scores in patients with SAUD ($M=3.77$, $SE=0.06$) than HC ($M=3.49$, $SE=0.06$), as well as a significant main effect of attribution type [$F(1,120)=47.30$, $p<0.001$, $\eta^2_p=0.28$], with benign attribution scores ($M=3.99$, $SE=0.06$) being higher than hostile attribution scores ($M=3.27$, $SE=0.07$). The group x attribution type interaction was also significant [$F(1,120)=6.10$, $p=0.015$, $\eta^2_p=0.05$]. The follow-up between-groups *t*-tests showed that the group effect on benign attribution scores was non-significant and very small [$t(120)=0.19$, $p=0.851$, $d=0.03$; SAUD: $M=4.00$, $SE=0.09$; HC: $M=3.97$, $SE=0.08$] whereas the group effect on hostile attribution scores was significant and associated with a medium effect size [$t(120)=3.68$, $p<0.001$, $d=0.67$; SAUD: $M=3.54$, $SE=0.11$; HC: $M=3.00$, $SE=0.10$], indicating that patients with SAUD had higher hostile attribution scores compared to HC, but equivalent benign attribution scores. Additional within-groups follow-up *t*-tests confirmed that benign attribution scores were higher than hostile attribution scores both in patients with SAUD [$t(120)=3.00$, $p=0.003$, $d=0.39$] and HC [$t(120)=6.90$, $p<0.001$, $d=0.87$].

3.3 WSAP-H scores as a function of group, attribution type, and gender (Figure 7)

In addition to replicating the above-mentioned significant effects of group, attribution type and group x attribution type interaction (ps<0.023), the ANOVA model including gender revealed a significant group x attribution type x gender effect [$F(1,118)=10.16$, $p=0.002$, $\eta^2_p=0.08$]. We analyzed this interaction via group x attribution type ANOVAs separately conducted in men and women.

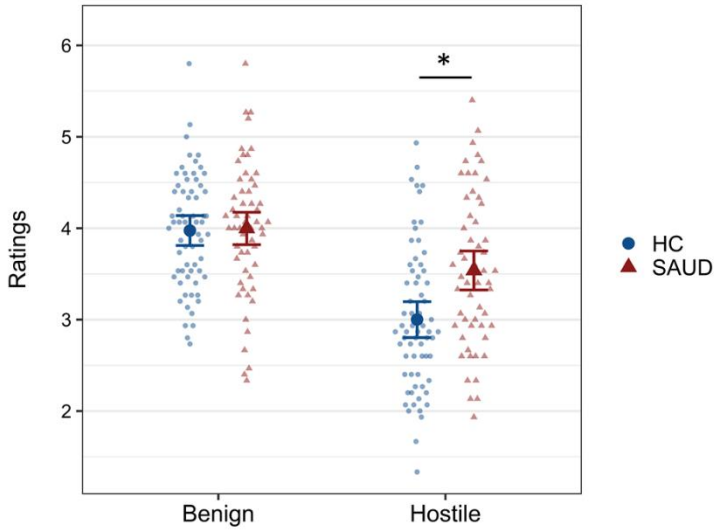

Figure 6*. Mean scores for benign and hostile attributions in patients with SAUD and HC.*

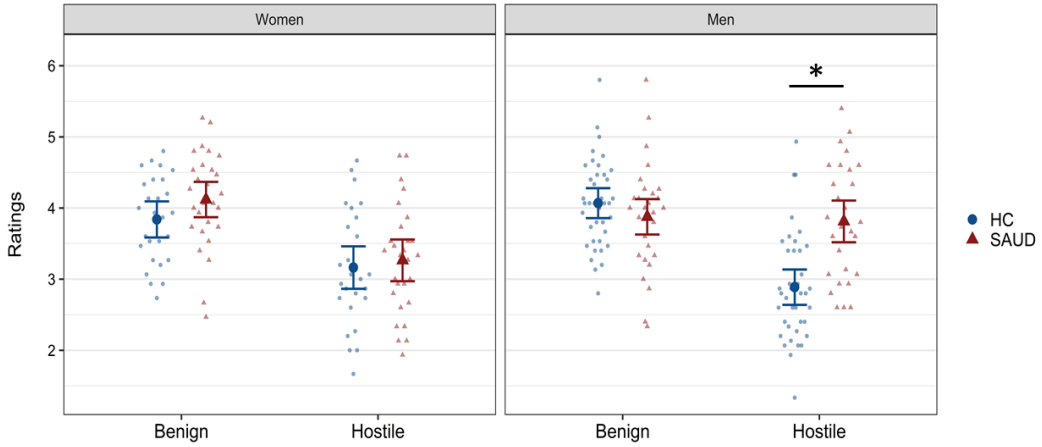

Figure 7. *Mean scores for benign and hostile attributions in patients with SAUD and HC as a function of gender.*

In women, there were no significant group [$F(1, 53)=3.19$, $p=0.080$, $\eta^2_p=0.06$] or group x attribution type [$F(1, 53)=0.31$, $p=0.580$, $\eta^2_p=0.006$] effects, but there was a significant attribution type effect [$F(1, 53)=22.75$, $p<0.001$, $\eta^2_p=0.30$], indicating greater benign ($M=3.98$, $SE=0.09$) than hostile ($M=3.21$, $SE=0.11$) attribution scores in both groups.

In men, the group [$F(1, 65)=8.02$, $p=0.006$, $\eta^2_p=0.11$; SAUD: $M=3.84$, $SE=0.09$, HC: $M=3.48$, $SE=0.10$], attribution type [$F(1, 65)=23.41$, $p<0.001$, $\eta^2_p=0.26$; Benign: $M=3.97$, $SE=0.09$, Hostile: $M=3.35$, $SE=0.10$], and group x attribution type effects were significant [$F(1, 65)=18.82$, $p<0.001$, $\eta^2_p=0.22$]. Follow-up between group *t*-tests showed that the interaction was due to patients showing higher hostile attributions [$t(65)=4.75$, $p<0.001$, $d=1.20$; SAUD: $M=3.81$, $SE=0.15$, HC: $M=2.89$, $SE=0.13$] whereas there was no group difference for benign attributions [$t(65)=1.13$, $p=0.261$, $d=0.29$; SAUD: $M=3.88$, $SE=0.13$, HC: $M=4.07$, $SE=0.11$]. Within-group *t*-tests showed that benign scores were significantly higher than hostile scores in HC [$t(65)=7.10$, $p<0.001$, $d=1.13$] but not in SAUD [$t(65)=0.06$, $p=0.745$, $d=0.06$]. Additional between-group *t*-tests showed that 1) men with SAUD not only had significantly increased hostile scores compared to HC men, but also compared to both women groups (ps<0.011), 2) HC men did not differ from both women groups on hostile or benign scores (ps>0.055). Finally, given that men where on average younger than women, we examined whether the critical group x attribution type x gender interaction remained after controlling for age, which vas verified [$F(1, 114)=10.68$, $p=0.001$, $\eta^2_p=0.09$].

3.4 Links between WSAP-H scores, psychopathology symptoms, and interpersonal problems in patients with SAUD (Appendix 2)

Considering the above-mentioned results, we report these relationships both in patients with SAUD as a whole, and in men and women with SAUD separately, but will mostly focus our interpretations on findings in the whole group and in men. In the SAUD group as a whole, but not in men or women with SAUD separately, hostile attribution scores were significantly and positively associated with state anxiety[1]. Given that there was a specific effect of SAUD on state anxiety in men (i.e., significantly higher state anxiety in men with SAUD compared to HC men, but no difference in state anxiety between women SAUD compared to HC women group, see Appendix 1), we verified that our effects of interest remained unaltered after including state anxiety in our models. This was confirmed as the group [$F(1,114)=9.66$, $p=0.002$, $\eta^2_p=0.08$], group x attribution type [$F(1,114)=4.63$, $p=0.034$, $\eta^2_p=0.04$], and most importantly group x attribution type x gender effects [$F(1,114)=7.94$, $p=0.006$, $\eta^2_p=0.07$] remained significant in the model including all participants, and the group x attribution type [$F(1,63)=13.91$, $p=0.004$, $\eta^2_p=0.18$] and ensuing specific group differences for hostile [$t(63)=4.22$, $p<0.001$] but not benign [$t(63)=0.84$, $p=0.404$] remained in the models including men only. Hostile attribution scores also correlated significantly with Domineering, Self-centred, and Cold/Distant interpersonal problems in the SAUD group as a whole. The associations with Domineering and Cold/distant (at a trend level in women) interpersonal problems persisted in both gender groups separately whereas the association with the self-centred scale was only significant in women. Benign attribution scores were not significantly related with psychopathological symptoms or interpersonal problems, except negatively with Cold/Distant interpersonal problems in women. Finally, given the relatively wide range of abstinence durations in our SAUD sample, we explored their potential association with

[1] It should be noted that there were no significant correlations between psychopathological symptoms and hostile attribution scores in HC as a whole or in either gender group separately, all ps>0.12. Hence, we only investigated the confounding role of state anxiety as it was the only psychopathological variable differing between groups and correlated with hostile attribution scores.

attribution scores. We found no significant correlation in the whole sample (Benign: r=-0.06, p=0.660; Hostile: r=-0.14, p=0.308) or among men (Benign: r=0.07, p=0.727; Hostile: r=-0.21, p=0.295) or women (Benign: r=-0.27, p=0.168; Hostile: r=0.02, p=0.908).

4. Discussion

We probed and confirmed preliminary findings of an association between SAUD and HAB (Pabst et al., 2020b) while relying on an improved design overcoming key methodological limitations. We recruited a larger sample and used a task assessing spontaneous HAB in a more implicit way, and without the involvement of external raters. Our results further strengthen previous conclusions by showing that patients with SAUD specifically show greater hostile attributions, not lower benign attributions, than HC. We thus provide evidence that the group-level association between SAUD and HAB *at the group* level is genuine and replicates across samples and tasks. This underscores HAB as a critical social cognition component in this disorder, and more generally reaffirms the value of expanding the social cognition literature in SAUD beyond emotion recognition or theory of mind (Pabst et al., 2022).

Our secondary analyses also revealed that these group-level findings masked gender-specific effects. Indeed, SAUD-related increases in HAB were selectively observed in men. These findings align with the emerging literature reporting gender differences in SAUD-related social cognition alterations (Frigerio et al., 2002; Lewis et al., 2019; Onuoha et al., 2016), and extend them toward HAB. Importantly, however, these previous studies, assessing emotion recognition of Theory of Mind, found women with SAUD to be particularly affected, suggesting that gender may influence social cognition alterations in SAUD differently depending on the component assessed. The heterogeneity in social cognition alterations in SAUD may thus not only concern the extent to which individuals are generally impaired (Maurage et al., 2021; Pabst et al., 2021), but also the specific components that are affected, and gender may represent an important stable factor in that regard. Our results therefore advocate for a greater consideration of gender, as well as for joint assessments of different social cognition components, to improve our understanding of the complex profile of SAUD-related alterations in that domain.

In addition to identifying patients at higher HAB risk, our results point to potential mechanisms of real-life HAB. Indeed, the fact that patients' benign attributions were not lower than their hostile attributions suggests that they may judge benign and hostile attributions as similarly adequate when these are rendered salient (benign and hostile words appeared below the sentences). Yet, Pabst et al. (2020) found that in the absence of cues, patients privilege hostile attributions nonetheless. A possible explanation is that, rather than being significantly more strongly adhered to within patients, hostile attributions are more readily accessed than benign ones. Once accessed, the stronger endorsement of hostile attributions compared to controls, which we evidence here, may hamper the consideration of alternatives and prevent reappraisal. Such a proposal is compatible with cognitive models of HAB, according to which certain individuals are more prone to produce spontaneous hostile interpretations, to allocate greater and reinforcing cognitive resources to such interpretations, and to show difficulties regulating them (Wilkowski & Robinson, 2010). Moreover, studies showing increased recall of negative memories in SAUD (Cuervo-Lombard et al., 2016; Nandrino & Gandolphe, 2017) support the idea that negative material is more accessible,

whereas evidence of impairments in emotion regulation, and specifically in the cognitive reappraisal of negative affect in SAUD (Petit et al., 2015) aligns with the view that patients with SAUD may not, or fail to, challenge hostile attributions when they arise. A direct test of these proposals is now warranted.

We finally investigated the links between attributions, psychopathological symptoms, and interpersonal problems in SAUD. Using a different task in a different sample, we corroborated the pattern of findings from Pabst et al. (2020). Specifically, we confirmed the link between HAB and state anxiety at the group level indicating that HAB may be exacerbated in patients currently experiencing higher anxiety (we assessed state anxiety just before the task). This is consistent with HAB theories incorporating affect, and according to which negative emotional states facilitate access to hostile attributions and hinder their reappraisal (Lemerise & Arsenio, 2000; Smeijers et al., 2019). Importantly, however, state anxiety did not entirely account for group differences in HAB. It should also be noted that, while we controlled for the current intensity of depressive and anxious symptoms, we did not test the influence of past depression/anxiety diagnosis nor of current tobacco use disorder. We thus cannot totally exclude that these comorbid psychiatric diagnoses partly influenced our results. We also confirmed associations between HAB in SAUD and specific interpersonal problems, and notably in the "domineering" domain, which comprises items that are characteristic of aggressive behaviors. This reinforces the idea that HAB may play a role in the conflicts and interpersonal violence associated with SAUD (Gautier et al., 2023). The specific increase of HAB in men may further partly explain gender differences in SAUD-related aggression (e.g., Fukushima Tedor et al., 2018), although in our sample, women with SAUD did not differ from men with SAUD on the "domineering" subscale. HAB were also consistently related to cold behaviors that are incompatible with the forming and maintaining of satisfying and enduring relationships, highlighting the various ways in which HAB may compromise interpersonal functioning. Finally, the absence of correlation between HAB and abstinence duration suggests that these biases do not spontaneously evolve during the initial steps of recovery and could constitute quite stable factors in SAUD.

Taken together, and in complement to Pabst et al. (2020), our results bear clinical implications. We first confirm the presence and functional significance (in terms of relations with interpersonal problems) of HAB in SAUD, and thus their relevance as a treatment target. We further suggest that men with SAUD are at particular risk of elevated HAB, and that assessments and treatments should be tailored accordingly. Given the specific increase in HAB in SAUD, and the equivalent adherence to benign and hostile attributions when these are salient, we further propose that there may be therapeutic value in 1) raising patients' awareness of their HAB tendencies and promoting reasoning about the holistic social situation before committing to an interpretation (Mathes Winnicki & Schmidt, 2023), 2) increasing the *accessibility/ saliency* of benign alternatives via repeated interpretation training and facilitating attention to positive social cues (Cougle et al., 2017; Pabst et al., 2023b; Smith et al., 2018). Finally, our replication of the state anxiety – HAB association suggests that interventions aimed at decreasing stress in anticipation of social interactions (Pabst et al., 2023a) may also be beneficial.

Our cross-sectional design precludes causal inferences regarding the links between variables, and our sample of recently detoxified patients, while constituting a key population to explore the role of social cognition in early treatment adherence and outcome (Rolland et al., 2019; Rupp et al., 2021, 2017) may not be representative of the global population with SAUD.

Beyond these limitations, we provide converging evidence that SAUD is associated with HAB and relates to interpersonal problems in this group. We further show that elevated HAB in SAUD may be selectively driven by men with SAUD, and that this effect is due to increased HAB, not decreased benign attributions in patients compared to healthy controls. Moreover, patients' ratings of benign and hostile attributions were not significantly different. These findings offer interesting insights into potential mechanisms and bear clear clinical implications. Future studies should elucidate the causes of the observed gender differences, and longitudinally assess the effects of HAB on treatment adherence and relapse in SAUD.

PART 3 : SECOND LINE OF EMPIRICAL STUDIES - INVESTIGATION OF POTENTIAL MECHANISMS

Chapter 7

Altered attentional processing of facial expression features in severe alcohol use disorder: an eye-tracking study

This chapter is adapted from:

Pabst, A., Bollen, Z., Masson, N., Gautier, M., Geus, C., & Maurage, P. (2023). Altered attentional processing of facial expression features in severe alcohol use disorder: An eye-tracking study. *Journal of psychopathology and clinical science*.

1. Introduction

Severe alcohol use disorder (SAUD) is associated with a broad range of social cognition difficulties, including reduced Theory of Mind and social perception/ knowledge, as well as biased social attributions (Maurage et al., 2015; Pabst et al., 2020b; 2021). Among them, problems in emotional facial expression (EFE) recognition are the most firmly established: patients with SAUD identify EFE less accurately (although the recognition of positive EFE seems preserved), and tend to incorrectly perceive them as socially hostile (e.g., angry, contemptuous, disgusted) (Bora & Zorlu, 2017; Castellano et al., 2015; Pabst et al., 2020a). These EFE recognition difficulties are linked with real-life interpersonal problems (Hoffman et al., 2019a), a major relapse predictor (Sliedrecht et al., 2019; Zywiak et al., 2003), as well as treatment drop-out (Rupp et al., 2017). They further do not appear to naturally recover with abstinence (Rupp et al., 2021b). Hence, interventions targeting this ability should be developed in SAUD. To this end, it is essential to gain insights on the mechanisms underlying these impairments.

Although their relative importance is debated, it is generally accepted that social cognition, including EFE recognition, depends both on 1) processes allowing for the extraction of relevant external signals, as well as 2) higher-order processes involved in the interpretation and integration of sensory cues with top-down information (e.g., current mental state, expectations, prior knowledge), and controlled decision-making (e.g., Adolphs, 2002; Barrett et al., 2011; Crick & Dodge, 1994; Phillips et al., 2008)). In SAUD, it remains generally unclear where the difficulties originate from. However, cognitively oriented explanations have tended to focus on the latter set of processes (Uekermann & Daum, 2008), and corroborating studies have evidenced links between higher-order cognitive abilities such as episodic memory and executive functioning, and EFE recognition in SAUD (Quaglino et al., 2015). By comparison, the consideration of mechanisms that could interfere with the extraction of relevant socio-affective cues has been surprisingly limited in this group, with the notable exception of recent preliminary work suggesting that EFE recognition impairments in SAUD may also arise from difficulties in the low-level visual decoding of

certain spatial frequencies (Creupelandt et al., 2019, 2022). Here, we address this issue and extend the investigation of cognitive mechanisms underlying EFE recognition impairments in SAUD toward the up-to-now neglected attentional domain. Specifically, we ask whether patients with SAUD show alterations in their attentional processing of EFE.

Indeed, several influential emotion theories contend that emotional states map onto distinct sets of characteristic physical changes, and most notoriously activations in facial muscles located around the eyes, mouth, and nose (see Barrett et al., 2019, for a review). From this perspective, attending to these specific facial areas would be particularly important for efficiently and accurately recognizing EFE. Several lines of evidence support this assertion. First, these areas capture the overwhelming majority on individuals' overt attention (i.e., eye fixations) during EFE recognition (Calvo et al., 2018; Eisenbarth & Alpers, 2011; Guo, 2012; Schurgin et al., 2014). Second, overt attention allocation to the eye region positively relates to EFE recognition (Hall et al., 2010; Sullivan et al., 2007; Vaidya et al., 2014). Third, directing participant's attention predominantly toward the eyes and mouth compared to other areas (e.g., cheeks, forehead) increases activation in face processing brain areas (Spilka et al., 2019). Fourth, experimentally occluding the eyes or mouth reduces EFE recognition performance (Schurgin et al., 2014). Fifth, clinical groups presenting EFE recognition difficulties (i.e., patients with psychiatric, developmental or neurological disorders) attend less to the eyes or mouth compared to their healthy counterparts (e.g., Günther et al., 2021; Kordsachia et al., 2018; Setien-Ramos et al., 2022; Toh et al., 2011; Waldthaler et al., 2019), suggesting that reduced attention to these areas affects performance.

In SAUD, impairments in attention, and specifically attentional control (Maurage et al., 2014) have been reported, which may impede goal-directed focus on specific areas (Schurgin et al., 2014). SAUD is further linked with modifications in attentional processing event-related potentials (N2b/P3a) when viewing EFE (Maurage et al., 2008). Additionally, patients with SAUD present reduced gray matter volume (Le Berre et al., 2013; Makris et al., 2008; Trick et al., 2014) and functional activity during EFE processing (Marinkovic et al., 2009; O'Daly et al., 2012; Salloum et al., 2007) in the amygdala and frontal cortex, which are involved in guiding gaze toward informative areas, and notably the eyes (Adolphs et al., 2005; Gamer et al., 2013; Kennedy & Adolphs, 2010; Vaidya & Fellows, 2019; Wolf et al., 2014), albeit possibly via different routes (i.e., initial direction of attention for the amygdala; later attentional engagement for the frontal cortex). Finally, SAUD is associated with heightened sensitivity to socially threatening or hostile cues, including angry and disgusted EFE (Maurage et al., 2012; Pabst et al., 2020b; Park et al., 2015, 2016), which may either interfere with efficient attention allocation or motivate patients to direct their attention away from informative areas of these stimuli to avoid distress (as described in social anxiety; Horley et al., 2004). In summary, an emerging literature suggests that SAUD may also be marked by altered facial attention when processing EFE. However, the evidence is highly preliminary and relies on decontextualized or indirect (neurophysiological) indices, thus highlighting the need for confirmation using a direct measure of attention. Moreover, the available studies do not offer definitive insights as to 1) which facial areas (eyes, mouth, nose) are abnormally attended to, 2) whether difficulties arise at initial (first fixations) and/ or later (dwell-time, total fixations) stages of attention, nor 3) whether they are emotion-specific or general. Addressing these limitations is crucial to understand the etiology of and intervene on EFE processing difficulties in SAUD.

Consequently, using an eye-tracking paradigm, we conducted the first direct test of the general hypothesis that patients with SAUD show reduced attention to informative facial areas during EFE recognition compared to healthy controls. Additionally, we determined which facial areas (eyes, mouth, nose) are concerned. We further disentangled which stages of attention (initial vs. later) are affected, and whether effects are emotion-specific (e.g., only observed for angry, or disgusted EFE). Secondarily, in line with previous behavioural results (Bora & Zorlu, 2017; Freeman et al., 2018; Maurage et al., 2021), we also hypothesized that patients with SAUD would be less accurate in recognizing EFE, especially low-intensity hostile ones (i.e., anger, contempt, disgust), and would more often incorrectly attribute hostile emotions than healthy controls.

In complement to traditional indices of attentional focus during EFE processing (i.e., "what" is attended to), we explored gaze entropy, or the predictability of gaze patterns (Krejtz et al., 2015; Shiferaw et al., 2019). When processing EFE, lower gaze entropy reflects a more predictable gaze pattern indicating that attentional exploration is more influenced by top-down emotional priors, and hence more structured and strategic (Cuve et al., 2021; Gehrer et al., 2018). This measure offers valuable additional insights regarding "how" patients with SAUD attend to EFE, and notably evaluate whether SAUD is associated with a less strategic, more random facial exploration. Finally, we explored possible associations between indices of attention and clinical variables, and investigated potential confounding effects of psychopathology symptoms.

2. Method

2.1 Open science statement

We preregistered the hypotheses, design, sample size rationale and main analysis plan on the Open Science Framework: https://osf.io/qd2zr. We present departures from this original plan in the corresponding sections below and exploratory analyses without pre-registered hypotheses are presented as such. The data and R code that we used for our analyses can also be found on the OSF page.

2.2 Participants (Table 5)

We recruited 40 patients with a DSM-5 (American Psychiatric Association, 2013) diagnosis of SAUD undergoing detoxification in specialized Belgian hospitals (Cliniques Saint-Pierre Ottignies, Le Beau-Vallon, Centre Hospitalier Le Domaine). Patients had all abstained from alcohol for at least 10 days. Prior to hospital admission, a trained psychiatrist interviewed them to ensure the absence of major physical, neurological or additional psychiatric disorders. Included patients had no other lifetime neurological or psychiatric diagnoses besides depression, anxiety or nicotine use disorder, and reported SAUD as their current primary problem. We also recruited 40 age-and-gender-matched healthy controls (HC) via social media, University participant pools, and flyer advertisements. They reported no lifetime neurological or psychiatric disorders except nicotine use disorder, and had no family history of SAUD. Additionally, they reported drinking less than 10 units per week and never more than 3 units per day, and had an Alcohol Use Disorder Identification Test (AUDIT; Babor et al., 2001) score below 8. HC were compensated 5 euros per 30min of participation.

All participants had normal or corrected-to-normal vision. The study protocol was approved by the biomedical ethical committee of the local faculty of medicine (UCLouvain) and complied with the Declaration of Helsinki. All participants provided informed written consent.

We determined the sample size required to test our main eye-tracking hypotheses by an a priori power analysis conducted on G*Power v3.1.9.4 (see Gehrer et al., 2019, for a similar approach). It revealed a necessary sample of 13 participants per group to detect a mixed group x ROI x emotional expression interaction (15 measurements) and 36 participants per group to detect a mixed group x ROI (3 measurements) interaction, assuming a small-to-medium (f=0.175) effect size and a desired power of 0.90 with an alpha of 0.05. We recruited slightly more participants per group (n=40) than required to detect the least powerful interaction (n=36) to counter unforeseeable data loss and maximize power for exploratory analyses.

2.3 Stimuli

We used a total of 160 colored photographs depicting 8 Caucasian actors (4 females) expressing anger, contempt, disgust, fear and sadness from the Radboud database (Langner et al., 2010). The actors were trained to express these emotions by executing the facial movements described in the Facial Action Coding System [FACS; Ekman et al., 2002; see Langner et al. (2010), Figure 2 for a list of the specific facial movements performed for each emotion]. We chose this database because the location of facial features is standardized within actors and because it comprises contemptuous expressions which are abnormally recognized in SAUD (Maurage et al., 2021; Philippot et al., 1999). Based on meta-analytical evidence suggesting a relatively preserved recognition of positive EFE in SAUD (Bora & Zorlu, 2017), we decided to minimize testing time by including only negative emotions. We equalized all photographs for luminance, and on-screen dimensions were 21.2x18.3cm (height x length). To reflect the facts that daily-encountered EFE vary in intensity, and that decoding impairments in SAUD may be stronger for subtler stimuli (Maurage et al., 2021), we created morphs of varying intensities by combining each emotion of each actor with the neutral expression of the same actor using Fantamorph 5.0 (Abrosoft, http://www.fantamorph.com). Each emotion was presented twice at 0, 10, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 80, 90 and 100% intensity. We included the 0 intensity to investigate response biases when no emotion was expressed (i.e. neutral expression). Each actor was presented 4 times for each emotion, at different intensity levels. Stimuli were divided in two blocks of 80 photographs, each comprising one set of 4 identities (2 females in each block) to allow for a break. All participants viewed the two blocks. Block order was counterbalanced and within-block stimuli presentation was randomized.

2.4 Task

Participants were instructed to identify the emotion expressed by each photograph as accurately as possible, without thinking too long about their answer. A 6-trial training phase with stimuli not included in the experimental blocks preceded the task. Each trial began with a fixation cross acting as a drift check randomly appearing on the left or right side of the screen. This was done to prevent artificial orientation of participants' gaze toward the center of the photographs before their appearance. After registration of a 1000ms fixation on the

fixation cross, the photograph immediately appeared in the center of the screen for 3000ms. Following this, a response display simultaneously comprising the labels "anger", "contempt", "disgust", "fear", and "sadness", in random order, was presented until an answer was selected via mouse-click. We did not include a "neutral" label despite the presence of 0-intensity expressions to prevent default answers when faced with uncertainty and to facilitate the observation of biases.

2.5 Setting, Apparatus & Software

The experiment took place in a quiet, dimly lit room, with participants seated on an adjustable chair. Stimuli appeared on an Asus laptop with a 17.3" Full HD screen (1080x1920p, 120Hz refresh rate), located 60cm away from participants' eyes. We used Opensesame (Mathôt et al., 2012) for stimuli presentation and eye-tracking synchronization. We recorded eye movements from the right eye using the state-of-the-art Eye-link Portable Duo (SR Research, Canada; 1000 Hz sampling rate; average accuracy range 0.25°-0.5°, gaze tracking range of 32° horizontally, 25° vertically) and we parsed gaze events into fixations using the EyeLink DataViewer software. Before training and before each experimental block, participants underwent a standard 9-point calibration.

2.6 Eye-movement processing

We extracted participants' fixations (as defined by the EyeLink DataViewer's default settings) on the face photographs. We then merged fixations separated by less than 1° of visual angle and deleted fixations shorter than 100ms (Manor & Gordon, 2003). We removed fixations starting before the onset of the photographs and trimmed the duration of fixations lasting until after their disappearance to focus exclusively on photograph-contingent gaze behaviour. In order to analyze participants' fixations on specific facial features, we further defined regions of interest (ROI) tailored to each actor (facial features were aligned within actors). These consisted of large rectangles superimposed on each eye, the mouth, the nose, and the whole face (excluding background, shirt, and hair). We selected these ROIs based on theory and previous research indicating that these facial areas are most often attended to and/or are most informative during emotion recognition (Calvo et al., 2018; Eisenbarth & Alpers, 2011; Guo, 2012; Schurgin et al., 2014).

2.7 Psychopathology questionnaire measures

We measured depression symptoms with the Beck Depression Inventory (BDI; Beck & Steer, 1987), anxiety symptoms with the State-and-Trait Anxiety Inventory (STAI; Spielberger & Gorsuch, 1983), and social anxiety symptoms with the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987).

2.8 Analyses

2.8.1 Data exclusion

For eye-tracking analyses, we excluded data from 72 trials in the SAUD sample (1.12% of SAUD trials) and 8 trials in the HC sample (0.12% of HC trials), for which more than 50% of fixations occurred outside the face ROI.

2.8.2 Main analyses: eye-tracking data

To index initial attention to facial features, we computed for each participant and emotion, the proportion of trials in which the first fixation occurred on the eyes (left and right combined), mouth, or nose ROI. To index later attention to facial features, we computed, for each participant and emotion the mean proportion of fixations and dwell-time (sum of fixation durations) on the eyes, mouth, and nose, relative to the face ROI. We preferred proportions over absolute attention indices, as the latter may be affected by patients with SAUD's reduced visual processing speed (e.g., Bertera & Parsons, 1978). Relevant reliability estimates are provided as Appendix 3 and were all acceptable. We submitted the initial attention allocation index to a 2 (group, between) x 3 (ROI, within) x 5 (emotional expression, within) mixed ANOVA. Because groups unexpectedly differed in completed education years (see Results section), and preliminary correlation analyses showed significant or almost significant associations between education and proportions of total fixations and dwell time indices (education was not associated with other eye-tracking indices), we deviated from our pre-registered analysis plan and submitted both indices of overall attention to 2 (group, between) x 3 (ROI, within) x 5 (emotional expression, within) mixed ANCOVAs with education (centered) as a covariate, instead of ANOVAs. We excluded 0-intensity trials from these analyses to maintain a meaningful emotional expression factor.

2.8.3 Secondary analyses: behavioral emotion recognition data

To index EFE recognition accuracy, we computed for each participant, emotional expression, and intensity category, defined as low (10-35%), medium (40-60%) and high (65-100%), the proportion of trials with correct emotion recognition (0%-intensity trials were excluded from this analysis). To index biases in emotion recognition, we computed, for each participant and emotion expression displayed (0%-intensity trials were included and considered to display a neutral expression), the proportion of incorrect trials in which a given emotional expression was selected. As education was significantly associated with emotion recognition performance indices, the proportions of trials with correct emotion recognitions were submitted to a 2 (group, between) x 5 (emotional expression, within) x 3 (intensity class) mixed ANCOVA with education as a covariate, instead of ANOVA. Proportions of incorrect emotion selections were submitted to a 2 (group, between) x 5 (selected emotion, within) mixed ANOVA.

We applied Greenhouse-Geisser corrections where appropriate. We performed all analyses on R (R Core Team, 2019), supplemented with the "afex" (Singmann et al., 2021) and "emmeans" (Lenth et al., 2021) packages. We estimated the sizes of relevant effects using partial eta squared and Cohen's d.

2.8.4 Additional exploratory analyses

Gaze transition entropy

Gaze transition entropy reflects the extent to which ROI transition destinations are predictable given current fixation locations, and thus indexes how much visual exploration is structured, strategic (influenced by top-down factors) vs. random. Based on matrices of fixation transition frequencies from each ROI (eyes, mouth, nose, rest of the face) to the same or a different ROI (fixations occurring outside the face were excluded) obtained for each participant and each emotional expression (0-intensity trials excluded), we computed gaze transition entropy using the formula detailed by Shiferaw et al. (2019):

$$H(x) = -\sum_{i=1}^{n} p_i \sum_{j=1}^{n} p(i|j) log_2 p(i|j)$$

H is the uncertainty of x given its prior state, p_i is the observed absolute probability of viewing the i^{th} ROI (max n=4) and $p(i|j)$ is the probability of transitioning from i to j. Scores were normalized by maximum entropy, defined as the binary logarithm of the number of different ROIs (i.e., 4) that could characterize the location of gaze. Higher gaze transition entropy indicates more random gaze transitions. We submitted these scores to a 2 (group, between) by 5 (emotional expression, within) mixed ANOVA.

Links between eye-tracking indices and psychopathology symptoms and EFE recognition

We used Pearson correlations to explore associations between eye-tracking indices differing between groups and psychopathology symptoms differing between groups, and investigated the confounding effect of psychopathological symptoms found to be associated using ANCOVA. We also used Pearson correlations to explore the links between these eye-tracking indices and EFE recognition. Significant associations would provide empirical support to the view that altered attention to relevant facial areas plays a role in EFE recognition impairments.

3. Results

3.1 Sample characteristics

There were no group differences in age and gender and social anxiety (LSAS) symptoms, but patients with SAUD reported less education years than HC, together with elevated depression (BDI) and state/trait anxiety (STAI) symptoms. Patients with SAUD also logically reported higher AUDIT scores.

Table 5. Socio-demographic, psychopathological, and alcohol-related measures among participants with severe alcohol use disorder (SAUD) and healthy control participants (HC): mean (SD).

	SAUD (n=40)	HC (n=40)
Age	45.28 (9.55)	47.33 (11.68)
Gender [N(% females)]	12 (30%)	17 (42.5%)
Years of completed education years***	13.40 (2.18)	15.73 (2.21)
BDI***	9.89 (8.10)$^{++}$	2.68 (2.83)
LSAS	45.21 (22.24)$^{+}$	37.93 (26.61)
STAI trait***	48.93 (12.79)$^{++}$	35.78 (10.47)
STAI state*	32.58 (12.32)$^{+}$	27.02 (7.57)
AUDIT***	30.53 (5.48)$^{+}$	2.95 (1.50)
Weekly consumption (standard units)	18.86 (12.85)	
Duration of SAUD (years)	8.56 (7.34)	
Number of previous detoxifications	2.38 (4.07)	

*< .05, **< .01, *** < .001, $^{+}$ one missing value, $^{++}$ two missing values

3.2 Eye-tracking main results (Figure 8)

3.2.1 Initial attention allocation to facial features

The ANOVA on proportions of first fixations revealed a main effect of group ($F(1,78)=17.51$, $p<0.001$, $\eta^2_p=0.18$), with lower proportions of first fixations occurring on any ROI (proportions averaged across ROIs) in SAUD ($M=0.19$, $SE=0.007$) than HC ($M=0.23$, $SE=0.007$), meaning that patients made proportionally less first fixations toward any ROI than HC. The group x ROI ($F(1.22,94.89)=1.20$, $p=0.286$, $\eta^2_p=0.02$) and the group x emotional expression did not reach significance ($F(3.89,303.04)=1.20$, $p=0.377$, $\eta^2_p=0.01$), but there was a significant group x ROI x emotional expression interaction ($F(6.18,481.70)=2.24$, $p=0.033$, $\eta^2_p=0.03$). Follow-up uncorrected ANOVAs showed that this effect was due to group x emotional expression interactions selectively emerging for proportions of first fixations on the mouth ($p=0.021$) and nose ($p=0.017$). No group x ROI interaction emerged at any emotional expression level (all $ps>0.18$). Additional follow-up comparisons showed that patients with SAUD made proportionally more first fixations towards the mouth when faces expressed fear or disgust compared to anger and sadness ($ps<0.044$). No difference between emotional expressions was observed in HC (all $ps>0.84$). On the opposite, regarding the nose, an emotional expression effect was found in HC but not in SAUD (all $ps>0.32$), since HC made proportionally more first fixations towards the nose when faces expressed disgust compared to anger ($p<0.012$) and fear ($p=0.05$). Despite these complex group-specific emotional expression effects, there were no uncorrected significant between-group effects on the proportion of first fixations on the mouth or nose for any emotional expression (all $ps>0.13$). Hence, we did not consider this three-way interaction further.

3.2.2 Later attention to facial features

The ANCOVA on proportions of total fixations revealed again a main effect of group (F(1,77)=4.48, p=0.037, η^2_p=0.06), with lower proportions of fixations occurring on any ROI (proportions averaged across ROIs) in SAUD ($M_{education\ adjusted(EA)}$=0.27, SE=0.003) than HC (M_{EA}=0.28, SE=0.003). There was also a significant group x ROI interaction (F(1.36, 104.64)=3.80, p=0.041, η^2_p=0.05). Uncorrected follow-up between-subjects comparisons showed that this interaction was due to patients with SAUD having lower proportions of total fixations on the eyes (SAUD: M_{EA}=0.39, SE=0.03; HC: M_{EA}=0.49, SE=0.03; t(77)=2.26, p=0.026, d=0.52) and higher (although only at a trend level) proportions of fixations on the nose (SAUD: M_{EA}=0.20, SE=0.02; HC: M_{EA}=0.15, SE=0.02; t(77)=1.86, p=0.066, d=0.42) than HC, with no difference regarding proportions of fixations on the mouth (SAUD: M_{EA}=0.22, SE=0.02; HC: M_{EA}=0.19, SE=0.02; t(77)=0.87, p=0.387, d=0.20). The group x emotional expression (F(3.75, 288.62)=0.29, p=0.873, η^2_p=0.004), and the group x ROI x emotional expression interactions were not significant (F(6.42, 493.97)=1.42, p=0.201, η^2_p=0.02).

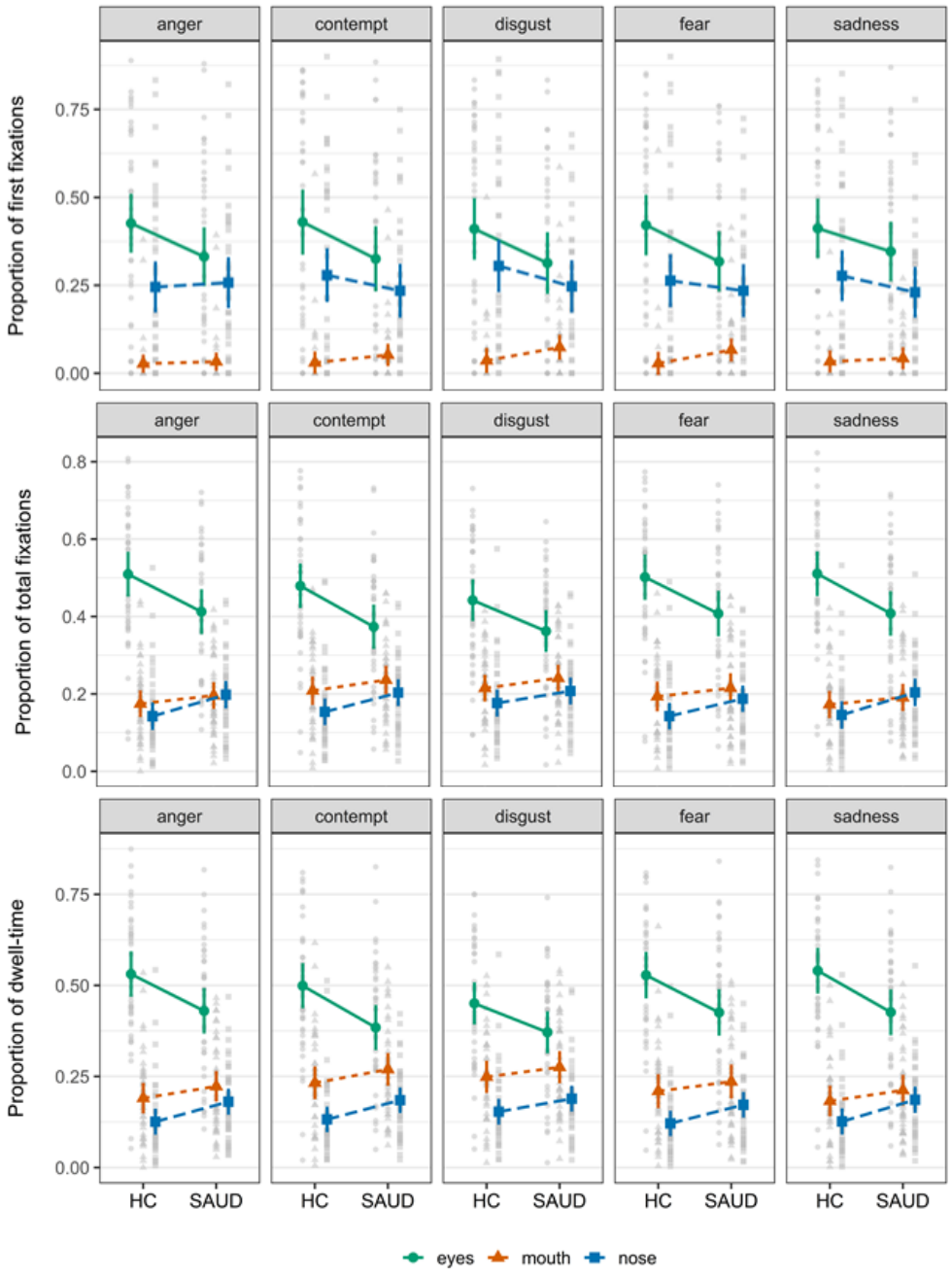

Figure 8. *Mean proportions of first fixations, total fixations, and dwell-time occurring on the eyes, mouth and nose, relative to the rest of the face, as a function of group and emotional expression.*

The ANCOVA on proportions of dwell-time showed no main effect of group (F(1,77)=2.65, p=0.107, η^2_p=0.03) but again revealed a significant group x ROI interaction (F(1.42,109.52)=3.67, p=0.043, η^2_p=0.05). Uncorrected follow-up between-group comparisons again showed that this interaction was due to patients with SAUD having lower proportions of dwell-time on the eyes (SAUD: M_{EA}=0.41, SE=0.03; HC: M_{EA}=0.51, SE=0.03; t(77)=2.23, p=0.028, d=0.51) and higher (although only at a trend level) proportions of dwell-time on the nose (SAUD: M_{EA}=0.18, SE=0.02; HC: M_{EA}=0.13, SE=0.02; t(77)=1.96, p=0.054, d=0.45), than HC, with no difference regarding proportions of dwell-time on the mouth (SAUD: M_{EA}=0.24, SE=0.02; HC: M_{EA}=0.21, SE=0.02; t(77)=0.94, p=0.350, d=0.21). The group x emotional expression (F(3.75, 288.75)=0.60, p=0.652, η^2_p=0.01), and group x ROI x emotional expression interactions were not significant (F(6.54, 503.69)=1.49, p=0.175, η^2_p=0.02).

3.3 Eye-tracking exploratory results: Gaze transition entropy

The ANOVA on gaze transition entropy revealed a main effect of group (F(1,77)=4.21, p=0.044, η^2_p=0.05), with higher scores (i.e., less strategic exploration) in patients with SAUD (M=0.83, SE=0.02) than HC (M=0.78, SE=0.02). The group x emotional expression interaction was not significant (F(3.37, 262.55)=1.44, p=0.229, η^2_p=0.02).

3.4 Behavioural main results (See Appendices 4 and 5 for descriptive statistics)

The ANCOVA on proportions of correct emotion recognition trials revealed that the main effect of group (F(1,77)=0.52, p=0.47, η^2_p=0.01), the group x emotional expression (F(3.51,269.90)=0.85, p=0.481, η^2_p=0.01), the group x intensity class (F(1.87,143.62)=1.57, p=0.213, η^2_p=0.02), and the group x emotional expression x intensity class interactions (F(5.87,451.90)=0.48, p=0.822, η^2_p=0.01) were all non-significant. Similarly, the ANOVA on the proportions of incorrect emotion selections revealed that the relevant group x selected emotion (F(2.77,216.32)=0.06, p=0.974, η^2_p=0.0008) was not significant. An additional exploratory (non-preregistered) analysis conducted only on 0-intensity neutral trials again revealed a non-significant group x selected emotion interaction (F(1.85, 144.14)=0.43, p=0.638, η^2_p=0.005).

3.5 Additional exploratory results

3.5.1 Links between eye-tracking indices and psychopathology

Given the above-presented results, we explored links between depression, state anxiety, and trait-anxiety symptoms on one hand, and proportions of first and total fixations occurring on any ROIs (averaged across ROI), proportions of fixations and dwell-time on the eyes, and gaze transition entropy on the other hand. No significant correlation emerged regarding proportions of first fixations, proportions of dwell-time, or gaze transition entropy in either group (all ps>0.34). There were however correlations between proportions of total fixations averaged across ROIs and depression (r=-0.36, p=0.025) and, at a trend level, trait anxiety

(r=-0.27, p=0.088) in HC. Adding depression and trait anxiety symptoms as covariates in the previously described ANCOVA on proportions of total fixations did not alter its general conclusions: the group (F(1,73)=3.27, p=0.075, η^2_p=0.04), and group x ROI (F(1.36,98.95)=3.39, p=0.056, η^2_p=0.04) effects remained marginally significant and the follow-up between group comparisons confirmed the lower proportions of fixations on the eyes (t(73)=2.03, p=0.046, d=0.48) and higher proportion of fixations on the nose (t(73)=2.17, p=0.033, d=0.51) in the SAUD group compared to HC.

3.5.2 Links between eye-tracking indices and EFE recognition

We explored the links between percentages of first and total fixations on relevant areas (averaged across ROI), percentages of dwell time and total fixations on the eyes, and gaze transition entropy on the one hand, and EFE recognition accuracy indices for each emotion on the other hand, both in the full sample and in patients with SAUD only. In the full sample, fear recognition correlated positively with the percentage of first (r=0.36, p=0.0009) and total (r=0.22, p=0.048) fixations on relevant facial areas, as well as with the percentages of dwell-time (r=0.20, p=0.07) and total fixations on the eyes (r=0.22, p=0.049), all other ps were > 0.09. The pattern of results was similar in patients with SAUD only: fear recognition correlated with the percentages of dwell-time (r=0.30, p=0.06) and total fixations (r=0.32, p=0.04) on the eyes. However, the correlation with the percentages of first (r=0.22, p=0.18) and total (r=0.09, p=0.58) fixations on relevant facial areas became non-significant, all other ps were > 0.19.

4. Discussion

We provided the first direct investigation of attention allocation during EFE recognition in SAUD. Our main findings support the hypothesis that SAUD is associated with reduced attention to key facial features, and predominantly the eyes, and further allow for a characterization of this effect.

This reduced attention concerned both initial, and later attention indices. Patients with SAUD's first fixations occurred proportionally less often on relevant ROIs compared to HC. Although the effect appears most consistent for the eyes, the absence of a significant interaction precludes the conclusion that this result is due to reduced first fixations toward this region specifically and rather suggests that patients with SAUD have a globally reduced initial tendency to orient their attention to informative facial features. Patients with SAUD also displayed reduced proportions of total fixations and dwell-time compared to HC, on the eye region but not on the mouth/nose. This suggests that the classical attentional focus on the eye region, repeatedly observed earlier (e.g., Schurgin et al., 2014) and confirmed in our HC group, is attenuated in SAUD. Finally, the effects did not significantly differ by emotional expression, indicating that they are not explained by differences in the attentional processing of specific (e.g., hostile) EFE. In summary, patients with SAUD showed reduced early, automatic attention to informative facial areas in general, and reduced later attention to the eyes specifically, regardless of the expressed emotion. Importantly, these findings were independent of, or persisted after controlling for, education and relevant psychopathological symptoms.

These results indicate that attentional impairments in SAUD (Maurage et al., 2014) extend to socio-affective stimuli, confirming previous indirect electrophysiological results showing modified attentional processing of EFE (Maurage et al., 2008). This reinforces proposals to conceptualize SAUD, not only as a "cold" cognitive, but also as a socio-affective disorder (e.g., Maurage et al., 2021). Indeed, it suggests that socio-affective information processing alterations in SAUD can be traced back to a mechanism as fundamental to social cognition and interpersonal interactions (Cañigueral & Hamilton, 2019; Itier & Batty, 2009) as attentional allocation to key facial features such as the eyes. Interestingly, the magnitude of the reported effects is comparable to those found in other psychiatric conditions primarily marked by social impairments, such as autism (Setien-Ramos et al., 2022) and social anxiety disorder (Günther et al., 2021). Besides further stressing the interpersonal dimension of SAUD, these observations also highlight the transdiagnostic relevance of altered facial attention. Most importantly, the current findings add to efforts aimed at identifying the cognitive mechanisms underlying EFE recognition difficulties in SAUD, by emphasizing altered attention to key facial areas as a crucial factor potentially preventing the efficient extraction of relevant facial information, and hence reducing performance.

The simultaneous reduction of initial and later attention to central facial features can be discussed in light of dominant dual-process models viewing addiction as a combination of increased sensitization to the substance, and reduced cognitive control (Koob & Volkow, 2010; Stacy & Wiers, 2010b). On the one hand, reduced initial attention to key facial areas in general may reflect reduced sensitivity to social stimuli, following the hijacking of the salience systems by substance-related cues, at the expense of alternative, naturally valued and attention-grabbing social stimuli (Kalivas & Volkow, 2005; Volkow et al., 2011). On the other hand, reduced controlled attention to the eyes may result from an impaired ability to mobilize cognitive resources to voluntarily orient attention toward goal-relevant areas (Maurage et al., 2014). This interpretation is consistent with the contention that initial fixations reflect rather exogeneous stimulus-based, and later fixations rather endogenous controlled, attention, although both processes likely influence both indices to some extent (e.g., Nummenmaa et al., 2006). Further research is required to clarify if and how social impairments in SAUD can be integrated in dual-process models. Additionally, this combined alteration suggests that structural and functional impairments found in both limbic and frontal brain areas might be involved in social cognition deficits in SAUD (Le Berre et al., 2013; Makris et al., 2008; Marinkovic et al., 2009; O'Daly et al., 2012; Salloum et al., 2007; Trick et al., 2014), particularly through their purported role in initial and later attention to relevant facial areas, respectively (Adolphs et al., 2005; Gamer et al., 2013; Kennedy & Adolphs, 2010; Vaidya & Fellows, 2019; Wolf et al., 2014). Studies combining eye-tracking and neuroimaging techniques in SAUD are necessary to confirm this proposal. Finally, the absence of modulation by emotion indicates that the effects are not driven by emotion-specific mechanisms such as increased sensitivity to socially hostile stimuli (Pabst et al., 2020b).

Our exploratory eye-tracking analyses additionally revealed that patients with SAUD also differ from HC in the structure of their attention allocation to EFE. Their increased gaze transition entropy indicates that their attentional exploration of EFE is less structured and strategic than HC's (Cuve et al., 2021; Krejtz et al., 2015; Shiferaw et al., 2019). This may again be attributable to patients' reduced attentional control (Maurage et al., 2014). Alternatively, within a predictive coding framework in which eye-movements are informed by, and constitute means to test, top-down sensory predictions (Friston et al., 2012), increased

gaze entropy during EFE may represent novel evidence of reduced influence of emotional predictions in patients with SAUD (Cuve et al., 2021). Additional research is needed to pinpoint the mechanisms underlying increased gaze transition entropy during EFE recognition in SAUD.

Despite modified attentional processing, we found no group differences on EFE recognition indices. This contradicts previous findings (Bora & Zorlu, 2017; Castellano et al., 2015; Freeman et al., 2018; Maurage et al., 2021), and apparently challenges the proposed relationship between abnormal attention allocation and EFE recognition difficulties in SAUD. However, methodological aspects may have reduced the task's sensitivity to behavioural differences in EFE recognition performance. First, to optimize our task for our primary eye-tracking measures, we fixed EFE exposure time at 3000ms before presenting response options. Response speed could hence not be emphasized and was not recorded. Most previous EFE categorization paradigms presented stimuli for shorter durations (Freeman et al., 2018; Kornreich et al., 2013, 2016), allowed for responses as soon as stimuli appeared (e.g., Carmona-Perera et al., 2014; Maurage et al., 2021), and/or encouraged participants to answer as fast as possible (Foisy et al., 2007b; Kornreich et al., 2016). We therefore allowed for increased EFE processing time compared to previous studies and did not collect subtler performance indicators such as reaction times, potentially obscuring group differences related to patient's reduced visual processing speed (Bertera & Parsons, 1978). Second, we focused on a subset of five, negative, EFE whereas other paradigms typically entail at least six EFE, including happiness and/or surprise (e.g., Cox et al., 2018; Kornreich et al., 2013; Maurage et al., 2021), which may have reduced the cognitive demand imposed on participants. Third, we did not allow for neutral responses, preventing spontaneous errors related to impressions of total absence of emotion, which may be expected in patients with SAUD in light of their higher detection thresholds (D'Hondt et al., 2015; Maurage et al., 2021). Fourth, with HC accurately recognizing 74.9% of EFE (72.3% in patients with SAUD), our task was easier (partly because of the abovementioned points), than comparable ones yielding group differences (Freeman et al., 2018; Kornreich et al., 2013; Maurage et al., 2021). For these reasons, and although our behavioural findings are valuable as they point to boundary conditions for EFE recognition impairments in SAUD, and because such null-results will be important to integrate in future meta-analyses, we argue that the null-findings on EFE recognition in the presence of modified attentional processing do not imply functional independence. Indeed, the link between attention to key facial areas and EFE recognition is well established (Hall et al., 2010; Schurgin et al., 2014; Spilka et al., 2019; Sullivan et al., 2007; Vaidya et al., 2014). Furthermore, and despite our EFE recognition task's reduced sensitivity, the fact that increased presentation time may have allowed individuals to gather sufficient information despite proportionally reduced attention to important features, and our limited sample size, our complementary analyses revealed that fear recognition was associated with reduced first and total fixations to relevant face areas in the whole sample, and with reduced dwell time and fixations to the eyes in both the whole sample and the subsample of patients with SAUD. Although such exploratory and uncorrected results must be interpreted cautiously, they align with previous studies showing that attention to key facial features, and notably the eyes, are especially relevant for the recognition of fear (Eisenbarth & Alpers, 2011; Schurgin et al., 2014; Vaidya et al., 2014), which is principally characterized by a widening of the eyes. Crucially, the joint significance of the links between SAUD and altered facial attention, and between altered facial attention and EFE recognition performance, offers direct empirical support to the view that reduced attention to key facial areas actively contributes to impaired EFE recognition in SAUD

specifically (Kornreich, 2017; MacKinnon et al., 2002), underscoring the clinical relevance of the current findings. We urge for replications using more sensitive tasks and experimental manipulations of attention using visual cues (Spilka et al., 2019) or verbal instructions (Wolf et al., 2016) during EFE processing to confirm that reduced attention to informative facial features is a mechanism in EFE recognition difficulties in SAUD.

Importantly, patients' reduced attention to the eye region, being independent of emotional content, may have clinically relevant consequences beyond impairing EFE identification. The eyes carry additional information regarding the source and social significance of individuals' expressions (Roelofs et al., 2010; Sander et al., 2007). For example, angry faces looking toward perceivers' eyes versus looking elsewhere have drastically different personal implications. Failing to take this information into account may lead patients with SAUD to erroneously interpret negative expressions as being self-directed and hostile (Pabst et al., 2020b). Moreover, looking at the eyes provides information about others' non-emotional mental states such as intentions, current attentional focus, or desire to communicate and establish intimacy, and also logically constitutes a valuable signal facilitating others' access to our own (emotional) mental states (Cañigueral & Hamilton, 2019; Itier & Batty, 2009). This latter aspect is particularly relevant in clinical settings where practitioners' poor understanding of patients may deter the therapeutic alliance and reduce the adherence to and effectiveness of interventions. Hence, our findings shed light on a potential mechanism impacting the ability to understand and be understood by others in SAUD, and thus participating in social cognition and interpersonal functioning impairments more broadly.

Our work comprises limitations. First, our framework was cognitively oriented and we focused on but one potential mechanism of EFE recognition difficulties in SAUD. Alterations in higher order processes such as social memory, expectations or decision-making, as well as in non-cognitive processes such as emotional reactivity or motor facial mimicry may additionally be involved. It will be important for future work to further investigate these processes and their relationships in order for an integrative model to emerge. Second, in line with previous behavioural EFE recognition studies in SAUD, we employed static stimuli lacking ecological validity, and we focused on Caucasian faces, hampering the investigation of cross-cultural/ethnical effects. We additionally considered negative EFE only, preventing generalizations of our conclusions to positive EFE. It should nevertheless be noted that the decoding of positive emotions, and centrally happiness, appears preserved in SAUD. Third, while the proportion of rejected trials (i.e., trials for which more than 50% of fixations occurred outside the face ROI) was very low in both groups, it was higher in SAUD, potentially reflecting temporary attentional lapses or reduced understanding of the instructions in this group. Fourth, although gaze measurement through eye-tracking is a gold-standard measure of overt (i.e., foveal) attentional processing, it cannot track participants' covert (i.e., peripheral) attention and hence patients might have compensated their reduced overt attention through increased covert attention. This would however not diminish the relevance of our findings since the importance of overt attention *per se* is established for EFE processing (Spilka et al., 2019; Vaidya et al., 2014). Fifth, our cross-sectional design prevents inferences on the causal relationships between SAUD and modified attentional EFE processing. Recent studies among individuals with familial history of alcohol use disorder and sub-clinical populations of adolescents and young adults presenting excessive alcohol consumption suggest that EFE recognition impairments may partly precede SAUD (Lannoy et al., 2021; Le Berre et al., 2019). However, it is currently impossible to determine whether EFE recognition difficulties, and their attentional correlates, are a pre-existing factor and/or

a consequence of SAUD. Future studies should also determine whether our results, observed in recently detoxified patients with SAUD, can be generalized to other populations presenting alcohol use disorders. Finally, our sample size did not allow for meaningful investigations of gender-contingent effects, which may be important to consider in SAUD-related social cognition research (Lewis et al., 2019).

In conclusion, we provide novel direct evidence that patients with SAUD differ from HC in their overt attention allocation during EFE processing. They centrally show reduced initial attention to informative facial features and reduced later attention to the eyes specifically. Their gaze pattern is moreover less structured than HC's. These results increase our understanding of socio-affective information processing difficulties in SAUD, confirm earlier neuroimaging studies, and may have important implications for improving social cognition and interpersonal functioning in SAUD in clinical settings.

Chapter 8

An eye-tracking study of biased attentional processing of faces in severe alcohol use disorder

This chapter is adapted from:

Pabst, A., Bollen, Z., Masson, N., Billaux, P., de Timary, P., & Maurage, P. (2023). An eye-tracking study of biased attentional processing of emotional faces in severe alcohol use disorder. *Journal of Affective Disorders*, *323*, 778-787.

1. Introduction

Interpersonal difficulties are increasingly recognized as an important component of severe alcohol use disorder (SAUD; Maurage et al., 2021). SAUD is notably characterized by frequent conflicts (Levola et al., 2014), reduced community engagement (Chou et al., 2011), as well as smaller and less diverse social networks (Mowbray et al., 2014). These interpersonal problems and associated lack of social support are, in turn, associated with elevated internalized symptoms (Akerlind & Hörnquist, 1992; Rawls et al., 2021) but also higher rates of treatment attrition and relapse (Mau et al., 2019; Sliedrecht et al., 2019; Zywiak et al., 2003). Hence, developing interventions addressing social impairments in SAUD holds considerable clinical potential, and gaining insights into their underlying mechanisms is an essential first step in this direction (Heilig et al., 2016).

Social cognition research has recently made a substantial contribution in this regard: studies showed that patients with SAUD exhibit impairments in a wide range of socio-cognitive abilities, including emotion recognition, Theory of Mind (Bora & Zorlu, 2017; Le Berre, 2019), attributional biases (i.e., biased causal attributions of social events; Pabst et al., 2020b); and social perception/knowledge (i.e., identifying social contexts, relationships and latent social rules; Pabst, Peyroux, Gautier, de Timary, & Maurage, 2021). Moreover, such impairments have been associated with interpersonal problems and poor SAUD prognosis (Hoffman et al., 2019a; Rupp et al., 2017), supporting their relevance for understanding the above-mentioned difficulties. However, although these high-level abilities are increasingly investigated, more basic aspects of social cognition, such as attentional processing of socio-affective information, remain unexplored in SAUD. Optimal attention allocation is decisive for the extraction and encoding of relevant cues at the early stages of the socio-affective processing stream. Attentional disruptions are thus thought to influence later elaborative processes such as social interpretation and decision-making (Crick & Dodge, 1994). Therefore, investigating this process in SAUD may increase our comprehension of social impairments in this group. In the current study, we specifically focus on socio-affective

attentional biases (SAB), defined as the disproportionate allocation of attention to specific socio-affective information.

SAB, in the form of increased attention to social threat (e.g., angry or disgusted facial expressions) and/or reduced attention to social reward (e.g., happy facial expressions) have been widely evidenced across psychopathological states such as depression (Suslow et al., 2020), anxiety (Bar-Haim et al., 2007; Clauss et al., 2022; but see Kruijt et al., 2019) or eating disorders (Cardi et al., 2013). They are considered as transdiagnostic factors maintaining psychopathology through negative social interactions (e.g., Reinhard et al., 2019). Two lines of findings are particularly relevant to SAUD-related social dysfunction research. First, increased SAB to social threat exacerbate distress following social exclusion (Heeren et al., 2012) and are linked with aggressive tendencies (Manning, 2020). Conversely, increased SAB to social reward may facilitate the regulation of social stress (DeWall et al., 2009; Taylor et al., 2010). Second, SAB lead to biased interpretations of social scenarios (Krejtz et al., 2018; White et al., 2011) and are associated with reduced complex emotion identification (Ribeiro & Fearon, 2010). In other terms, SAB could play a key role in patients with SAUD's elevated vulnerability to social stress (Maurage et al., 2012) and maladaptive interpersonal behaviors (Chermack & Giancola, 1997). Additionally, by leading to the prioritization of certain types of social information (and hence the neglect of other types), SAB may explain impairments observed at more complex social cognition tasks (Pabst et al., 2020a). Therefore, it is warranted to extend the exploration of SAB, up to now undeveloped in addictions, to SAUD.

General support for biased processing of socio-affective information comes from behavioral emotion recognition studies, in which patients with SAUD misperceived neutral or non-threatening negative (e.g., sadness) expressions as threatening (e.g., angry, disgusted; Foisy et al., 2007; Freeman et al., 2018; Frigerio et al., 2002; Maurage et al., 2009; Philippot et al., 1999). In the same vein, compared to healthy controls, patients with SAUD more often interpret negative social events depicted in written scenarios as resulting from other's hostile intentions (Pabst et al., 2020b). Moreover, neuroimaging evidence suggests that patients with SAUD display increased anterior cingulate cortex and insula (involved in salience attribution; Kawamoto et al., 2015) activation to social threat cues (Maurage et al., 2012; Park et al., 2015; Salloum et al., 2007) and an absence of ventromedial prefrontal cortex (involved in reward processing; Martins et al., 2021) activation to happy faces (Salloum et al., 2007). Patients with SAUD may thus have an increased/decreased sensitivity to social threat/reward, respectively, that may lead to biased attention allocation to such stimuli. However, direct empirical evidence for this hypothesis is lacking, as SAB have never been directly investigated in SAUD.

Here, we filled this gap using an adapted dot-probe task (MacLeod et al., 1986) with emotional faces, which is the classical paradigm used to measure SAB. We not only included socially threatening emotional faces (angry, disgusted), as usually done, but also non-socially threatening negative (sad) and positive (happy) ones. Moreover, we used an eye-tracker to record participants' overt attention allocation throughout the task. Eye-tracking based indices of SAB offer critical advantages over classical reaction-time (RT) ones as they (1) constitute a direct measure of attention, (2) can distinguish earlier/automatic (e.g., first fixations) from later/controlled (e.g., total dwell-time) attentional processing, providing valuable information about the cognitive mechanisms involved (Armstrong & Olatunji, 2012; Maurage et al., 2019), and (3) present improved psychometric properties (Bollen et al., 2021; Christiansen

et al., 2015a; Skinner et al., 2018). This methodology therefore allows us to determine if and for which socio-affective material (positive, negative, socially threatening) patients with SAUD present SAB, and to determine whether these SAB reflect rather automatic or controlled processes.

On the basis of the available behavioral literature linking SAUD and biased processing of social threat, we hypothesized that patients with SAUD would present SAB toward social threat (i.e., angry and disgusted faces). No further a priori hypotheses were pre-specified due to lack of empirical evidence in SAUD. However, the possibility that patients with SAUD would present reduced SAB to social reward, namely positive emotional faces (Pabst et al., 2020a) was also considered.

2. Methods

2.1 Pre-registration

The present study's hypotheses, design, sample size rationale and analysis plan were pre-registered on the Open Science Framework: https://osf.io/jds84. Exceptional departures from the original plan are described and justified in the corresponding sections.

2.2 Participants

Thirty patients with a DSM-5 (American Psychiatric Association, 2013) diagnosis of SAUD (i.e., at least 6 symptoms), established with the Mini International Neuropsychiatric Interview (Sheehan et al., 1998), who were in the third week of their detoxification stay at specialized Belgian inpatient units (Saint-Luc and Beau-Vallon hospitals), and 30 age-, gender- and education-matched healthy controls (HC) took part in the study. A trained psychiatrist interviewed patients with SAUD prior to hospital admission to ensure the absence of physical or psychiatric conditions that could interfere with successful detoxification or necessitate prior treatment. At testing time, all patients had abstained from alcohol for at least 14 days and were free of current psychiatric comorbidities, except for nicotine use disorder. They never received a psychiatric diagnosis besides depression, anxiety, or nicotine use disorders. HC were recruited via social media, University participant pools and study flyers. They were free of lifetime psychiatric disorders, except for nicotine use disorder. They reported drinking less than 10 units (1unit=10g of ethanol) per week and less than 3 units per day, had an Alcohol Use Disorder Identification Test (AUDIT; Babor et al., 2001) score lower than 8, and reported no first degree family history of SAUD. They were asked to abstain from alcohol during the 72 hours preceding testing and were financially compensated for their participation. Exclusion criteria for both groups included polysubstance use disorders and/or neurological disorders. All participants had normal or corrected-to-normal vision and were fluent in French. The study was presented to the participants as an experiment exploring the association between alcohol consumption and information processing.

2.3 Task & Stimuli

We used an adaptation of the dot-probe task (MacLeod et al., 1986) to assess participants' attentional biases. Stimuli consisted of colored face photographs of 16 middle-aged actors (aged 39-55, 8 females), extracted from the validated FACES database (Ebner et al., 2010). Each actor displayed full-blown facial expressions of sadness, anger, disgust, happiness and neutrality (80 stimuli in total). We selected actors with the highest mean accuracy scores, as provided in the database, for the included emotions. The actors' age-class was chosen to match our sample demographic because evidence suggests superior recognition of own-age faces (Rhodes & Anastasi, 2012). Each trial started with a drift correction phase through a central fixation cross that remained on screen until a 1000ms fixation was registered. Afterwards, a neutral-emotional pair of photographs from the same actor appeared on the screen, one on the left, the other on the right, for 2000ms (Christiansen et al., 2015). Participants were told that they could freely explore the photographs. The photographs were rectangles of 7 (height) x 5.6 (length)cm. They were centered along the x-axis and separated by 5.4cm. Both pictures then disappeared and an arrow randomly pointing upwards or downwards appeared at the location previously occupied by the emotional (congruent trials) or neutral (incongruent trials) photograph. Participants had to indicate the direction of the arrow as fast as possible by pressing the upward/downward key on the computer keyboard. There were 256 trials [16 (actors) x 4 (emotions) x 2 (photograph location) x 2 (congruence)] in total, divided in 4 blocks of 64 trials to minimize fatigue and allow for breaks. Actors and emotional expressions were equally often represented in each block. The locations of the neutral and emotional expressions, the location of the subsequent arrow, and congruency for each emotion were counterbalanced within blocks.

2.4 Setting, Apparatus & Software

Participants sat in a quiet, dimly lit room on an adjustable chair. Stimuli were presented on a 17.3-inch FHD Asus laptop screen (resolution 1080x1920p; 120Hz refresh rate). The eye-screen distance was approximatively 57cm. The OpenSesame (Mathôt et al., 2012) software controlled stimulus presentation and synchronization with the eye-tracker. Eye-movements were recorded with the EyeLink Portable Duo remote-mode device (SR Research, Canada; sampling rate 1000 Hz; average accuracy range 0.25°-0.5°, gaze tracking range of 32° horizontally, 25° vertically) and gaze events were parsed into saccades and fixations using the EyeLink DataViewer software.

2.5 Procedure

Participants first provided written informed consent. They then answered sociodemographic and alcohol-consumption-related questions (see Table 6) and completed the state form of the State-Trait Anxiety Inventory (STAI; Spielberger & Gorsuch, 1983). They then performed the dot-probe task, lasting about 40min and including a short practice session with different photographs from those used in the experimental blocks. The order of blocks was randomized across participants and each block was preceded by a standard 9-point calibration. At the end of the task, participants completed the trait form of the STAI, as well the Beck Depression Inventory-Short Form (BDI; Beck & Steer, 1987), the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987) and the 64-item Inventory of Interpersonal Problems (IIP;

Horowitz et al., 2003). Finally, participants had to guess the hypotheses of the study, which none could successfully do, and were fully debriefed about its specific objectives and methodology. The study protocol complied with the Declaration of Helsinki and was approved by the local ethical board of the faculty of medicine of the UCLouvain.

2.6 Analysis

2.6.1 Power analysis

An estimated effect size of d=0.78 for a between-group difference in attentional bias was computed by averaging sample size-weighted effect sizes from previous studies either comparing attentional biases of various psychiatric populations to HC (Bantin et al., 2016; Deroost & Cserjési, 2018; García-Blanco et al., 2017; Hommer et al., 2014; Leyman et al., 2007) or reporting abnormal processing of social threat in patients with SAUD (Freeman et al., 2018; Maurage et al., 2009b, 2012). The power analysis revealed that a sample of 27 participants per group was necessary to detect such a between-group effect with a power of 0.80 and an alpha of 0.05. Given the novelty of our investigation in SAUD and to counter unforeseeable data loss, we chose to increase this sample size to 30 participants per group. This sample size was further sufficient to detect medium (f=0.22) within-between subjects interactions, which were targeted by our planned group x emotion ANOVAs.

2.6.2 Pre-processing

For behavioral data analyses, we excluded trials with reaction times (RT) lower than 200ms (no trial) or higher than 2000ms (21 trials, 0.14% of trials), as well as remaining trials below or above 3.5 deviations from each participant's means (122 trials, 0.79% of trials). Moreover, although not mentioned in the pre-registration, we removed the remaining trials with incorrect responses (116 trials, 0.76% of trials) since they indicate lapses in attention and are therefore routinely excluded from dot-probe studies (e.g., Price et al., 2015). For eye-tracking analyses, we additionally excluded data from 3 patients with SAUD and 1 HC who were considered "starers" i.e., participants not producing a single fixation to either photograph on more than 50% of trials (van Ens et al., 2019). Sample characteristics of non-starers are displayed in Table 6. Fixations were defined according to the Eyelink DataViewer's default settings. Fixations separated by less than 1° of visual angle were merged and those lasting less than 100ms were deleted (Manor & Gordon, 2003). Only fixations occurring during picture presentation were analyzed. Fixations starting before picture onset were discarded as they were not related to our stimuli of interest.

2.6.3 Attentional bias indices

Based on RT, we calculated a difference score by subtracting mean RTs for congruent trials from mean RTs for incongruent trials. Positive and negative scores reflect an attentional bias toward and away from the emotional face, respectively (MacLeod et al., 1986; Mogg et al., 2004).

We computed four commonly investigated eye-tracking indices (Waechter et al., 2014). To measure early/automatic attentional biases, we computed (1) the mean percentage of trials on

which the first fixation occurred on the emotional face relative to trials on which it occurred on either face (first fixations could also occur outside of the areas of interest), with scores above and below 50% respectively indexing a bias toward and away from the emotional face (first fixation direction), and (2) the difference between the mean latency to first fixation when first fixations occurred on the emotional face and the mean latency to first fixation when it occurred on the neutral face, with lower latencies to emotional faces (positive scores) indicating biases toward the emotional face and vice versa (first fixation latency). To measure late/controlled attentional biases, we computed (3) the mean percentage of dwell-time (i.e., sum of fixation durations) on the emotional face relative to the sum of dwell-time on both faces (dwell-time), and (4) the mean percentage of fixations occurring on the emotional face relative to the sum of fixations occurring on both faces (number of fixations), with scores above and below 50% respectively indicating an attentional bias toward and away from the emotional face. We did not compute indices of raw differences in dwell-time or number of fixations between emotional and neutral expressions because preliminary analyses showed that patients with SAUD emitted fewer fixations to and dwelled less on face pairs than HC ($ps < 0.002$). Reliability estimates for each attentional bias index are provided as Appendix 6.

2.6.4 Main analyses

We performed all analyses with R (R Core Team, 2019). RT and eye-tracking-based indices were submitted to 2 (groups, between) x 4 (emotions, within) x 4 (blocks, within) repeated-measures ANOVAs. The inclusion of the block factor constitutes a deviation from our pre-registration and was decided since the same actors were presented across blocks and reports indicate that stimulus repetition affects eye-movements and attentional biases (Amir et al., 2009; Kaspar & König, 2011; Liu et al., 2006). Greenhouse-Geisser corrections for departures from sphericity were used where appropriate. Follow-up tests were Bonferroni corrected in line with calls for conservativeness when reporting relatively new findings (Benjamin et al., 2018).

2.6.5 Exploratory analyses

We explored the associations between attentional bias indices for which a significant group difference emerged and psychopathological symptoms, alcohol consumption variables (number of previous detoxifications, age of SAUD onset, number of units consumed per day prior to detoxification, AUDIT score) and interpersonal problems using bivariate Pearson correlations within each group.

Table 6. Sociodemographic, alcohol consumption, psychopathology and interpersonal problems variables in "non-staring" patients with SAUD and HC [Mean (SD)]

Non-starers	SAUD (N=27)	HC (N=29)
Age	48.22 (10.83)	47.72 (10.83)
Gender, N(%) of females	13 (48.15%)	14 (48.28%)
Education	**13.93 (3.19)**	**15.48 (2.60)**
Number of previous detoxifications	1.63 (3.04)	/
Age of SAUD onset	37.15 (10.86)	/
Number of alcohol units per day	16.63 (6.77)	/
AUDIT score	**31.78 (6.56)**	**2.86 (1.96)**
BDI	**8.46 (5.88)**	**2.31 (3.54)**
STAI-State	**34.83 (10.66)**	**28.69 (8.40)**
STAI-Trait	**50.00 (9.14)**	**35.31 (10.61)**
LSAS	**50.81 (26.25)**	**31.86 (24.28)**
Total	**93.71 (36.49)**	**55.72 (37.06)**
Domineering	**8.56 (5.30)**	**4.28 (3.68)**
Self-centered	**9.37 (4.94)**	**4.03 (3.67)**
Cold/distant	**9.04 (6.24)**	**4.34 (5.36)**
Socially inhibited	**11.75 (6.32)**	**7.10 (7.47)**
Non-assertive	**13.72 (8.07)**	**8.59 (7.96)**
Overly accommodating	**14.76 (7.43)**	**10.69 (6.19)**
Self-sacrificing	**14.96 (6.55)**	**10.82 (6.98)**
Intrusive/needy	**11.52 (5.20)**	**5.76 (4.92)**

[1]BDI = Beck Depression Inventory (Beck and Steer, 1987).
[2]STAI = State (A) and Trait (B) Anxiety Inventory (Spielberger et al., 1983)
[3]LSAS = Liebowitz Social Anxiety Scale (Liebowitz, 1987)
Note = Bold lines indicate a significant difference between groups.

3. Results

3.1 Sociodemographics, alcohol consumption, psychopathological symptoms, and interpersonal problems.

The characteristics of the "non-starers" samples are displayed in Table 6. Among non-starers, groups did not statistically differ on age or gender but patients with SAUD had less successfully completed education years. Exploratory analyses therefore also encompassed correlations between attentional bias indices and education. Patients with SAUD also reported higher state anxiety (STAI-state), trait anxiety (STAI-trait), social anxiety (LSAS)

depression symptoms, AUDIT scores, and interpersonal problems, as indicated by the total score and every subscale of the IIP.

3.2 Main analyses

There were no significant group, emotion, block or interaction effects on RT-based difference scores (all *p*s>0.13), first fixation directions (all *p*s>0.11) or first fixation latencies (all *p*s>0.11).

Regarding dwell-time, there was a significant main effect of emotion (F(1.48, 80.04)=4.50, p=0.02, η^2_p=0.08) and, more relevant to the study's aims, there was a significant group x emotion x block interaction (F(6.90, 372.74)=2.05, p=0.049, n^2_p=0.04). All other main or interaction effects were nonsignificant (all *p*s>0.11). The three-way interaction was decomposed using 4 separate Bonferroni-corrected group x emotion ANOVAs, one at each level of block. The group x emotion interaction was significant in Block 1 only (F(2.07, 111.58)=6.01, p_{BC} =0.01, η^2_p =0.10). To determine for which emotion there was a group difference in Block 1, 4 Bonferroni-corrected follow-up between-group t-tests were conducted, revealing that groups differed for happiness only (t(54)=2.83, p_{BC} =0.026, d=0.76), with patients with SAUD dwelling relatively less on happy vs neutral expression than HC (see Figure 9A for results in the first block of stimuli, and Appendix 7 for results in each block).

Regarding the number of fixations, there was again a main effect of emotion (F(1.71, 92.426)=3.11, p=0.057, η^2_p =0.05), as well as a group x emotion x block interaction (F(6.70, 361.870)=1.99, p=0.058, η^2_p =0.04), both falling just below the significance threshold (all other *p*s>0.13), see Figure 9B and Appendix 8. Bonferroni-corrected follow-up group x emotion ANOVAs at each block level revealed that the group x emotion interaction was significant in block 1 only (F(2.361, 127.5)=4.67, p_{BC} =0.03, η^2_p =0.08). Bonferroni-corrected follow-up between-group t-tests revealed that groups differed for happiness only (t(54)=2.76, p_{BC} =0.032, d=0.74), with patients with SAUD fixating relatively less often on happy vs neutral expressions than HC.

Within-group one-sample t-tests were performed to further qualify the results and determine whether percentages of dwell-time and number of fixations on happy vs neutral expressions in the first block differed from 50%. HC fixated proportionally longer (t(28)=3.28, p=0.002) and more often (t(28)=3.38, p=0.002) on happy vs neutral expressions. In patients with SAUD, neither the percentage of dwell time (t(26)=-0.66, p=0.51) nor the percentage of number of fixations (t(26)=-0.70, p=0.49) on happy vs neutral faces significantly differed from 50%.

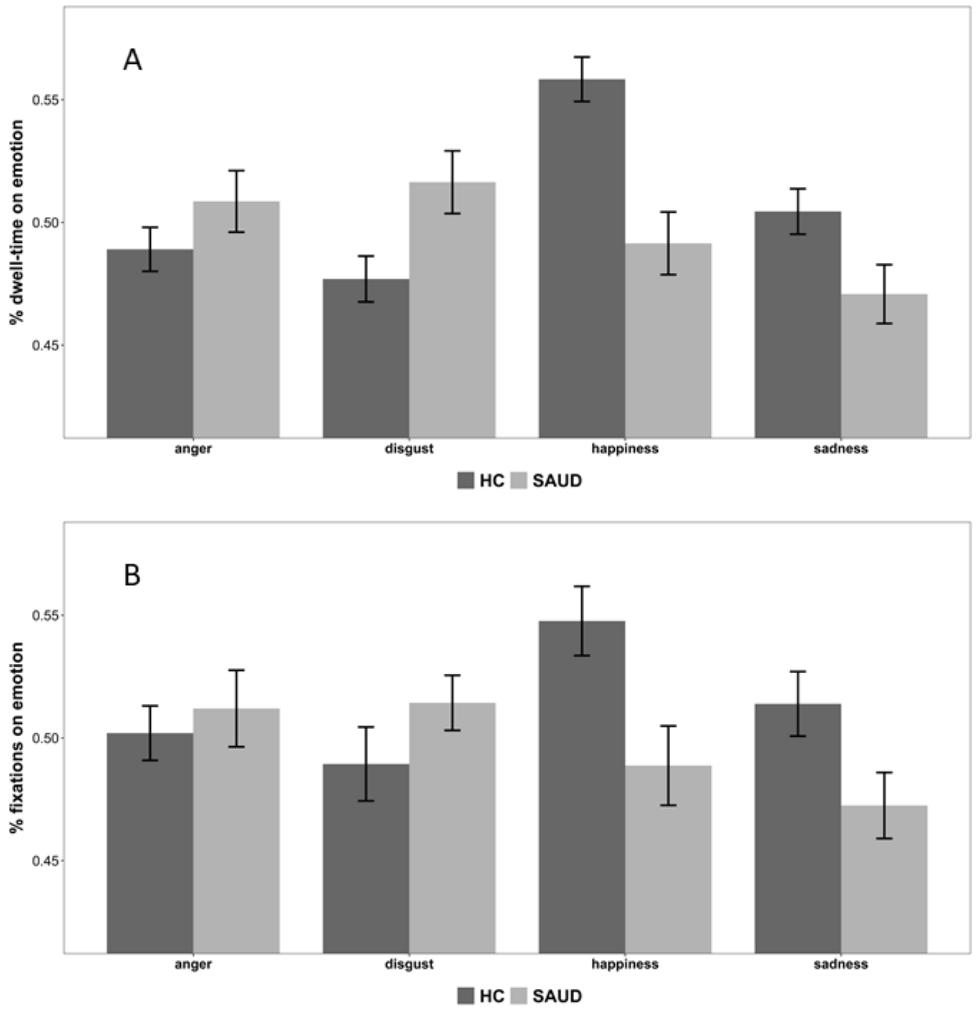

Figure 9. *Percentages of dwell time and total fixations on the emotional vs neutral expression according to group and emotion in the first block of stimuli.*

3.3 Exploratory analyses

In light of the main results, the only attentional bias indices considered were the percentages of dwell-time and number of fixations on the happy vs neutral face in block 1. As shown in Appendix 9, within the SAUD group, age of SAUD onset was significantly and positively associated with percentages of dwell-time ($r(25)=0.41$, $p=0.03$) and number of fixations ($r(25)=0.40$, $p=0.04$) on the happy vs neutral face, such that patients with an earlier onset of SAUD fixated proportionally less often and for a shorter duration on the happy vs neutral expressions. No other correlation reached significance in either group and we therefore did

not test for the confounding effect of psychopathological symptoms on our main results (Pabst et al., 2020b).

4. Discussion

We tested for the first time the presence of SAB, largely observed in other psychopathological states, in SAUD, through a pre-registered eye-tracking-improved dot-probe task. Contrary to our hypothesis of SAB to social threat, patients with SAUD did not significantly differ from HC in their attention towards angry or disgusted vs. neutral faces. This was also true for sad faces. However, patients with SAUD fixated less often and dwelled less on happy relative to neutral faces compared to HC in the first block.

The absence of a group difference in SAB to socially threatening expressions stands in apparent contrast with previous studies suggesting biased social threat processing during emotion recognition (Foisy et al., 2007b; Freeman et al., 2018; Frigerio et al., 2002; Maurage et al., 2009b; Philippot et al., 1999b) or attribution (Pabst et al., 2020b) in SAUD. Importantly, performance on these tasks, which are more explicit in nature, also likely depends on more elaborative processes such as memory and interpretation (Barry et al., 2019; Crick & Dodge, 1994; Quaglino et al., 2015). Therefore, if our finding reflects a true absence of SAB to social threat in SAUD, it still provides valuable mechanistic insights indicating that patients' documented social cognitive biases are better explained by disruptions at later processing stages than by disproportionate attention allocation to social threat. A second possibility is that SAB to social threat in SAUD exist, but manifest in opposing ways. Recent evidence in highly anxious individuals shows that SAB can take the form of disproportionate SAB toward, but also away from social threat, depending on individuals' level of cognitive control (Bardeen et al., 2020; Clauss et al., 2022; Taylor et al., 2016). Hence, given that patients with SAUD constitute a heterogeneous group with regard to cognitive control (Alarcon et al., 2015; Schmid et al., 2021a), individual differences in SAB expression may potentially have obscured the present effect. Importantly, a third possibility is that the absence of a significant SAB to social threat in this study results from insufficient statistical power. Indeed, we based our sample size estimation on previous studies reporting medium-to-large SAB effects, which may be smaller in SAUD. Therefore, we caution against definitive conclusions that SAUD is not associated with SAB toward social threat before lager studies provide corroborating evidence.

Although groups did not significantly differ on SAB to social threat, we found moderate-to-large differences in SAB to happy facial expressions. Specifically, whereas HC fixated more often and for longer durations on happy vs. neutral expressions (e.g., Isaac et al., 2014; Kelberer et al., 2018), patients with SAUD did not present such preferential processing of positive information. Such evidence of modified attention to happy faces complement previous emotion recognition studies (e.g., D'Hondt et al., 2015; Maurage et al., 2011) in challenging the view that the processing of positive socio-affective information is unaltered in SAUD (Bora & Zorlu, 2017). These differences were only observed for number of fixations and dwell-time-based indices, suggesting that they were not driven by differential automatic attentional capture but rather reflect relatively controlled processes (Armstrong & Olatunji, 2012; Maurage et al., 2019). A selective effect in the first block of stimuli further indicates that patients with SAUD and HC crucially differ in the processing of relatively novel positive social cues. This is consistent with previous studies (Amir et al., 2009; Liu et

al., 2006) showing decreased SAB over blocks, and may reflect habituation due to the repeated exposure to identical stimuli.

This absence of SAB to happy faces in SAUD may be understood in light of reward models of addiction positing increased valuation of substance-related cues and concomitant devaluation of alternative, and notably social, rewards in addicted individuals (Volkow et al., 2011). Indeed, happy faces are considered to be inherently rewarding (Tamir & Hughes, 2018) and basic studies in healthy participants demonstrate that reward, and particularly social reward, is a crucial factor in preferential attention allocation (Anderson, 2016; Hayward et al., 2018). Hence, echoing neuroimaging findings of inactivity in reward-processing brain regions in response to happy faces (Salloum et al., 2007), and evidence in cocaine dependence (Preller et al., 2014), the present results carry crucial theoretical implications by offering original behavioral evidence of blunted social reward processing in SAUD. It is worth noting that, although reduced SAB to social reward have also been reported in other emotional disorders (e.g., Suslow et al., 2020), we found no significant correlation between proportion of fixation frequency or duration on happy vs. neutral faces and depression, anxiety or social anxiety symptoms in either sample. This lowers the probability that co-occurring psychopathology symptoms in the SAUD group drove the current results. Nevertheless, the lack of SAB to social reward warrants consideration as a potential mechanism underlying the frequent comorbidity between SAUD and emotional disorders (Grant et al., 2015).

Beyond etiological considerations, the absence of SAB to social reward has implications for understanding, and potentially addressing social difficulties in SAUD. Such positivity biases in healthy participants are thought to serve an adaptive purpose by fostering distorted but self-serving representations of their environment (Alloy et al., 1990; Alloy & Abramson, 1979; Armstrong & Olatunji, 2012). Among people lacking such biases, socially negative information may not be optimally outweighed (Bronfman et al., 2018), increasing negative (or less than positive) social interpretations and memories. Hence, the absence of SAB to social reward may affect performance during social cognition tasks, particularly those requiring the integration of both negative and positive information, in SAUD (Pabst et al., 2020a). Reduced attention to happy faces could further directly lead to missed opportunities for social network extension (Martin et al., 2017). Finally, given the purported importance of prioritized processing of acceptance signals in the regulation of social stress (DeWall et al., 2009), the absence of SAB to happy faces may leave patients with SAUD more vulnerable to longer and more intense distress following exclusion. In summary, the lack of SAB to positive social cues may be both a marker of, and an active process maintaining, reduced sensitivity to social reward in SAUD. Indeed, by diminishing positive interpretations of social situations and favoring mostly negative interpersonal interactions, they could prevent patients from experiencing pleasurable and rewarding social relationships.

Finally, our correlational analyses revealed a significant positive association between SAB to happy faces and age of SAUD onset, with those attending less to the happy vs. neutral faces reporting an earlier onset. Interestingly, no association emerged between SAB to happy faces and indices of SAUD severity (AUDIT score, number of drinks per day), and complementary analyses showed no association with disorder duration (age at testing – age at SAUD onset). Although caution must prevail when interpreting such an exploratory finding, it may indicate that reduced SAB to social reward partly precedes the disorder and may confer greater risk for early SAUD onset (Blum et al., 1996; Joyner et al., 2019).

This study comprises limitations. First, as previously mentioned, it was powered to detect medium-to-large effects, subtler ones, notably related to SAB toward socially threatening stimuli, may have been missed. It should further be noted that, in line with previous research (e.g., Bollen et al., 2021; Waechter et al., 2014), eye-tracking-based indices of early/ automatic SAB (first fixation proportions and latencies) had very low reliability, which may explain our null-findings for these variables and prompt the need for further studies to draw valid conclusions regarding differential SAUD effects on early vs. late attention to socio-affective cues. Eye-tracking based indices of later SAB (dwell-time and total fixation proportions) had good reliability when computed across blocks in both groups, but often had lower-than-conventional-thresholds reliability when computed block-wise in patients with SAUD (although reliability was generally improved compared to behavioral indices). This may have further decreased our power to detect certain effects and calls for replication of our central results using improved paradigms. Finally, the cross-sectional nature of the design precludes firm conclusions regarding the temporal relationship between SAB and SAUD, pointing to the need for longitudinal studies.

In conclusion, we showed that patients with SAUD do not present a specific SAB towards social threat, but lack the attentional bias toward happy faces found among healthy participants, extending, for the first time, the mounting literature on abnormal socio-affective processing in SAUD to the attentional domain. These SAB may affect higher order social cognition and interpersonal functioning more directly. Hence, the current findings increase our understanding of the mechanisms involved in SAUD-related social problems and point to a potentially relevant treatment target.

Chapter 9

Social episodic memory in severe alcohol use disorder: Positive bias at encoding and negative bias in the accessibility of of interpersonal information

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This chapter is adapted from:

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1. Introduction

Numerous studies have documented alterations in high-level social cognition abilities (i.e., emotion recognition, Theory of Mind, attributional biases, social perception and knowledge) in patients with severe alcohol use disorder (SAUD; Bora & Zorlu, 2017; Hoffman et al., 2019; Pabst et al., 2020b, 2021; Rupp et al., 2017), as well as their interpersonal/ clinical correlates. Social cognition is thus consensually considered a priority treatment target in this population (Verdejo-Garcia et al., 2023). Unfortunately, the current dearth of research investigating basic underlying mechanisms compromises conceptual progress and the development of precise and efficient interventions.

Social memory processes represent relevant candidate mechanisms to explain these deficits. Indeed, a growing and diverse body of fundamental evidence implicates memory in social cognition and behaviour. For instance, affect sharing, mental state inference, and prosocial behaviour can be increased by asking participants to retrieve specific social memories or to imagine future social events (a process heavily reliant on memory retrieval; Gaesser et al., 2018; Gaesser & Schacter, 2014; van Genugten, 2022; Vollberg et al., 2021). Remembering aspects of past interaction partners relates to more adaptive social judgments and decisions upon reencounter (Kadwe et al., 2022; Murty et al., 2016; Sklenar et al., 2021, 2022). In addition, episodic memory and social cognition tasks elicit activations in overlapping regions of the default mode network (Rabin et al., 2010; Spreng & Grady, 2010; but see DiNicola et al., 2020). This literature substantiates proposals that individuals partly leverage the memory of past social experiences and knowledge to interpret novel interpersonal input and reach social decisions (Crick & Dodge, 1994; Gaesser, 2020; Spreng & Mar, 2012). Accordingly, social memory disruptions or biases may negatively affect social cognition (Pabst et al., 2020a), in line with transdiagnostic observations that psychiatric groups featuring marked impairments in social skills (e.g., individuals with borderline personality disorder, depression, schizophrenia, or autism) also show alterations in various aspects of memory for

socio-affective information (Harvey & Lepage, 2014; Lee et al., 2018; Macinska & Jellema, 2022; Niedtfeld et al., 2020; Ridout et al., 2009).

SAUD is linked with memory impairments, particularly for its episodic component (Le Berre et al., 2017; Stavro et al., 2013), and studies highlight associations between episodic, but not semantic, memory and emotion recognition and Theory of Mind in SAUD (Nandrino et al., 2014; Quaglino et al., 2015). This is again consistent with a functional link, with past interpersonal experiences being particularly relevant to current social cognitive abilities in this group. In spite of this, episodic memory research in SAUD has mainly focused on non-social material. Therefore, it remains unclear whether the well-established episodic memory alterations in SAUD generalize to social stimuli, of which the encoding and retrieval may recruit partially different processes (Harvey et al., 2007; Meyer et al., 2019). Beyond investigating general social episodic memory abilities, it is also important to determine if patients with SAUD show particular memory difficulties, or conversely, biases for, certain socio-affective categories. Indeed, SAUD is frequently associated with hostility biases. Patients misperceive neutral or sad facial expressions as displaying anger, contempt or disgust (Freeman et al., 2018) and attribute hostile intentions to others in ambiguous situations (Pabst et al., 2020b). Disproportionate memory for threatening, or a reduced preference for positive, social information may be involved in such biases (Barry et al., 2019).

To fill these gaps, we assessed two important and complementary aspects of social episodic memory in patients with SAUD to obtain fine-grained mechanistic insights. We first examined the encoding (and initial retrieval) of *novel* socio-affective stimuli. We did so using an updated Social Remember/Know/Guess Task (D'Argembeau et al., 2003; Jermann et al., 2008). Briefly, participants viewed clips of dynamic negative (angry) and positive (happy) facial expressions. Afterwards, they were presented with pictures of the same individuals presenting neutral expressions, along with foils, and had to indicate if they had previously seen the face and if so, what its emotional expression was. They also specified whether they had a specific recollection of the faces and expressions or a general sense of familiarity, indexing encoding depth. One previous study assessed episodic memory for facial expressions in SAUD using a similar paradigm (Oscar-Berman et al., 1990) and did not find SAUD effects. However, this study employed a restricted set of black and white static photographs that may lack ecological validity, did not investigate valence effects, and comprised small samples, underlining the need to replicate and extend these preliminary findings. Second, we investigated the accessibility of or fluency for already existing interpersonal memories, as well as their level of specificity, using an adaptation of the Good Day Bad Day Task (Hitchcock et al., 2019), the Social Memory Accessibility Task. Participants had to separately retrieve as many specific memories of positive and negative interpersonal events as possible within equal time limits. They later described each memory so that they could be coded for specificity. We preferred this task over those timing participants' retrieval of memories related to individual cues (e.g., Joormann and Siemer, 2004), as we were interested in the accessibility of broad categories of interpersonal memories. As a whole, we tested whether patients with SAUD differ from controls in 1) the amount and/ or valence of new socio-affective information that they initially store into memory 2) the ease with which they can bring to mind previously experienced interpersonal events of different valences. Both processes are relevant to social cognition because they might influence the interpersonal memory content that is generally available, and the content most likely to be selected, when interpreting current social interactions.

Based on previous work showing generally impaired cognitive functioning (Stavro et al., 2013), and reduced non-social episodic encoding and retrieval, as well as reduced specificity in SAUD (D'Argembeau et al., 2006; Nandrino et al., 2014, 2016; Noël et al., 2012; Pitel et al., 2007a; Poncin et al., 2015; Whiteley et al., 2009), we expected patients to exhibit generally lower performance than controls on both tasks (i.e., lower recognition of faces and emotions, and fewer and less specific interpersonal memories retrieved across valences). In addition, and centrally, we hypothesized that whereas controls would show marked positivity biases on both tasks, in line with previous findings (D'Argembeau et al., 2003; D'Argembeau & Van der Linden, 2011; Hitchcock et al., 2019; Ridout et al., 2003), patients would lack this bias or even show a negativity bias (Pabst et al., 2020a). This rests on recent evidence that SAUD is linked with a lack of bias toward positive social stimuli in the attentional domain (Pabst et al., 2023b), as well as with an increased spontaneous recall of negative memories (Cuervo-Lombard et al., 2016; Nandrino & Gandolphe, 2017).

2. Method

2.1 Transparency and openness

We preregistered our hypotheses, design, sample size rationale and analytic plan for the Social Remember/Know/Guess Task on the Open Science Framework: https://osf.io/r7cd5. We did not preregister the use of the Social Memory Accessibility Task but our hypotheses and analyses closely aligned with those of the Social Remember/Know/Guess Task. We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study. All procedures complied with the Declaration of Helsinki and were approved by the biomedical ethical committees of UCLouvain. The data and code underlying this article can be found at https://osf.io/3chxt.

2.2 Participants

We recruited 40 patients with a DSM-5 diagnosis of SAUD (≥ 6 criteria) from specialized detoxification centres in Belgium as well as 40 age, gender, and education-matched healthy control (HC) participants. We determined this sample size following a power analysis conducted on G-power, which revealed that 34 participants per group were necessary to detect small-to-medium (f=0.175) 2x2 mixed-design interaction effects (corresponding to our central effects of interest) with a power of 0.80, setting significance at 0.05. We increased this number to 40 to maximize power for our other analyses. Patients had all abstained from alcohol for a minimum of eight days and a maximum of three months at testing time. All patients reported SAUD as their primary problem and had no lifetime diagnosis of psychiatric or neurological disorder besides depression, anxiety, and nicotine use disorder. HC were recruited using social media advertisements, study flyers, and University participant-pools. HCs and their first-degree relatives (parents and siblings) reported no history of alcohol use disorder and HC were free of lifetime psychiatric or neurological disorders besides nicotine use disorder. They had an Alcohol Use Disorder Identification Test (AUDIT; Babor et al., 2001) score below eight, indicating low-risk consumption, and reported drinking less than 10 alcohol units (1 unit = 10g of ethanol) per week and no more than three units per day. All participants provided informed written consent.

Table 7. Socio-demographic, psychopathological, interpersonal problems, and alcohol consumption measures in patients with severe alcohol use disorder (SAUD) and healthy controls (HC): Mean (SD).

	SAUD	HC
Gender (M/F)	20/20	20/20
Age	49.90 (10.14)	47.75 (10.75)
Education level (in years)	14.45 (2.30)	14.125 (2.43)
BDI	**10.99 (5.81)**	**2.98 (3.68)**
STAI-State	**33.30 (9.58)**	**28.15 (7.33)**
STAI-Trait	**53.75 (8.70)**	**37.50 (9.26)**
LSAS	**54.87 (28.95)**	**35.27 (24.78)**
Total IIP	**99.15 (32.77)**	**56.70 (29.01)**
Domineering	**7.31 (3.04)**	**4.65 (3.13)**
Self-centered	**8.74 (5.25)**	**5.05 (3.83)**
Cold/Distant	**10.64 (7.36)**	**5.10 (4.22)**
Socially Inhibited	**12.69 (9.80)**	**6.30 (6.24)**
Nonassertive	**15.05 (8.67)**	**9.18 (6.66)**
Overly accomodating	**15.69 (7.10)**	**10.10 (5.49)**
Self sacrificing	**18.69 (6.29)**	**10.85 (6.04)**
Intrusive	**13.00 (7.37)**	**5.33 (3.75)**
AUDIT	**30.00 (5.55)**	**3.00 (2.36)**
Number of abstinence days	27.46 (21.80)	
Number of previous detoxifications	1.60 (2.16)	
Duration of SAUD (in years)	11.53 (9.90)	
Number of alcohol units per day[3]	17.64 (10.39)	

[1] Beck Depression Inventory (Beck & Steer, 1987).
[2] State/Trait Anxiety Inventory (Spielberger & Gorsuch, 1983).
[3] Before detoxification (an alcohol unit corresponds to 10 gr of ethanol).
[4] Inventory of Interpersonal Problems (Horowitz et al., 2003)
Note = Bold lines indicate a significant difference between groups.

2.3 Social Remember/Know/Guess Task

2.3.1 Stimuli

For the study phase, we selected 64 three-second morphed video clips of individual faces transitioning from a neutral to an emotional expression (32 actors, 16 women, each expressing both happiness and anger) from the validated FACES database (Holland et al., 2019). To control for potential actor effects on memory, we formed two sets (A & B). Both contained 32 clips of different actors, with half (8 women) expressing happiness and the other half expressing anger, but the actors expressing anger in set A expressed happiness in set B and vice-versa. Happy and angry expressions did not differ between sets in terms of intensity (happy : p=0.18, angry : p=0.87), naturalness (happy : p=0.62, angry : p=0.72) and

recognition accuracy (happy : p=0.80, angry : p=0.90), as per the ratings provided in the validation study (Holland et al., 2019). For the test phase, we used video clips from the 32 actors presented in the study phase, albeit with a neutral expression, as well as 16 additional neutral video clips from previously unseen actors (8 women), which served as distractors.

2.3.2 Procedure

During learning phase, participants viewed all video clips from set A or B (counterbalanced across participants) once in a random order. We asked them to imagine that the actors' emotional expressions were directed toward hem. To make sure participants properly processed the stimuli and their valence, and to rule out the possibility that any memory effects would be due to differences in initial evaluation, we instructed participants to carefully attend to each actor and to rate, as accurately as possible, the interpersonal signal expressed on a 10-point Likert scale (from 0 "extremely hostile" to 9 "extremely friendly"). This was preferred over explicit emotional judgments (i.e., identifying anger or happiness) to minimize the potential impact of emotional decoding impairments on encoding performance (e.g., Maurage et al., 2021, see Harvey et al., 2009, for a similar reasoning). A pilot study using all selected video clips, along with sad ones from the same database, conducted in 24 healthy individuals who did not take part in the final experiment, ensured that 1) angry clips were rated as more hostile than neutral (p<0.001) and sad (p<0.001) ones, 2) happy clips were rated as more friendly than neutral ones (p<0.001), and 3) there were no between-set differences in ratings of angry (p=0.57) or happy (p=0.75) clips.

Immediately after the learning phase, participants underwent an unexpected memory test in which they viewed the neutral video clips of all the actors from the study phase and from 16 distractors. For each clip, they indicated whether they had previously seen ("YES"/"NO") the actor (identity recognition). For "YES" responses, we asked participants to specify whether they *Remember* (i.e., the clip brings back a conscious recollection of the actor's appearance or of an associated thought or feeling; R), *Know* (i.e., the clip elicits a feeling of familiarity without triggering a specific memory; K), or *Guess* (G) having seen the actor. Finally, they were asked whether the actor's expression was hostile or friendly (expression recall) during the study phase, and also reported the associated state of awareness (R/K/G). Throughout both phases, participants sat in a quiet room approximately 50cm (eye distance) away from a 15.6-inch Dell Latitude E5530 laptop screen equipped with a mouse. We collected all responses via mouse clicks.

2.4 Social Memory Accessibility Task

A subsample of 29 patients with SAUD and 30 HC (whose characteristics were comparable to those of the general sample, see Appendix 10) agreed to also complete this adaptation of Hitchcock et al.'s Good Day Bad Day Task (2019). We asked participants to retrieve as many specific autobiographical memories of positive and negative social interactions from their recent or distant past as possible during two periods of three minutes, and to write down a single keyword per memory. The order (negative, positive) was counterbalanced across participants. The keywords had to be evocative of these memories and allow for later description. After the three minutes, participants described the events associated with each keyword without time limits. We provided detailed instructions defining specific

autobiographical memories as events in which they were personally involved, that happened at a particular time and place, and that lasted less than a day. Positive/ negative interpersonal memories were defined as memories in which one or more person(s) did or said something to participants that made them view the interaction as positive/ negative. To ensure their understanding of both concepts, participants underwent a non-social training session with feedback in which they had to retrieve as many specific memories related to nature as possible, and were provided with three examples of both positive and negative interaction memories.

2.5 Additional measures

We assessed depression, state and trait anxiety, and social anxiety symptoms using the short form of the Beck Depression Inventory (BDI; Beck & Steer, 1987), the State-Trait Anxiety Inventory (STAI; (Spielberger & Gorsuch, 1983), and the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987), respectively. We measured interpersonal problems with the eight subscales of the 64-items Inventory of Interpersonal Problems (IIP; Horowitz et al., 2003).

2.6 Data analysis

Because preliminary visual inspection of our data indicated potential deviations from distribution assumptions and the presence of outliers in some of our variables of interest, we extended our pre-registered analysis plan and compared the results of each statistical model presented below to those of a robust alternative (Field & Wilcox, 2017). Specifically, we used the *bwtrim* (a method based on trimmed means) and *pbcor* functions from the *WRS2* R package with default settings for ANOVAs and Pearson correlations, respectively. We explicitly highlight instances where the conclusions from classical and robust models differed in the results section. When such differences occurred, we based our interpretations on the results of the robust alternative.

2.6.1 Social Remember/Know/Guess Task

We first verified that angry and happy video clips were rated differently on the hostile-friendly scale, and tested whether there were group differences by submitting ratings to a 2 (Group: SAUD vs HC, between) x 2 (expression: angry vs happy, within) mixed ANOVA. Ratings from one patient with SAUD are missing due to a technical failure.

For identity recognition, we categorized answers as hits (answering “YES” for previously seen actors), misses (answering “NO” for previously seen actors), false alarms (answering “YES” for previously unseen actors; FA) and correct rejections (answering “NO” for previously unseen actors).
We computed corrected identity recognition scores for each participant and separately for each expression category by subtracting the percentage of FAs from the percentage of hits. Since expression-specific FAs could not be calculated as all actors had a neutral expression during the recognition phase, general FAs were subtracted. We computed expression recall scores for each participant and each expression by calculating the percentage of correctly recalled expressions relative to the number of identity recognition hits for that expression.

To address our central hypotheses and determine whether patients with SAUD differ from controls in their encoding and initial retrieval of novel socio-affective information, we submitted identity recognition and expression recall scores to two separate 2 (group: SAUD vs HC, between) x 2 (expression: hostile vs. friendly, within) mixed ANOVAs.

Second, to examine differences in level of awareness (R/K/G) for identity recognition, we submitted recognition scores (percentage of hits minus percentage of FAs) separately calculated for R, K, and G responses and each expression to three (one for each response type) separate 2 (group: SAUD vs HC, between) x 2 (expression: angry vs. happy, within) mixed ANOVAs. We performed separate ANOVAs for each awareness level instead of adding awareness level as a third factor because percentages of responses at different levels are dependent. Similarly, we analyzed differences in level of awareness in relation to emotion recall by submitting the percentage of R, K, and G responses for correctly recognized emotions to three separate 2 (group: SAUD vs HC, between) x (expression: angry vs. happy, within) mixed ANOVAs.

2.6.2 Social Memory Accessibility Task

We recorded participants' descriptions of positive and negative events. The first author as well as a graduate student who was unrelated to the current study and blind to hypotheses and participants' group status coded each memory to determine if it was valid (i.e., it referred to an interpersonal event; percent agreement: 0.88) or not and specific (i.e., it referred to a particular event lasting less than a day; percent agreement: 0.85) or not.

To examine differences in accessibility and specificity of autobiographical interpersonal memories, we submitted the number of 1) valid and 2) valid and specific (hereafter referred to as specific) memories to two separate 2 (group: SAUD vs HC, between) x 2 (valence: negative vs. positive, within) mixed ANOVAs.

2.6.3 Additional analyses

We finally conducted Pearson correlations to explore associations between memory variables for which a group difference was observed and psychopathology, interpersonal problems, and alcohol consumption variables in the group of patients with SAUD.

3. Results

Table 7 displays sample characteristics. As planned, groups did not differ in age, gender, or education. However, patients with SAUD had significantly higher depression, state and trait anxiety, social anxiety, and, as expected, AUDIT scores, than HC. They also reported significantly more interpersonal problems on every subscale of the IIP than HC.

3.1 Social Remember/Know/Guess Task

3.1.1 Ratings during the learning phase

There was a significant effect of expression [$F(1,77)=1315.71$, $p<0.001$, $\eta^2_p=0.945$], with angry video clips receiving lower ratings ($M=1.77$, $SD=0.78$) than happy ones ($M=6.98$, $SD=0.77$). Furthermore, angry [$t(78)=31.14$, $p<0.001$] and happy [$t(78)=28.64$, $p<0.001$] video clip ratings were significantly lower and higher than the hostility-friendliness scale's midpoint, respectively. The group effect [$F(1,77)=0.84$, $p=0.36$, $\eta^2_p=0.011$) and the group x expression interaction effect [$F(1,77)=0.80$, $p=0.37$, $\eta^2_p=0.010$] were not significant. Hence, angry and happy video clips were indeed clearly distinguished and rated as hostile and friendly, respectively, with no differences between groups.

3.1.2 Identity recognition scores

Corrected recognition scores are shown on Figure 10A, as a function of group and expression (descriptive statistics are provided as Appendix 11). The ANOVA on identity recognition scores revealed a marginal effect of group [$F(1,78)=3.34$, $p=0.07$, $\eta^2_p=0.041$], with identity recognition being lower in patients with SAUD, as well as a significant effect of expression [$F(1,78)=17.47$, $p<0.001$, $\eta^2_p=0.183$], with better identity recognition for happy compared to angry video clips. Importantly, the group x expression interaction was not significant [$F(1,78)=0.02$, $p=0.89$, $\eta^2_p=0.0002$], see Figure 10A. We obtained similar results from the ANOVA on R responses: the group effect was marginal [$F(1,78)=3.92$, $p=0.051$, $\eta^2_p=0.041$], the expression effect was significant [$F(1,78)=12.23$, $p<0.001$, $\eta^2_p=0.136$], and the group x expression effect was not significant [$F(1,78)=0.37$, $p=0.54$, $\eta^2_p=0.005$]. The ANOVAs conducted on K and G responses showed no significant effects (all $ps>0.36$).

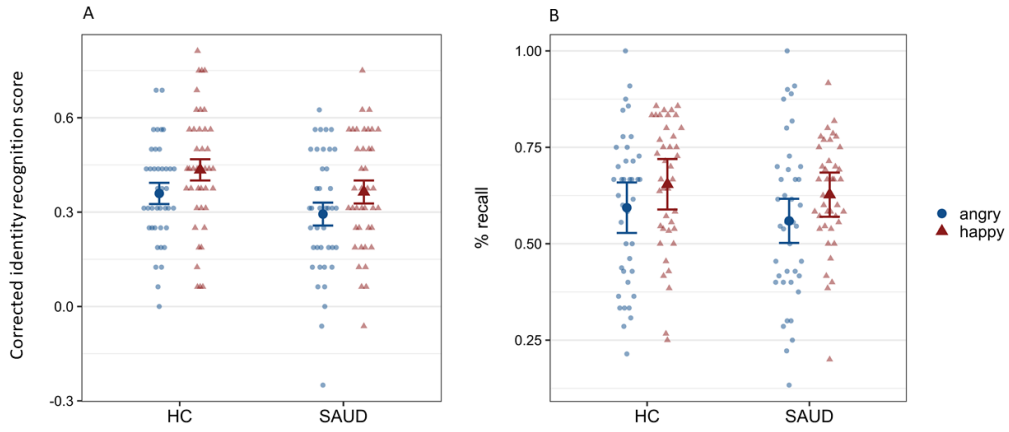

Figure 10. *Corrected identity recognition scores for identity recognition as a function or emotional expression during the study phase and group (A) and proportions of correct emotional expression recalls as a function emotional expression and group (B).*

3.1.3 Expression recall scores

Expression recall scores are shown on Figure 10B, as a function of group and expression (descriptive statistics are provided as Appendix 12). The ANOVA on expression recall scores revealed a significant effect of expression [$F(1,78)=4.48$, $p=0.037$, $\eta^2_p=0.054$], with better recall for happy compared to angry expressions, but both the group effect [$F(1,78)=1.35$, $p=0.25$, $\eta^2_p=0.017$], and the group x expression interaction effect [$F(1,78)=0.01$, $p=0.91$, $\eta^2_p=0.0002$] were not significant, see Figure 10B. The ANOVAs conducted on R, K, and G responses showed no significant effects (all ps>0.14).

Importantly, all results from the Social Remember/Know/Guess Task were replicated in the subsample of participants completing the Social Memory Accessibility Task.

3.2 Social Memory Accessibility Task

The proportion of valid memories was high in both groups (SAUD: negative=0.90, positive=0.90; HC: negative=0.98, positive=0.95), although it was slightly lower in patients ($p=0.015$). Importantly, however, there was no main effect of valence ($p=0.627$) and there was no group x valence interaction ($p=0.484$).

The number of valid (A) and specific (B) memories reported as a function of group and valence are shown in Figure 11. The ANOVA on the number of valid memories did not reveal an effect of valence [$F(1,57)=0.49$, $p=0.488$, $\eta^2_p=0.008$], but there was a main effect of group [$F(1,57)=8.22$, $p=0.006$, $\eta^2_p=0.126$], with patients with SAUD reporting more memories than HC, as well as a significant group x valence interaction [$F(1,57)=12.03$, $p=0.001$, $\eta^2_p=0.174$]. Follow-up between-group contrasts showed that groups significantly differed for negative interpersonal memories [$t(1,57)=3.88$, $p<0.001$, $d=1.03$], with a higher number of memories reported by patients with SAUD, but not for positive memories [$t(1,57)=1.27$, $p=0.208$, $d=0.34$]. Moreover, follow-up within-group contrasts showed that whereas HC recalled more positive than negative memories [$t(1,57)=2.97$, $p=0.004$, $d=0.76$], patients with SAUD tended to recall more negative than positive memories [$t(1,57)=1.94$, $p=0.057$, $d=0.29$]. The ANOVA on the number of specific memories revealed a similar pattern with no significant effect of valence [$F(1,57)=0.42$, $p=0.838$, $\eta^2_p=0.001$] but a significant effect of group [$F(1,57)=9.72$, $p=0.003$, $\eta^2_p=0.146$] and a group x valence interaction [$F(1,57)=9.54$, $p=0.003$, $\eta^2_p=0.143$]. Follow-up contrasts again showed that patients with SAUD recalled more specific negative memories than HC [$t(1,57)=2.49$, $p<0.001$, $d=1.10$], but that groups did not differ on specific positive memories [$t(1,57)=1.45$, $p=0.153$, $d=0.38$]. Finally, HC recalled more positive than negative specific memories [$t(1,57)=2.34$, $p=0.022$, $d=0.59$], while the opposite was true for patients with SAUD [$t(1,57)=2.02$, $p=0.048$, $d=0.31$].

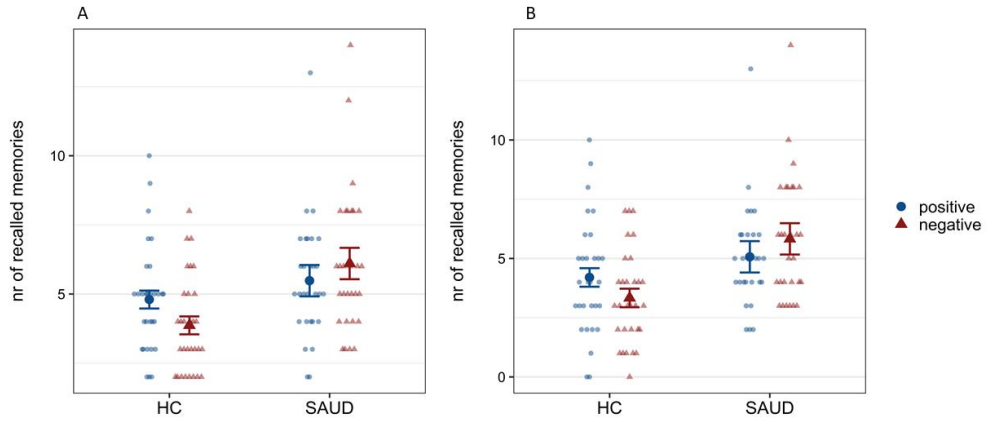

Figure 11. *Number of valid (A) and valid and specific (B) memories recalled as a function of valence and group.*

3.3 Associations between memory scores and relevant variables

Given the above-mentioned results, we investigated identity recognition scores (averaged across expressions) as well as the difference between the number of valid negative and positive memories (which correlated at more than 0.95 with the difference between specific negative and specific positive memories, which were therefore not independently considered) in the exploratory correlational analyses within the SAUD sample. We provide correlation coefficients as Appendix 13. There were no significant correlations between interpersonal problems or consumption variables and either memory index, except positive relations between identity recognition scores and cold/ distant interpersonal problems, and between the difference between the number of negative and positive valid memories and AUDIT scores. The first might be explained the fact that patients with SAUD experience more negative social situations, and hence a better encoding of social situations overall would lead to colder, more detached behaviour, whereas the second might suggest that patients with more severe symptoms are particularly prone to negative accessibility biases. However, given the overall absence of significant relations, the exploratory nature of these analyses, the fact that these were uncorrected, and in light of the limited sample sizes for correlational analyses, we refrain from definitive interpretations until replication is provided. Importantly, psychopathology variables were not significantly related to any social memory index in either the SAUD or HC sample and were hence not considered as potential confounders.

4. Discussion

In an effort to identify basic mechanisms contributing to social cognition alterations in patients with SAUD, and to address a gap in the memory literature, we investigated two aspects of social episodic memory in this group. We tested whether patients differed from HC in 1) their initial encoding of novel socio-affective material (i.e., angry and happy dynamic facial expressions), and 2) their access to/ fluency for already existing specific negative and positive interpersonal memories.

On the Social Remember/Know/Guess task, patients with SAUD tended to recognize facial identities less accurately than HC regardless of their emotional expression. This effect was specific to "Remember" responses, suggesting reduced encoding depth (Gardiner, 1988; Gardiner & Parkin, 1990). This effect aligns with our hypotheses and previous studies investigating the encoding of non-social material (e.g., Pitel et al., 2007). Patients did not, however, show difficulties recalling the emotional expressions of correctly recognized identities. Regarding valence effects, the identity and emotion of happy faces were better recognized and recalled than that of angry faces, and, centrally, this effect was not modulated by group. The effect of expression valence in HC is in full agreement with previous studies (e.g., D'Argembeau, Van der Linden, Comblain, et al., 2003; D'Argembeau & Van der Linden, 2011) and supports the validity of our task. The fact that patients with SAUD *also* displayed a positivity bias in the encoding of socio-affective information, on the other hand, contradicts our hypothesis and the recent social cognition literature, notably evidencing reduced attentional biases to positive facial expressions (Pabst et al., 2023b). Indeed, we expected this attentional pattern to translate in the encoding of information in memory (Craik et al., 1996). However, these discrepant results may be reconciliated by considering task specificities. Indeed, contrary to Pabst, Bollen, et al. (2023), who presented happy faces simultaneously with neutral faces with no instruction to focus on either, here we displayed stimuli sequentially and emphasized the importance of closely attending to each. The discrepancy in positive bias effects across the two paradigms may thus reflect the fact that patients could devote more attention to positive stimuli in the current study. We discuss the implications of this possibility below.

On the Social Memory Accessibility Task, we found no support for our hypothesis that patients with SAUD would generally recall fewer and less specific memories than HC. This deviates from past reports, and notably studies investigating the retrieval of emotional but not explicitly social autobiographical memories (D'Argembeau et al., 2006; Poncin et al., 2015; Whiteley et al., 2009). This discrepancy may be due to the interpersonal nature of the current stimuli, suggesting that patients with SAUD fully benefit from the memory enhancing effects of social cues (e.g., Stewardson et al., 2023), to the extent that these compensate for more general difficulties. Alternatively, the difference might be accounted for by a methodological factor. Indeed, whereas we imposed only broad category constraints on the nature of memories participants had to retrieve, previous studies required memories to correspond to more specific cue words. Thus, and as proposed by Hitchcock (Hitchcock et al., 2019), previous results might reflect patients' reduced ability to retrieve specific autobiographical memories in response *to particular cues*, rather than a reduced ability to generate and specify memories in general (e.g., in less constrained retrieval situations). Executive difficulties reported in SAUD (Stavro et al., 2013) may compromise the implementation of search strategies or the inhibition of irrelevant material, and selectively impact the retrieval of cue-specific memories. Future work is needed to disentangle the

sources of this discrepancy, as support for the latter option would warrant an important reconsideration of previous studies' interpretations.

Importantly, the effect of valence on the recall of interpersonal memories differed between patients with SAUD and controls. In line with our hypotheses, HC showed the expected positivity bias (Hitchcock et al., 2019), whereas patients with SAUD displayed the opposite pattern and recalled more negative than positive interpersonal memories. This effect was due to patients recalling more negative memories than HC, with no group difference for positive memories. These results held for both valid (marginally) and specific memories. The negative bias observed in patients with SAUD echoes those reported in studies focused on the recall of self-relevant memories (Cuervo-Lombard et al., 2016; Nandrino & Gandolphe, 2017). Besides generalizing previous results to social stimuli, the present findings make original contributions to the memory literature in SAUD by introducing a novel paradigm and domain of inquiry (i.e., memory accessibility for categories of interest) in SAUD, as well as by clarifying the mechanism through which negative biases might arise. Indeed, while it has been hypothesized that reduced encoding or access to positive material might be responsible (Nandrino & Gandolphe, 2017), the current data support neither view and instead point to increased access to or fluency for negative memories, with past evidence of reduced recall of positive ones likely reflecting restrictions on the maximum number of memories to be retrieved.

Together, our results thus provide a novel, rich and detailed description of social episodic memory functioning in SAUD. They suggest that patients show a tendential difficulty to encode interpersonal cues as indexed by impoverished short term recognition of facial identities individuals' novel identities. Furthermore, and centrally, they highlight a dissociation between a preserved positive bias in the encoding of novel social information, and a negative bias in terms of access to/ fluency for already established interpersonal memories. Of note, the discrepancy in valence biases cannot be attributed to sample differences since all results from the Social Remember/Know/Guess Task were replicated in the subsample that performed the Social memory Accessibility Task. A likely explanation is that patients with SAUD, a highly stigmatized group (Schomerus et al., 2011) simply experience more negative interpersonal situations. Moreover, since categorical memory fluency partly depends on the level of integration between category items (Hitchcock et al., 2019), it is also possible that although they do not preferentially encode negative social stimuli, patients subsequently spend more time elaborating and coherently linking them together, in line with reports of increased rumination tendencies in SAUD (e.g., Caselli et al., 2013) .

In addition to clarifying the memory profile associated with SAUD, our findings also meaningfully extend our understanding of the basic mechanisms involved in patients' social difficulties. Given the wealth of theoretical and empirical work stressing the role of memory in social cognition (Crick & Dodge, 1994; Gaesser, 2020; Gaesser et al., 2018; Gaesser & Schacter, 2014; Nandrino et al., 2014; Quaglino et al., 2015; Spreng & Mar, 2012; van Genugten, 2022), the current evidence supports alterations in social memory as a novel class of clinically relevant mechanisms in their own right. Indeed, lower identity recognition and negative biases in accessing negative interpersonal memories may interfere with social cognitive judgments. Failing to recognize counterparts as acquaintances may deprive from knowledge derived from past interactions and consequently lead to erroneous inferences of the mental states underlying current expressions and behaviors (Stolier & Freeman, 2016).

Likewise, facilitated access to negative versus positive interaction memories may negatively taint one's social world-view and increase pessimistic apprehensions of future interactions (Pabst et al., 2023a). Crucially, and analogously to recent reasoning in schizophrenia (Barry et al., 2019), this bias may lead patients to rely more frequently on negative social experiences to interpret incoming social information and partially explain the well-documented hostile attributions (Freeman et al., 2018; Pabst et al., 2020b) that characterize SAUD. That said, we argue that our insights should also be contextualized alongside previous research notably highlighting modifications in social attention in SAUD as additional mechanisms. Integrating both results indeed improves models of the natural unfolding and interrelations of the basic social processes that culminate in patients' higher-level social cognition alterations. This in turn allows for precise localizations of preserved and perturbated functioning along the processing stream, as well as for better clinical decisions. For instance, lower encoding and recognition of facial identities may partly flow from patients' modified facial attention. Indeed, SAUD is linked with reduced attention to the eyes (Pabst, Bollen, et al., 2023b), an important region not only for emotion, but also identity recognition (Chuk et al., 2017). Normalizing facial attention may therefore be beneficial/ necessary to rehabilitate this ability. In a similar vein, one might hastily conclude from our observed positivity bias finding that patients will normally encode more positive than negative social stimuli provided these are equally encountered. While this may be true and constitute an interesting lever in conditions where attention is drawn to positive stimuli, recent findings of a lack of attentional bias toward positive social cues (Pabst, Bollen, et al., 2023a) indicate that this would likely not hold in naturalistic situations where several social cues compete for cognitive ressources. Again, this indicates that considering attention would be essential for interventions aimed at ensuring the proper storage of positive interactions. As a whole, we suggest that episodic social memory processes should form an integral part of cognitively oriented mechanistic conceptualizations of social cognition and behaviour in SAUD.

Our study comprises several strengths. It is based on a substantial clinical sample that was gender balanced and carefully matched with a control group in term of demographics. It also relies on a rich experimental paradigm comprising two complementary memory tasks, allowing for nuanced mechanistic insights. We further strove to maximize the ecological validity and reliability of our paradigm, notably by using dynamic instead of static faces and increasing the total number of stimuli in the Social Remember Know Guess Task. However, some limitations must also be acknowledged. Although we asked participants to imagine that the faces from the Social Remember Know Guess task were directed towards them, it is possible the stimuli lacked personal relevance. In addition, our two tasks differed in terms of the nature of stimuli (facial expressions vs. interactions), which may partly underlie the discrepancy in terms of valence biases.

To conclude, we conducted the first proper investigation of episodic social memory in SAUD. We found evidence of general impoverished encoding of novel social material (facial identity) with a preserved bias for the encoding of positive vs. negative ones. Further, patients did not show general difficulties in terms of the number and specificity of social interactions memories recalled, but contrary to HC, they showed a greater access to or fluency for negative compared to positive memories. These results only partially align with non-socially focused memory studies and therefore extend our knowledge about memory in SAUD. Most importantly, our results refine our basic understanding of how patients with SAUD process socio-affective information, and shed light on memory mechanisms that may contribute to

patients' higher order social cognition difficulties and which may be targeted in clinical settings.

PART 4: GENERAL DISCUSSION

The present thesis aimed to advance the state of knowledge regarding the relation between social cognition and SAUD. It had two distinct but complementary main objectives that were each addressed through three empirical studies.

The first objective was to extend the field of investigation beyond classically assessed emotion recognition and Theory of Mind abilities, and toward other theoretically and clinically relevant components, to obtain a more comprehensive understanding of the social cognition profile of patients with SAUD.

The second was to contribute to the structured investigation of potential mechanisms underlying the above-mentioned social cognition impairments by evaluating more basic aspects of socio-affective information processing in SAUD.

In this last part, we will first summarize and discuss the studies and results pertaining to each objective separately, integrating them with previous research, and highlighting specific implications, limitations, and prospects for ulterior studies. We will then briefly discuss more general implications of the thesis for the study and conceptualisation of SAUD before underscoring general limitations of our approach. Finally, we will outline general perspectives for future work on social cognition or interpersonal problems more broadly in SAUD.

1. Expansion of investigated social cognition components

We grounded this line of studies within the four-component model developed by Green et al. (2008), and introduced in Chapter 2. This model resulted from an expert meeting aimed at delineating a minimal set of clinically relevant social cognition components in schizophrenia. Since its introduction, it has proven to be a useful organizing framework for social cognition research in this disorder, but also in other psychiatric states, supporting its transdiagnostic value (Plana et al., 2014; Tauro et al., 2022). We therefore used it as a starting point to broaden social cognition research in SAUD. The four-component model highlights social perception and knowledge (i.e., the ability to identify interpersonal roles, contexts, and rules to interpret social situations as wholes) and attributional biases (i.e., the tendency to attribute the causes of social situations to certain factors rather than others) as important domains besides emotion recognition and Theory of Mind, which have already been investigated in SAUD. In Chapter 2, we showed that these components were under-investigated in SAUD. Hence, Chapters 4 to 6 were dedicated to their evaluation in patients with SAUD.

1.1 Summary of studies and results

1.1.1 Social perception and knowledge

In Chapter 4, we investigated this component using the Social Perception and Knowledge test (Peyroux et al., 2019), a task requiring participants to provide comprehensive descriptions of social situations depicted in static pictures, and to name the rule or convention that is being illustrated. We centrally found that patients with SAUD reported less relevant components pertaining to the context (“Where” the scenes take place), the roles and statuses of protagonists (“Who” the characters are), and the nature of protagonists’ interaction

("What" is happening) than healthy controls. Finally, we found that patients were less able to identify the social rules subtending social situations. Importantly, the observed group differences could not be attributed to general processing speed, attentional, or labelling impairments, since they remained after controlling for differences in the amount of items reported when asked to list as much elements contained in the pictures as possible.

Our complementary results further stressed inter-individual variability in the severity of impairments within the SAUD sample. Indeed, single-case analyses suggested that social perception and knowledge deficits occurred in 23% and 34% of patients, respectively.

1.1.2 Attributional biases

In Chapters 5 and 6, we investigated hostile attributional biases, a category of attributional biases characterized by the tendency to ascribe the causes of ambiguous social situations to others' hostile intentions (Crick & Dodge, 1994; Green et al., 2008).

In Chapter 5, we used the Ambiguous Intentions Hostility Questionnaire (Combs et al., 2007b), comprising five written vignettes of ambiguous social interactions for which participants are asked to provide open ended explanations. These explanations are then rated by a blind assessor on a hostility scale. We centrally found that patients with SAUD attributed more hostile intentions than healthy controls.

In Chapter 6, we overcame a series of methodological limitations present in Chapter 5. We used the Word-Sentence Association Paradigm-Hostility (Dillon et al., 2016; Pabst et al., 2023c), an alternative task requiring participants to rate, as spontaneously and naturally as possible, the extent to which socially ambiguous sentences *relate to* hostile *and* benign words. It provides a less direct/ more implicit assessment of both hostile and benign attributional biases and removes the need for external raters. Using this task, we found that patients with SAUD showed increased hostile attributions, but did not differ from healthy controls regarding benign attributions. Our complementary analyses further revealed that this effect was moderated by gender, such that SAUD-related group differences were selectively observed in men.

In addition, in both studies, we found that hostile attributional biases positively related to self-reported interpersonal problems, and notably increased aggressivity (at a trend level in Chapter 5), in the whole sample of patients with SAUD.

1.2 Integration with previous results and implications

1.2.1 Social cognition alterations in SAUD extend beyond emotion recognition and Theory of Mind

In our comprehensive review of social cognitive studies in SAUD (Chapter 2), we identified no study directly assessing social perception (i.e., the interpretation of social situations). The main results of Chapter 4 thus provide original evidence of impairments in the ability to identify social roles, relationships, and context in patients with SAUD.

Our review further identified only two studies pertaining to peripheral aspects of social knowledge. One found no difference in patients' ratings of the moral acceptability of a list of specific behaviours (Khemiri et al., 2012), whereas the second found that patients showed reduced abilities to reason about previously described social rules (i.e., logically determine whether a social rule was violated; Kornreich et al., 2011). However, none of these studies directly assessed the core ability to pinpoint *which* tacit rules and underlying behavioural expectations currently apply in social situations, which more directly relates to the definition of social knowledge and represents an essential skill for adaptive everyday social functioning. Hence, our results offer novel evidence of impairments in this central component of social cognition and sketch a preliminary profile of social knowledge difficulties in SAUD: while fundamental knowledge of moral norms, specifically, appears to be preserved (a finding to be replicated considering the small sample size), patients may struggle in the online identification of the social rules at play, and in determining whether they were appropriately followed. In sum, our main results provide evidence that SAUD is associated with social perception and knowledge impairments.

Regarding attributional biases, our review identified a single study directly assessing the construct in SAUD. Moss and Whiteman (1985) found no evidence that patients selected more negative than positive social descriptors to characterize ambiguous pictures of two hands from different people placed in varying positions to give an impression of interaction. We suggested that this null-finding may be due to methodological specificities (e.g., pictures of hands being too abstract for biases to emerge). This was supported by our studies in Chapters 5 and 6, which provided strong evidence of hostile attributional biases across two different paradigms in two independent samples of patients with SAUD. These results are broadly coherent with indirect evidence from emotion recognition tasks, where patients tend to wrongly interpret stimuli as displaying hostile emotions (e.g., Creupelandt et al., 2020; Freeman et al., 2018; Philippot et al., 1999), and provides further support, at the level of higher order social cognition judgments, to our proposition that SAUD relates to biases in the processing of threatening social information.

Together, these studies represent an original extension of the social cognition literature in SAUD, and their results critically increase our knowledge of the range of impairments. Indeed, they indicate that patients' difficulties are not circumscribed to the classically investigated emotion recognition and Theory of Mind domains, which are the only ones covered by available reviews and meta-analyses (Bora & Zorlu, 2017; Castellano et al., 2015; Le Berre, 2019; Onuoha et al., 2016), but also englobe the other core components of social perception and knowledge and attributional biases. An alternative way to frame these findings to highlight their conceptual contribution is to say that they offer novel evidence that social cognition alterations in SAUD extend beyond person-centered to more situation-centered judgments, and do not only take the form of reduced ability (i.e., performance decrements at tasks comprising "correct" answers), but also manifest as biases or reduced tendencies (i.e., dispositions to endorse certain judgments in the absence of correct answers). In sum, our results support the view that SAUD is associated with generalized alterations in social cognition, as defined in the four-component model (Green et al., 2008).

In addition to broadening our fundamental understanding of the social cognitive alterations associated with SAUD, our findings of social perception and knowledge impairments and hostile attributional biases also offer considerably increased explanatory power to account for the diversity of patients' interpersonal problems. Indeed, as mentioned in Chapter 1,

SAUD is associated with a wide range of interpersonal difficulties (e.g., Maurage et al., 2017) that are unlikely to be explained by emotion recognition or Theory of Mind difficulties alone. In support of this view, a recent study found emotion recognition difficulties to be associated with only three out of eight interpersonal problem domains (these represented difficulties asserting oneself or showing initiative, being overly accommodating, and being overly needy or intrusive) that were elevated in patients with SAUD (Hoffman et al., 2019a). Specifically, social perception and knowledge impairments may help explain why patients with SAUD show difficulties "fitting in", or behaving according to what is expected in the social situation at hand (Amenta et al., 2013), and, for example, fail to solve interpersonal problems in context-appropriate ways (Schmidt et al., 2016). Direct support for a relationship between social perception and knowledge, social skills and social problem solving has been found in patients with schizophrenia (Addington et al., 2006; Couture et al., 2006; Fett et al., 2011). Hostile attributional biases, on the other hand, have established links with aggression (e.g., Klein Tuente et al., 2019), and may contribute to patients' elevated rates of violent behaviour (Gautier et al., 2023). The positive relationships found between this component and interpersonal problems characteristic of increased aggressivity in the SAUD samples in both our studies corroborate this proposal, and provide direct evidence for its functional significance.

At a more general level, our main findings importantly support the four-component model as a useful framework within which to anchor social cognition research in SAUD to gain a more comprehensive sense of the range of difficulties presented by patients. They thus encourage reliance on this taxonomy to foster a more structured research field. This is in line with similar conclusions drawn in the context of other disorders such as eating or anxiety disorders (Plana et al., 2014; Tauro et al., 2022) and suggests that it may serve as a basis for expanding this scientific field across psychiatric and neurological states (Cotter et al., 2018).

1.2.2 There is heterogeneity in SAUD-related social cognition alterations

While our main findings indicate that, at a group-level, SAUD is associated with a broader range of social cognition alterations than previously documented, addressing our primary objective, our complementary analyses allow for a more nuanced characterization of these effects. Indeed, in Chapters 4 and 6, we investigated individual differences and found that patients with SAUD did not form a homogeneous group with regard to both social perception and knowledge and hostile attributional biases. Specifically, in Chapter 4, single case analyses revealed that only a subset of patients could be categorized as showing social perception and knowledge impairments and in Chapter 6, the effect of SAUD on hostile attributional biases was only evident in men.

The first results align with and extend those of previous studies reporting substantial heterogeneity in the extent of impairments in emotion recognition (Maurage et al., 2021) and Theory of Mind (Maurage et al., 2015; Schmid et al., 2021b) in SAUD. The second echo findings of an influence of gender on the relation between SAUD and emotion recognition (Frigerio et al., 2002; Lewis et al., 2019) and Theory of Mind (Onuoha et al., 2016). However, contrary to these studies, which found women to be particularly vulnerable to the effects of SAUD on social cognition, our study in Chapter 6 is to our knowledge the first to report selective SAUD-related social cognition alterations in men. This suggests that, while women

may be at higher risk of SAUD-related emotion recognition and Theory of Mind impairments, male patients may be especially likely to show hostile attributional biases. In other words, our evidence introduces the idea that gender moderates the effect of SAUD on social cognition differently depending on the specific component under investigation. What could drive such gender differences in the relation between SAUD and social cognition is unclear. Answers may be found in gender-specific 1) risk factors for SAUD (e.g., rejection experiences may be stronger predictors of SAUD in women than men; Oberleitner et al., 2015; Surakka et al., 2021), 2) physiological effects of alcohol/ withdrawal (Flores-Bonilla & Richardson, 2020), or 3) social consequences of SAUD (Nolen-Hoeksema, 2004).

Conjointly, our studies indicate that there are important inter-individual differences in the extent to which *all* social cognition components are altered in patients with SAUD. They further suggest that this heterogeneity may also concern the specific social cognition components that are altered (e.g., some patients showing primary emotion recognition difficulties but preserved hostile attributional biases, and vice-versa) and that gender constitutes a critical factor in this context.

1.3 Limitations

In addition to the general limitations of the thesis, which we will highlight in a dedicated section, we would like to mention specific caveats relevant to the interpretation of studies discussed above. First, in our investigation of social perception, we could not analyse whether patients presented generalized or specific difficulties in the accurate identification of context (Where), roles and statuses (Who), or interpersonal interactions (What). These abilities may depend on different processes and their separate consideration would have provided important insights into the nature and breadth of social perception impairments in SAUD.

Second, we assessed hostile attributional biases by asking participants to respond to short written descriptions of social scenes. While this rather simplistic and "pure" format allows controlling for the potential effects of perceptual processing demands of richer environments, it should be noted that such an experimental setting offers participants more freedom to collate past (and for patients, presumably more negative) experiences on the situation than real-life conditions, potentially inflating effects (Chen et al., 2020). That said, there are ecological situations in which hostile attributional biases can be observed that can be deemed comparable to our experimental setting in terms of the amount of information available to participants (e.g., when the situation is described in a text or mail, or reported by a third party).

Third, it must be highlighted that, while the tasks we used have strong face validity to assess their associated constructs, evidence for their psychometric qualities in general (e.g., the Social Perception and Knowledge task is relatively new) or in a sample of patients with SAUD specifically (except for the Word-Sentence Association Paradigm – Hostility), is limited or lacking.

Fourth, we assessed social cognition components individually in different samples [although there is some overlap between the samples from Chapters 4 and 5 and previous studies on emotion recognition and Theory of Mind (Maurage et al., 2016, 2021)]. A stronger claim that

SAUD is associated with alterations in all social cognition components could be made by evidencing them within the same sample.

Fifth, although measures of interpersonal problems were included in the two studies assessing hostile attributional biases, allowing us to provide direct evidence for the functional significance of this component, this was not the case for the study investigating social perception and knowledge. Our interpretation that impairments in this component might participate in patients' difficulties in social skills and social problem solving therefore rests on evidence obtained in a different population, and remains to be substantiated in the specific case of SAUD.

1.4 Perspectives

1.4.1 Replication and refinement of social perception and knowledge and attributional biases investigations

One obvious avenue for future studies aimed at characterizing the social cognition impairments associated with SAUD is to replicate the findings obtained in this thesis, especially regarding social perception and knowledge, as evidence regarding this ability comes from a single study.

Studies on this component could also investigate whether patients show specific or general difficulties in assessing Where/ Who/ What aspects of social situations to clarify the nature of impairments, and confirm the current evidence that fundamental knowledge of moral norms are preserved while identification and reasoning about rules in complex situations are compromised (Khemiri et al., 2012; Kornreich et al., 2011), through conjoint assessment of these subcomponents of social perception and knowledge. Further refinement of our understanding of alterations in this component could be achieved via tasks tapping into other relevant aspects such as the Social Knowledge Task (Achim et al., 2012; Thibaudeau et al., 2018), which examines knowledge about the mental states typically experienced in given situations.

Regarding attributional biases, it would be relevant to investigate whether the hostility biases can be replicated using visual material (e.g., Wilkowski et al., 2007), which could reduce participants' reliance on specific prior experiences. It would also be informative to determine whether attributional biases in SAUD are constrained to hostile interpretations or generalize to other tendencies. In particular, hostile attributional biases could largely be due to more general tendencies to attribute intentionality, and studies should therefore determine whether patients exhibit such tendencies in ambiguous situations with no negative personal consequences. This could be done using the Intentionality bias task (Rosset, 2008), and offer valuable insights regarding the situational specificity and hence potential sources of attributional biases in SAUD, and bear important functional implications. Situation-general intentionality biases (e.g., wrongly interpreting an accidental touch as a sign of affection) could indeed lead to broader interpersonal problems than hostility biases.

1.4.2 Back to basics: further research on emotion recognition and Theory of Mind

It may appear surprising, given the amount of available research dedicated to the study of emotion recognition and Theory of Mind in SAUD, that we would recommend further inquiry into these components. However, in our recent review (Pabst et al., 2022) that served as a basis for Chapter 2, we identified methodological limitations in these studies that stress the need for additional investigations, especially given the present empirical results.

For instance, there are now abundant conceptual and empirical arguments (Kittel et al., 2021; Oakley et al., 2016; Quesque & Rossetti, 2020) supporting the view that the Reading the Mind in the Eyes Test (Baron-Cohen et al., 2001), the most frequently used task to ostensibly assess Theory of Mind in SAUD, should instead be construed as a measure of emotion recognition. In a similar vein, we argued that performance on the Faux-Pas task (Stone et al., 1998), the second most frequently used task to assess Theory of Mind in SAUD, could actually largely reflect social perception and knowledge (especially since we evidenced impairments in this ability), as it essentially requires participants to indicate whether someone said or did something that they should not have (i.e., broke a social rule or convention) before specifically addressing participants' understanding of others' mental states.

These points stress the more general issue of construct-measurement alignment. Indeed, social cognition components (in and outside SAUD research) are often loosely and variably labelled and defined, and definitions of different components frequently overlap. This leads to measures tailored to different specific definitions being labelled identically/ interpreted interchangeably, and ostensibly different components (e.g., emotion recognition and Theory of Mind) being assessed with identical measures (e.g., Olderbak & Wilhelm, 2020; Quesque & Rossetti, 2020). In turn, this can have adverse consequences for the interpretation of research findings and hamper the development of a clear understanding of the social cognition profile of patients. Hence, it is essential that careful consideration is given to precisely defining the components or constructs under investigation, and to ensure that measurement procedures match those constructs (Pabst & Maurage, 2023).

Regarding emotion recognition, we notably pointed out that tasks typically presented emotional stimuli (e.g., faces) without context, and simultaneously with emotional words, serving as response options. This is problematic as recent theory and results emphasize the important role of context (e.g., body postures, visual background; which current results show patients may have difficulties processing), and affective language in shaping how individuals perceive facial expressions (Aviezer et al., 2017; Barrett et al., 2007; Barrett & Kensinger, 2010; Gendron et al., 2012; Lindquist et al., 2014; Lindquist & Gendron, 2013; Souter et al., 2021). It will therefore be important to use tasks that take these aspects into account to better approximate real-life emotion recognition.

Hence, we propose that progress in our understanding of social cognition alterations in SAUD depends both on a more systematic investigation of understudied components, as well as on continued efforts to update emotion recognition and Theory of Mind research in line with most recent theoretical and methodological developments. These efforts, if they are to contribute to a clear description of patients' difficulties in the different components, should further occur in the context of a more rigorous consideration of the alignment between assessed constructs and measurements.

1.4.3 Joint assessment of social cognition components and further examination of heterogeneity

As suggested above, assessing all components of social cognition in the same sample of SAUD could strengthen conclusions that the disorder is associated with generalized alterations.

In addition, this would allow investigating potential interrelations between components. Indeed, while they are presented as distinct, it is clear that there is overlap and likely functional relationships between them (e.g., Green et al., 2008; Riedel et al., 2021). For instance, difficulties in recognizing facial expressions of emotion or in the assessment of social situations and their rules might affect inferences about individuals' more complex mental states. Difficulties reasoning about others' intentions might favor the reliance on and strength of biased interpretations. Relatedly, misinterpretations of persons' intentions or misattributions of the causes of their action might also compromise evaluations of the nature of the social scene they are situated in. Studying these relationships in SAUD and determining the specific association between each component (controlling for the others), the diagnosis, and functional variables could shed light on the structure of social cognition in this disorder, and potentially identify components that should be considered priority clinical targets.

The joint assessment of the different social cognition components should further be coupled with a more systematic investigation of heterogeneity within patient samples. Beyond clarifying the extent of individual differences for each component separately, this approach would notably allow directly determining whether and which specific social cognition profiles (i.e., specific constellations of altered and preserved components) exist among patients, quantifying their frequency, and identify specific correlates of spared and different impaired profiles (e.g., gender, alcohol consumption, personality traits, family history of SAUD) that may aid in the precise characterization and treatment of patients at higher risk of difficulties as well as in our understanding of the potential sources of heterogeneity (e.g., Etchepare et al., 2019; Varo et al., 2022). Cluster analyses similar to those employed to parse heterogeneity in other, related, variables in SAUD (Maurage et al., 2017), appear particularly indicated to achieve these aims. Jointly assessing all components would also yield a better appreciation of the prevalence of *any* alterations in social cognition in SAUD. Previous studies focusing on a subset of components found that only a minority of patients presented with difficulties in at least one ability (Maurage et al., 2015, 2021; Schmid et al., 2021b). However, it may be that "preserved" patients were altered in components that were not assessed.

1.4.4 More systematic, rigorous, and diversified assessment of relationships with interpersonal and clinical variables

If the goal is to identify individual-level factors that can help explain patients' interpersonal problems and poor prognosis, it is essential that future research systematically determines the relative contributions of different social cognition alterations to relevant aspects of social functioning and clinical variables. To date, only a limited set of studies investigating emotion recognition (Hoffman et al., 2019b; Kornreich et al., 2002; Lewis et al., 2019; Maurage et

al., 2009a), and our own studies on hostile attributional biases have directly assessed relations between social cognition and interpersonal functioning.

Moreover, in these studies, interpersonal problems were measured using self-report questionnaires of maladaptive social behaviour. While valuable, such measures are sensitive to several memory and social desirability biases, which are likely exacerbated in patients with SAUD (Latkin et al., 2017; Le Berre et al., 2017). It would therefore be relevant to complement such measures with alternative ones such as informant-based (i.e., obtained from patients' entourage) or performance-based (i.e., direct measures of behaviour or decision-making in social context; Gautier et al., 2021) assessments.

In addition, it appears warranted to extend investigations to indices of social integration that are known to be important for the progression of the disorder, such as the availability of social support or the size and composition of patients' social network (Hunter-Reel et al., 2009; Nicaise et al., 2022). Relatedly, little research has investigated the links between social cognition and important clinical outcomes such as treatment dropout and relapse (Foisy et al., 2007a; Rupp et al., 2017), or the factors that could explain these associations (e.g. reduced therapeutic alliance), a gap that should be addressed by future studies. A better understanding of the mapping between specific social cognition components and specific aspects of interpersonal functioning and clinical outcomes is pivotal to develop precise and practically useful conceptualizations, and to tailor interventions to the specific needs of patients.

1.4.5 Investigation of the psychometric properties of social cognition tasks in SAUD

Finally, we would like to stress the general need to assess the psychometric qualities of social cognition tasks within samples of patients with SAUD (of course this applies also to tasks investigating potential mechanisms, but we highlight this point here given the relatively higher stakes associated with tasks aimed at evaluating social cognition difficulties or impairments). We are aware of no study besides the one described in Chapter 6, where we reported evidence of internal consistency (Chronbach's alpha and MacDonald's Omega), and validity (correlations with related constructs) of the Word-Sentence Association Paradigm – Hostility in our patient sample, that explicitly reported psychometric data (besides above-mentioned correlations between emotion recognition and interpersonal problems).

Reliability and validity of measurement are important to draw correct and replicable conclusions in research contexts, particularly when studying individual differences and relationships between them (Parsons et al., 2019; Rodebaugh et al., 2016), and therefore constitute a critical prerequisite for the successful implementation of the perspectives outlined above.

Psychometric soundness is also necessary for the use of tasks in clinical contexts. Indeed, it is essential, for instance, that measures used to determine if a given patient should be considered as impaired on a social cognition component and receive treatment, or to assess the evolution of this component over time (e.g., following an intervention), demonstrate high reliability (Rodebaugh et al., 2016).

Hence, we suggest that more systematic consideration and reporting of the psychometric properties of social cognition tasks in SAUD could have a marked positive impact on the field. We also call for large scale concerted initiatives aimed at identifying the best tasks for social cognition research in SAUD, similarly to what has been proposed in schizophrenia, autism, and bipolar disorder (Lewandowski et al., 2024; Morrison et al., 2019; Pinkham et al., 2018).

2. Investigation of potential underlying mechanisms

In a second line of studies, we went beyond the description of social cognition alterations, and tried to identify basic aspects of social information processing that could constitute underlying mechanisms. These studies were guided by a working model, described in Figure 3, according to which social judgments depend on the extraction of relevant social signals as well as on their interpretation based on top-down information derived from previous experience and knowledge.

We specifically tested whether patients with SAUD presented reductions and biases in their attention and memory for relevant socio-affective material, as alterations in these processes were likely considering previous evidence, not directly explored in SAUD, and could affect the adequate sampling of information from the environment and the information used at the interpretation stage, respectively.

2.1 Summary of studies and results

2.1.1 Attentional processing of social information

In Chapter 7, we investigated whether patients with SAUD showed reduced attention to important social cues, namely informative facial features, when having to recognize emotional expressions. We did so by directly recording participants' eye-movements towards the eyes, mouth, and nose regions using an eye-tracker while they categorized facial expressions of negative emotions. Our main results indicated that, compared to healthy controls, SAUD was associated with a reduction in their attention to informative facial features that was especially marked for the eye-region, and generalized across emotions. We also found tentative evidence for a positive relationship between attention to the eyes and performance in the recognition of fear.

In Chapter 8, we investigated the idea that patients with SAUD could present attentional biases to certain types of socio-affective information. We recorded participants' eye-movements to pairs of emotional and neutral facial expressions. We included expressions of anger and disgust, as we proposed in Chapter 3 that SAUD would be especially associated with biased processing of socially threatening information, as well as expressions of sadness and happiness. We found no conclusive evidence that SAUD was associated with increased attention to socially threatening vs. neutral information compared to healthy controls. However, patients differed from healthy controls regarding their attention to positive social cues: they showed reduced attention to smiling faces compared to controls and lacked the marked attentional bias to smiling vs. neutral faces displayed by the latter in the first block of stimuli.

2.1.2 Memory processing of social information

In Chapter 9, we investigated both performance and bias in two aspects of episodic memory for social information in SAUD. We first examined participants' encoding of newly presented social stimuli (clips of angry and happy facial expressions) by assessing their ability to recognize the identities of the faces and recall their expressions shortly after having been exposed to them. There, we found that patients showed only a tendential difficulty to encode social material regardless of expression, as indexed by reduced performance in the recognition of the identities of individuals presented in the video clips, with no difference in their ability to recall the emotion that individuals displayed. We further found no evidence of a biased encoding of socially threatening material as patients, like controls, showed better performance for positive clips.

Second, we assessed the accessibility of, or participants' fluency for, already existing social events by asking them to recall a maximum of specific memories of positive and negative social interactions within equal time limits. Patients showed no difficulties accessing specific interpersonal memories in general. They even showed superior access to or fluency for negative interpersonal memories compared to healthy controls. Moreover, whereas healthy controls exhibited clearly superior recall of positive versus negative social memories, patients with SAUD lacked this bias and showed an opposite trend favouring the recall of negative memories.

2.2 Integration with previous findings and implications

Two proposals have been formulated to explain social cognitive difficulties in SAUD. The first emphasizes the role of higher-order, frontally mediated processes such as executive functioning (Quaglino et al., 2015; Schmid et al., 2021b; Trick et al., 2014; Uekermann & Daum, 2008), implying that alterations arise at a relatively late stage of the information processing stream (e.g., as a consequence of difficulties in the inhibition of irrelevant material or in complex decision making). The second suggests that low-level visual alterations may interfere with the basic perceptual processing of socio-affective signals that (Creupelandt et al., 2019; D'Hondt et al., 2014).

While acknowledging the contributions both processes are likely to make, we noted evidence of 1) social cognition impairments in the absence of executive ones (e.g., Schmid et al., 2021), or at tasks where visual processing is not critical (Thoma et al., 2013), including those used in Chapters 4 and 5, 2) preserved abilities in visually-dependent person judgments such as facial gender or age (Foisy et al., 2007b; Maurage et al., 2008a), 3) little group-differences in visual modulations of socio-affective cues (Creupelandt et al., 2022a, 2022b).

These results indicate that executive and visual proposals are not sufficient to account for social cognition alterations in SAUD, and that additional mechanisms, affecting the extraction of social signals from the environment and the use of endogenous social information, might also be at play. Our results confirm this view.

2.2.1 Patients with SAUD attend differently to external social information

Our findings from Chapter 7 extend previous neuroimaging studies linking SAUD to 1) structural and functional compromises in the amygdala and frontal areas, which have been implicated in attention orientation to salient facial cues (Adolphs et al., 2005; Kennedy & Adolphs, 2010; Le Berre et al., 2013; Makris et al., 2008; Marinkovic et al., 2009; O'Daly et al., 2012; Salloum et al., 2007; Trick et al., 2014), and 2) event-related potential anomalies associated with modified attention during the processing of emotional faces (Maurage et al., 2008b). Specifically, they provide a confirmation, using a direct measure, that SAUD indeed relates to modified attention to social information, and clarify *how*, precisely, these modifications manifest: patients attend less to core facial features, and particularly the eyes, regardless of the emotion that is expressed.

The results from Chapter 8 further specify the range of social attentional alterations in this population. They indicate that, beyond showing a reduced attention to objectively informative cues within a single face in the context of a given goal (e.g., emotion recognition), patients also lack the spontaneous attentional prioritization of positive social information (i.e., smiling faces) that is characteristic of healthy participants (Isaac et al., 2014; Kelberer et al., 2018; Pool et al., 2016).

These results bear several conceptual implications. They offer original evidence that patients' established alterations in the attentional processing of neutral stimuli extend to socio-affective material. At the same time, they suggest that domain-general (including executive) impairments are unlikely to fully explain patients' attentional behaviour in social contexts. Indeed, accounts of generally diminished abilities in effortfully orienting attention to relevant indices would predict generalized rather than eye-specific reductions in gaze allocation to relevant facial cues during emotion recognition, and exacerbated attentional biases toward/ away from emotional cues (Derryberry & Reed, 2002; Schoorl et al., 2014) rather than a lack thereof for positive social stimuli selectively. This importantly supports the view that cognitive impairments and social cognitive alterations in SAUD are at least partly dissociable.

Accordingly, this prompts the consideration of other explanations for our results. Compromises in the above-mentioned brain regions involved in eye contact may contribute to the findings in Chapter 7 by attenuating the salience of this key-region. An alternative that we cannot completely rule out is that patients actively avoided the eyes as a way to minimize the distress of eye-contact. Such a hypothesis has been raised to explain similar behaviour in autism (Hutt & Ounsted, 1966; Kliemann et al., 2010). However, the fact that reduced eye attention was observed for earlier, more spontaneous and automatic (Thompson et al., 2019) indices (i.e., fist fixations) *as well as* later, more controlled indices (i.e., total dwell-time) lowers the likelihood that such an account fully explains our findings. As to the reduced attentional bias to smiling faces, we propose that it may reflect a blunted sensitivity to social reward, in line with fundamental evidence that smiling faces are highly rewarding and that social reward biases attention (Anderson, 2016; Hayward et al., 2018; Tamir & Hughes, 2018), and preliminary evidence of reduced activation of the ventromedial prefrontal cortex, a region that has been associated with reward processing, when confronted with happy faces in SAUD (Salloum et al., 2007). This latter hypothesis aligns with proposals that addiction patients' increased valuation of substance cues is mirrored in a corresponding devaluation of

other, normally rewarding, and notably social stimuli (Volkow et al., 2011). It requires confirmation as it would point to a novel domain of alteration of high relevance to social dysfunction (Barkus & Badcock, 2019).

Our findings also have implications with regard to our proposal that SAUD is associated with biases toward social threat. Indeed, if the absence of an attentional bias toward hostile information reflects a true effect (not due to our limited sample size), it interestingly suggests that the biases repeatedly evidenced at emotion recognition and attribution tasks (Foisy et al., 2007; Freeman et al., 2018; Frigerio et al., 2002; Maurage et al., 2009; Philippot et al., 1999; Chapters 5 and 6) do not find their origin as early in the information processing stream as we thought, but rather in later processes, as will be confirmed by our findings in the memory domain. Additionally, the group difference we *did* observe in the attentional processing of positive stimuli indicates that, at least for some cognitive processes, SAUD is related to a lack of positive rather than negative biases, allowing for a refinement of our proposal.

Most importantly given the objective of the present thesis, our results shed light on specific and well characterized social information processing alterations that might negatively impact a range of social cognition abilities by interfering with the extraction of relevant external signals. Most notably, several correlational, experimental, and clinical studies (e.g., Günther et al., 2021; Hall et al., 2010; Schurgin et al., 2014; Setien-Ramos et al., 2022; Spilka et al., 2019; Vaidya et al., 2014) have demonstrated the importance of attending to the eyes for emotion recognition. Reduced attention to this region may thus lead patients with SAUD to categorize facial expressions on the basis of incomplete information, and thus to be less accurate. It may further impact mental state inferences more broadly (especially given that the effect occurred regardless of emotional expression), as the eyes do not only carry critical cues regarding the emotions others experience (e.g., eye-widening in fear), but can also reveal the cause/ significance of that emotion (e.g., an angry person's averted gaze could indicate that the emotion is not directed toward oneself), as well as others' non-emotional states such as their attentional focus, intentions or interest in engaging in or sustaining conversation (Byom & Mutlu, 2013; Cañigueral & Hamilton, 2019; Itier & Batty, 2009). The reduced attentional preference for positive social information, on the other hand, could play an especially important role in social situations containing several, mixed social signals, including positive ones, which patients might appraise as less positive than healthy individuals (Bronfman et al., 2018). It may also indirectly affect higher-order social cognitive judgments by fostering less positive social representations and expectations over time.

2.2.2 Patients with SAUD differ in the way they store and remember social information

The study described in Chapter 9 was the first to properly and comprehensively investigate memory processing for positive and negative social stimuli specifically in SAUD. It offers novel evidence suggesting that patients are less able (at a trend) to encode newly encountered individuals' identities, but like healthy individuals, encode positive social information better than negative ones. Patients also accessed more negative than positive social memories (the opposite was true for healthy individuals), and this was specifically due to an enhanced ability to access past memories of negative social interactions.

The first finding interestingly complements the face processing literature in SAUD. Indeed, whereas previous findings suggested specific difficulties in emotion recognition ; but see Lewis et al., 2019), our results suggest that they may extend to identity recognition.

On a more general level, the emotion-independent reduction in identity encoding seems largely compatible with results in non-social studies (e.g., Pitel et al., 2007). However, difficulties did not generalize to the encoding of individuals' emotional expressions (which would have been predicted by visual and executive accounts), and patients did not show the reduced memory specificity repeatedly found in earlier non-social memory work (D'Argembeau et al., 2006; Whiteley et al., 2009; although this may be due to methodological factors), nor general difficulties accessing past social memories (which would be predicted by executive accounts), again pointing to the involvement of domain-specific processes in memory alterations for social information in SAUD.

The fact that patients presented the same positivity bias as controls in the encoding of social information is particularly noteworthy as it contrasts with our attentional results. This suggests that the lack of positive bias to social stimuli may be specific to attention and not concern encoding processes *per se*, although the encoding of social information may be affected by what is attended to, a point we will elaborate in the next section. Relatedly, the fact that we observed greater access to negative social information aligns with our findings of hostile attributional biases, and provides original support to our proposal that social threat processing biases extend to more basic aspects of information processing. This result further highlights a specific process that is concerned, and strengthens the view that these biases selectively emerge at rather late stages (i.e., access to interpersonal events rather attention and encoding of social cues). One reason for this specificity may be that patients, despite showing a positive advantage in the encoding of positive over negative information, are more often confronted to negative interpersonal events. Alternatively, they may elaborate and ruminate on negative social memories to a greater extent compared to positive ones, increasing their availability (Caselli et al., 2013; Grynberg et al., 2016; Hitchcock et al., 2019).

Like our findings in the attentional domain, these memory results point to specific processes likely to affect higher-order social cognition judgments, this time by influencing the "internal" information patients (can) resort to at the interpretation stage. Indeed, failing to recognize other people (their identity) may lead to erroneous judgments of their behaviour and underlying intentions by preventing access to previous experiences and knowledge associated with them (Stolier & Freeman, 2016). Similarly, enhanced access to negative versus positive social experiences may favor negative evaluations of social situations, especially in ambiguous contexts, and hence contribute to patients' well documented hostile attributional biases and interpretations (Barry et al., 2019; Freeman et al., 2018; Chapters 5 and 6).

Conjointly, our findings indicate that patients with SAUD show specific modifications in 1) the external social information they attend to in the environment, and 2) the novel social information they initially store into memory and the type of social memories they more easily access. These results demonstrate the value of, and detailed insights that can be obtained by, integrating social cognition research in SAUD in a model decomposing categories of relevant processes. They point to more extensive (and at least partly non-domain-general) social information processing changes than executive functioning and visual accounts would

predict and allow for a refinement of our proposal that SAUD is associated with biases in the processing of socially threatening information. Indeed, they suggest that negative/ hostile biases manifest at rather late processing stages, whereas earlier ones may be better characterized by a lack of positive biases. Altogether, their primary contribution in the context of the present thesis lies in the documentation of precise, basic processes that could constitute actionable mechanisms explaining part of social cognition alterations in SAUD by disrupting distinct information processing steps (Figure 12).

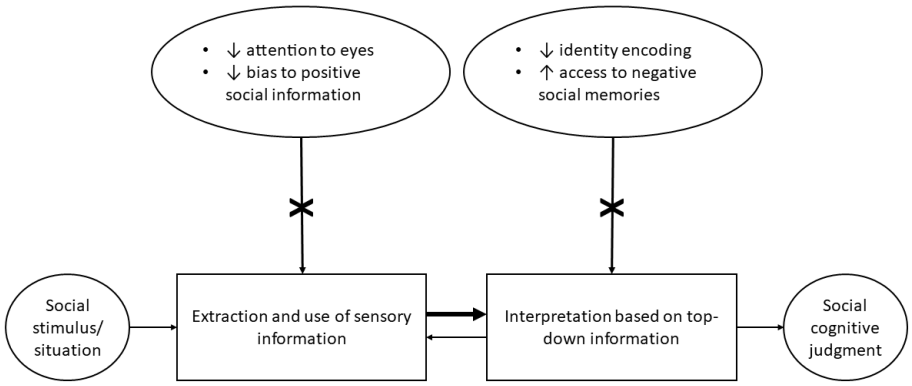

Figure 12*. Illustration of the possible impact of the observed attentional and memory mechanisms on the normal processing of social information.*

2.2.3 A preliminary model of basic social information processing in SAUD

In the previous sections, we discussed our results in the attention and memory domains in isolation and suggested that they independently point to processes potentially contributing to higher-order social cognition alterations in SAUD. Yet we propose they are most informative when considered in conjunction, within a model of basic social information processing that describes their potential relations and interactions in affecting social cognition judgments. Such an integration yields a more nuanced and richer depiction of how the different processes likely unfold and manifest in realistic settings. This also allows for better localizations of the probable sources of alterations along the processing stream. We provide a tentative proposal of such a model in Figure 13. It comprises the attentional and memory processes found to be altered (in addition to the preserved positive bias at encoding) and specifies potential relations between them and with social cognition judgments. It is by no means meant to exhaustively capture the complex relations among those processes, but to highlight those we think are of particular relevance from fundamental and applied perspectives in our context.

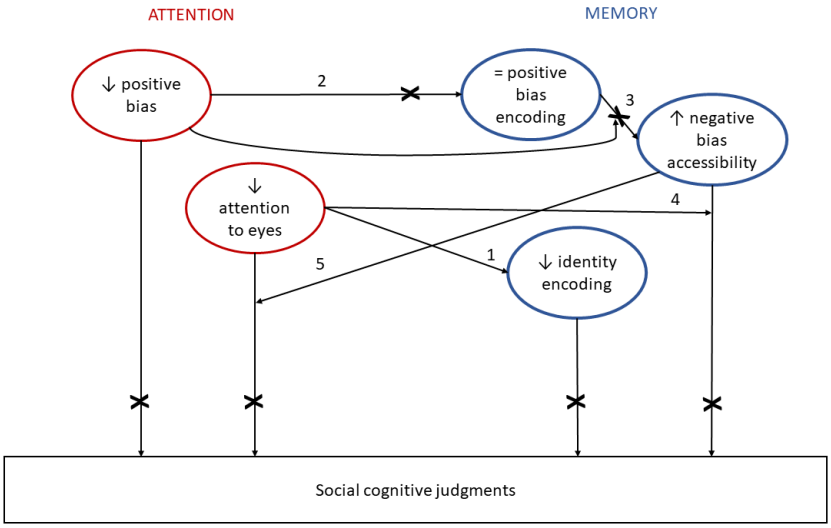

Figure 13. *Preliminary model of basic social information processes in SAUD their potential relations and interactions in affecting social cognitive judgments.*

The first relation we stressed is between reduced attention to the eye-region and reduced identity recognition (1). Previous work has shown that attention to the eyes is beneficial for identity recognition (Chuk et al., 2017; Peterson & Eckstein, 2012). Hence, patients' specific difficulties in the encoding of this specific feature, although manifesting at the memory level, may result from their reduced attention to the eyes. Similarly, we related patients' reduced processing and lack of bias to positive social information in the attentional domain to their preserved positive bias in the encoding domain (2), suggesting that the former may prevent the real-life manifestation of the latter: while patients may indeed show increased encoding of positive social cues in optimal situations where attention is drawn to each stimulus individually and a relatively deep level of processing is ensured (e.g., through hostility/ friendliness ratings), they are unlikely (due to their reduced spontaneous attention to such stimuli) to actually store more positive than negative social information in memory in ecological settings where several social signals simultaneously compete for resources. In turn, this may reduce the potential of increased encoding of positive information to mitigate patients' increased access to negative ones (3). We finally highlighted two complementary interaction effects (4,5). The first reflects the view that increased access to negative social information may exert a particularly strong influence on social cognition judgments when patients fail to attend to central regions such as the eyes, as this would increase the ambiguity of the information, but may conversely have a lesser effect in situations where participants disambiguate social stimuli by attending to and extracting the relevant facial information (4). The second conveys that reduced attention to the eyes may have different (often worse) consequences, for instance on emotion recognition, when coupled with highly accessible negative social memories (5), as the absence of the latter may lead to erroneous but not necessarily hostile inferences about others. These interactions are notably important to consider for predicting how social cognition alterations will vary under different circumstances and which situations are likely to yield most severe impairments (e.g., when

negative social information is highly accessible and facial information is not), as well as for identifying compensation strategies when one process cannot be modulated.

In sum, this model offers insights into the effects the different processes are likely to have on each other, and on how these interrelations may ultimately affect social information processing and social cognition judgments. Consequently, it hinges on which processes constitute more heuristic intervention targets in different situations.

2.3 Limitations

Again, specific limitations pertaining to the above-described studies need to be acknowledged. First, our interpretations of alterations in the social attentional and memory domains are based on single studies and several aspects of our results constrain their strength and definitiveness. For instance, in Chapter 8, our findings of reduced attention to positive facial expressions and lack of attentional bias in SAUD selectively emerged in the first block of stimuli. Similarly, in Chapter 9, group differences in encoding performance for individuals' identities were only marginally significant. Confirmation of these findings is therefore necessary.

Second, except in the case of the study described in Chapter 7, where we explored associations between attention to facial features and emotion recognition performance (although the task was not optimized for this purpose), we did not directly investigate the links between our putative mechanisms and the relevant social cognition components they could underlie. Therefore, although our findings highlight social information processing alterations that are theoretically relevant, if, to what extent, and how they actually affect social cognition judgments in SAUD, requires empirical substantiation.

Third, we assessed attentional and memory processing in isolation in different samples (all studies from the second block comprised different, non-overlapping samples). Hence, the proposed relationships and interactions between processes remain to be demonstrated.

Fourth, although our pattern of findings suggest that they cannot be comprehensively accounted for by domain-general or executive and visual impairments, we did not directly assess or control for these processes in our analyses.

2.4 Perspectives

2.4.1 Confirmation of our findings and investigation of links with social cognition components

In addition to confirming, through replication using different paradigms, that patients with SAUD indeed show alterations (or preserved functioning e.g., no attentional bias to social threat) in the above-described information processing components, it is essential to directly establish their link with performance/ bias at tasks assessing higher-order social cognition judgments, to clarify those they might be implicated in. Of note, this requires using paradigms that can capture the expected effects of the mechanisms. While classical tasks (Dillon et al., 2016; Dziobek et al., 2006; Gaudelus et al., 2015), already in use in SAUD, may be

considered suitable to detect the effects of reduced eye-gaze or increased access to negative social information, it may be important to resort to alternative measures to evidence the potential effects of reductions in attentional bias to positive social information and identity recognition. Indeed, we proposed that reduced attention to positive social cues would predominantly impact judgments in social situations that contain various, both negative and positive, signals. This could be assessed using tasks asking participants to rate the mean emotional signal conveyed by arrays of faces with different expressions (Bronfman et al., 2018; Yang et al., 2013). Similarly, reduced identity recognition should affect judgments of people that participants have already encountered. This could be evaluated using tasks assessing evaluations of individuals previously associated with negative/ positive traits or behaviours (Kadwe et al., 2022; Murty et al., 2016).

Beyond clarifying the relevance of the proposed mechanisms, studies using these novel tasks would offer insights regarding the breadth and variety of situations in which patients with SAUD experience social cognition difficulties.

This line of studies should also investigate the suggested interactions between attention to facial features and access to negative social information in affecting performance on relevant social cognition judgments (e.g., emotion recognition, Theory of Mind).

2.4.2 Investigation of interrelations between social information processing components

A second important avenue would be to empirically test the between-mechanisms relations highlighted in our model. The role of reduced attention to the eyes in identity recognition could for instance be investigated by recoding eye-gaze during the encoding task described in Chapter 9. The link between reduced/ preserved attentional/ memory biases to positive social information could be investigated using the same encoding task with emotional faces presented in pairs or groups rather than in isolation during the learning phase, and by recording participants' attention to positive versus negative faces.

Results from these studies would improve our understanding of the sources of social cognitive alterations (e.g., if encoding impairments persist despite normal, or after controlling for attention to the eyes, then the faulty process may at least partially be located at the memory level), specify the real-world relevance of our findings, and identify how many and which information processing stages should be targeted to yield maximal benefits (e.g., if positive encoding biases in SAUD do not emerge when several cues are simultaneously present and relate to attentional biases, then it seems important to directly address attention allocation to positive social cues to ensure their appropriate storage).

2.4.3 Consideration of other sources of socially relevant information

While the abovementioned perspectives aim at confirming the already described alterations and testing the preliminary model we proposed, there is obviously also considerable room for an extension of this model.

Within investigated domains, future studies should examine patients' processing of other socially relevant information. Regarding attention, it would be relevant to determine if patients differ in their attention to faces more generally, and other person-centered information such as body postures, in naturalistic social scenes (Rubo et al., 2023) or social cognition tasks (Dziobek et al., 2006). Indeed, such cues are critical for accurate social cognition judgments and are less attended to by impaired individuals (Aviezer et al., 2017; Frazier et al., 2017).

In both attentional and memory domains, it also seems warranted to go beyond person-centered information, as models increasingly emphasize the importance of processing external context (although context can also encompass non-facial person information, depending on the targets of judgments) for accurate social cognitive judgments (Achim et al., 2013; Aviezer et al., 2017; Barrett et al., 2011). How patients attend to and integrate context could be investigated via tasks assessing social cognition performance using both contextualized and de-contextualized social information (Sasson et al., 2016) and recording their eye-movements to persons and context. This could reveal whether patients benefit from contextual cues and whether their attentional pattern relates to (the absence of) context-related improvements in social cognitive judgments, or whether higher-level, integration processes are involved. Of note, some studies have shown that patients with SAUD fail to benefit from auditory cues when recognizing facial emotions (e.g., Maurage et al., 2007, 2013; but see Creupelandt et al., 2020), but it is unknown whether these effects are specific to auditory context or whether attention plays a role.

At the memory level, context processing could be investigated by similar tasks to the one used in Chapter 9, but using stimuli depicting interacting individuals in a given context (Lee et al., 2018). Such tasks would allow probing both persons and context encoding and recall. Together, results from context processing studies could offer critical mechanistic insights for social cognition alterations, and notably social perception and knowledge abilities, which are comparatively underserved by our current model. Indeed, insufficient attention to context may hinder appraisals of complex social situations and repeated difficulties in encoding the associations between individual behaviour/ expressions and specific contexts could impede the formation of knowledge regarding what is typically expected in those contexts.

2.4.4 Consideration of other social cognitive processes

In addition to expanding research on the type of social information patients are likely to improperly attend to or memorize, our model should be enriched by considering other processes that could interfere with social cognitive judgments.

Social expectations or internal representations of social objects are especially relevant. Indeed, what people expect of social situations before entering them, and what they believe instances of given social objects should look like, strongly influences how they perceive and interpret social information (Keating & Cook, 2023; Schwarz et al., 2016; Smeijers et al., 2019). In addition, modifications in these processes could constitute central hubs in our model. Altered expectations/ representations may be fuelled by systematic alterations in attention (e.g., reduced attention to positive social information may diminish future positive expectations or prevent the reappraisal of negative expectations) and memory (e.g., increased access to and rehearsal of negative social memories may increase negative expectations),

favour their occurrence (e.g., expecting others to be hostile may favour the processing of hostile information), and/ or mediate their impact on social cognition judgments (e.g., online hostile attributional biases may not directly be caused by increased access to specific negative memories, but by the general negative expectations they contributed to form).

We recently provided initial evidence of altered social expectations by showing that patients with SAUD show elevated rejection sensitivity (Pabst et al., 2023a), a disposition to specifically anticipate being rejected by others. Future work is needed to determine the breadth of social expectations or representations that may be altered in SAUD. These may concern very general social concepts (e.g., expectations that 'others' tend to be malevolent), that could be assessed via self-report social schema instruments used in other psychiatric groups (Humphrey et al., 2021). These may also concern much more specific concepts such as emotional expressions. Indeed, recent work evidenced substantial individual differences in people's internal representations of what typical facial expressions of given emotions look like, and showed that such differences predict emotion recognition performance (Binetti et al., 2022; Keating & Cook, 2023).

Determining whether there are systematic alterations in patients' emotional expression representations can be considered a priority avenue given the well documented functional and clinical relevance of emotion recognition in SAUD, and the far-reaching implications such modifications could have for their mechanistic conceptualization and treatment. For instance, fundamental differences in what patients believe facial expressions look like could prevent accurate recognitions even if normally processed: if an ostensible fearful face simply does not match what a patient thinks a fearful face is, or if does not better correspond to their representation of fear compared to that of other emotions, then it does not matter how it is attended to. It is also conceivable that representations are altered in a way that make the eye region less important to patients (e.g., fearful faces are not believed to be characterized by a marked widening of the eyes), which would cause reduced attention to the eyes, or that less eye-intensive representations are the long-term consequences of chronic reductions in eye processing. In those cases, reduced eye-gaze would either not be causally related to emotion recognition, or successful manipulation of eye-gaze would not be expected to directly translate to improvements in performance. A way to start investigating these possibilities could be to evaluate patients' representations of emotional expressions using a recently developed paradigm (Binetti et al., 2022; see Figure 14), along with facial emotion recognition performance and of attention to facial regions. This would allow establishing whether and where on the face group differences in representations exist (and confirming that differences in eye-attention do as well), whether they relate to emotion recognition performance and facial attention, and whether they can account for group differences in facial attention, or for the relation between attention and performance in patients.

All in all, expectations and internal representations form a promising avenue to extend our model and refine our understanding of the chains of mechanisms affecting social cognition judgments.

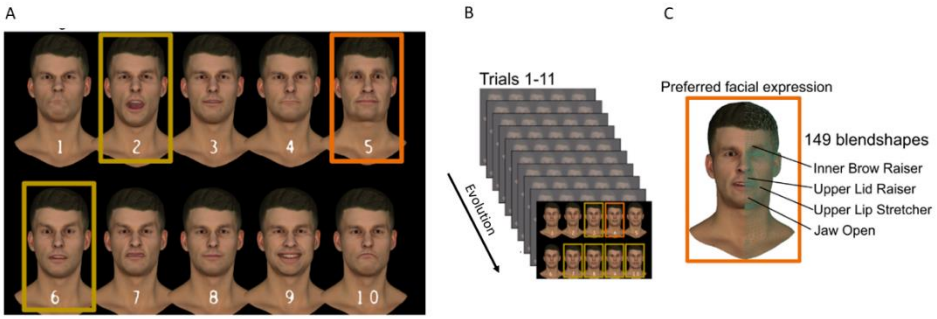

Figure 14. *Illustration of the task developed in Binetti et al., 2022. Participants select faces best representing a given emotion (A) across ten trials that adapt to previous selections using a genetic algorithm (B). The face selected on the last trial (C) indexes participants' representation of the given emotion. The level of activation of the 149 possible facial locations that can vary (blendshapes) are quantified in the last face for analyses.*

2.4.5 Making room for the elephant: Consideration of general cognitive impairments

We shed light on a pattern of social information processing alterations that are unlikely to be fully attributable to general cognitive difficulties (future studies should however further corroborate this claim by including non-social control conditions or statistically controlling for non-social cognitive impairments in studies investigating group differences, or identifying clusters of cognitively preserved patients with basic social information processing impairments). Importantly, this does not preclude that general cognitive processes such as visual perception or executive functioning represent additional contributors to social cognition impairments, as suggested by the proposals we reviewed in previous sections (Creupelandt et al., 2019; D'Hondt et al., 2014; Uekermann & Daum, 2008). Indeed, it is obvious that severe visual impairments, for example, would markedly affect social cognition. Our findings also do not exclude that these cognitive impairments play an important, moderating role on the relation between the social information processing alterations we evidenced and social cognitive judgments.

For instance, executive impairments, although probably not causing specific reductions in eye-gaze in the first place, may exacerbate patients' reduced attention to critical social cues, notably in more realistic social settings where several salient but irrelevant signals may need to be inhibited, or conversely help mitigating their effect through effortful redirection of attention. Relatedly, visual difficulties may accentuate the ambiguity of sensory information and thus reinforce the impact of accessible negative memories, whereas executive impairments may prevent patients from resisting the influence of these memories and impede the strategic search of positive material.

Hence, it is essential not to discard the contribution of general processes, and not to consider the two domains as unrelated. Documenting their associations will aid in the development

of a comprehensive understanding of social cognitive alterations in SAUD, and interventions should take into account patients' general cognitive profile.

2.4.6 Experimental manipulation

Ultimately, the value of this line of research resides in the identification of precise variables that are causally implicated in social cognition difficulties, and that can be modified to improve social cognition in SAUD. Hence, a determining step, following cross-sectional investigations confirming interrelations between relevant processes and specific relations with social cognition judgments of interest, will be to test whether and how these processes are indeed amenable to change and whether they yield the expected benefits. This step is necessary to confirm the causal role of the identified processes, and validate their status as mechanisms and clinical utility.

The causal role of eye-attention in patients' emotion recognition performance could for instance be tested by directing their gaze to this region using visual cues superimposed on relevant facial regions (Spilka et al., 2019) or explicit instructions to attend to them (Wolf et al., 2016). Improved performance compared to cue-or-instruction-less conditions mediated by effective increases in eye-attention would provide strong support for the mechanistic role of reduced attention to informative face regions in social cognition alterations. No effect would however point to a reconsideration of the model (e.g., see 2.4.4).

3. General implications, limitations, and outlook

Throughout this discussion, we elaborated on the respective contributions of each line of studies to our understanding of 1) the range of social cognition components patients with SAUD show difficulties in, and 2) the basic social information processing alterations that could underlie them. We also put forward specific limitations and perspectives for future research to move forward on these questions. Below, we want to briefly highlight more general implications of our work for the conceptualization of SAUD. We also mention how our results can contribute to improve the treatment of this disorder. Finally, we acknowledge general limitations of our approach and outline perspectives for future studies on social cognition and beyond in SAUD.

3.1 Implications for the conceptualization of SAUD

Our studies in Chapters 4-9, despite assessing different abilities or tendencies at different levels of analysis, using different procedures, consistently showed that patients with SAUD displayed alterations in some aspects of social processing. These findings do not only confirm previous findings that SAUD is associated with social cognition difficulties, but also show that the range (e.g., components affected) and depth (e.g., information processing stages affected) of these difficulties are substantially greater than previously documented. Moreover, across both lines of studies, we found evidence that
social cognition difficulties are not merely due to domain general cognitive impairments.

Together, these results offer additional support for the idea introduced in Chapter 1 that SAUD should be construed as *also* being an interpersonal disorder, and strengthen the view that interpersonal dysfunctions, as they can be traced back to "internal" and widespread cognitive alterations, find part of their origin within patients with SAUD themselves. Accordingly, our findings further stress the limitations of current individual-level frameworks that largely neglect interpersonal factors (Boness et al., 2021; Flaudias et al., 2019; Kwako et al., 2016; Noël et al., 2013; Wiers et al., 2007), and extend recent calls for an increased consideration of social functioning in conceptualizations of SAUD (Heilig et al., 2016; Rawls et al., 2021). Our conclusions specifically point to an increasingly well characterized social cognition system as a valuable addition to current neuropsychological models of SAUD (i.e., dual-process models and their extensions).

Enriching current models of SAUD through the incorporation of a social cognition system would considerably improve their predictive power by increasing their ability to account for interpersonal problems manifesting at the behavioural, social network, and subjective sense of disconnection/ loneliness levels. This would fill a major gap since we have described in Chapter 1 that, beyond inevitably reducing patients' quality of life, SAUD-related interpersonal problems explain a large proportion of the disorder's public health burden and harm to others, contribute to reduce help and treatment seeking, compromise treatment adherence, and rank among the strongest predictors of relapse following treatment. Understanding and addressing these problems can therefore go a long way toward addressing some of the most pressing challenges posed by SAUD, and a systematic consideration of social cognition in the conceptualization of the disorder may well serve that objective.

An increase in the ability of SAUD models to explain and offer treatment perspectives for interpersonal problems is however not the only benefit that can be expected from the integration of social cognition factors within them. Indeed, such an amendment would also foster meaningful investigations into the relations among the constituent systems of the model. We discussed the potential influence of reduced executive functioning (i.e., "cognitive control system) on social cognition in section 2.4.5, but *all* systems highlighted in recently proposed extended dual-process models (e.g., Koob & Volkow, 2016; Kwako et al., 2016; Noël et al., 2013) are likely to show some relationship to social cognition (see Figure 15).

For instance, as social rejection and distress increase the motivational salience of substance cues (Bach et al., 2024; Heilig et al., 2016), social cognition alterations may elevate the likelihood of biased processing of alcohol in social situations by increasing perceived or actual social rejection. Conversely, increases in processing biases for substance cues may elevate risks of social cognition alterations by diverting cognitive resources from relevant social signals, hence favouring reliance on biased internal information (Monk et al., 2023). Impaired interoception abilities may also contribute to alter social cognition, notably by reducing patients' access to their own feelings or body sensations to make sense of others' (Ondobaka et al., 2017), and interestingly, impaired social cognition could, in return, lead to misinterpretations of own bodily states (e.g., misinterpreting emotional contagion as craving). Finally, social cognition alterations, by deterring the (perceived) quality of relationships, may amplify negative affect, deprive patients from social resources that can buffer against emotional distress (Sahi et al., 2021), and contribute to devaluate non-substance reinforcers such as social interactions (e.g., Quednow, 2020). In turn, negative

affect may potentiate social cognition alterations, notably by increasing the accessibility of negative information to interpret ambiguous social situations (MacLeod & Campbell, 1992).

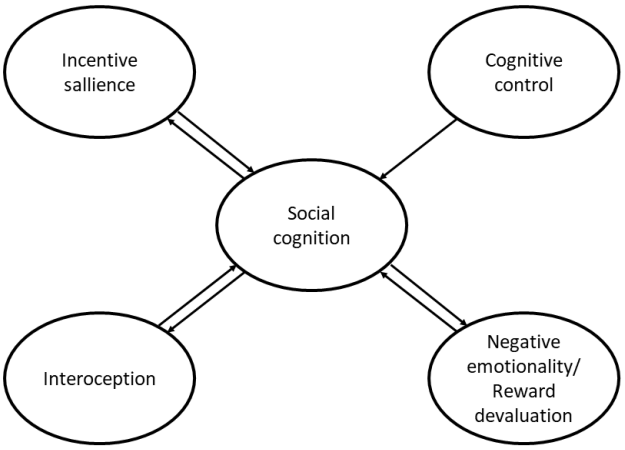

***Figure 15**. Illustration of the possible interrelations between social cognition and other relevant systems highlighted in extended dual-process models*

Hence, in addition to broadening the range of difficulties current models of SUAD can explain and offer therapeutic perspectives for toward the long-neglected interpersonal domain, the inclusion of a social cognition system within these conceptualizations would also open critical research avenues examining between-system relations. These can increase our understanding of the contributions of other systems to social cognition alterations, extending mechanistic investigations to non-purely cognitive processes, and specify the effects of social cognition on problematic consumption. More broadly, they may also lead to a refined sense of the role of other systems in SAUD, and clarify the extent to which their effects are accentuated by social cognition alterations. All in all, the proposed conceptual modification may allow for the development of a more ecologically valid, socially contextualized model of SAUD that can improve the prediction and management of clinically relevant outcomes more generally.

3.2 Clinical implications

In addition to their conceptual implications, our results also point to concrete actions that can be implemented in therapeutic settings to maximize SAUD treatment retention, efficacy, and long-term benefit maintenance.

3.2.1 Maximization of treatment adherence

Our main finding from our first line of studies is that patients' difficulties in the social cognition domain extend to hostile attributional biases and social perception and knowledge impairments. Both alterations could pose serious threats to treatment completion, in line with results focusing on other components (Foisy et al., 2007a; Rupp et al., 2017). Hostile attributional biases may notably compromise therapeutic alliances through misinterpretations of practitioners' actions or intentions. Social perception and knowledge impairments, on the other hand, may prevent patients from correctly identifying the roles and statuses of the variety of workers involved and/ or the rules in effect in different situations, leading them to adopt inappropriate behaviour that could create tensions. Hence, informing practitioners and staff (regardless of their specific discipline) about these social cognition alterations so that they can implement adaptations in the therapeutic environment and in their interactions with patients may represent a cost-effective way of leveraging our findings to increase patients' adherence to, and chances of benefitting from, treatments, whatever their nature.

These adaptations may take the form of clarifications of the roles of the different parties involved in the treatment process, including where or whom to ask for relevant information. Explicitly stating and reminding the rules and behaviour expected from patients in various settings (e.g., how to take turn during group meetings, what themes are appropriate to bring up in group vs. one-on-one settings, use of non-aggressive language, informing staff long enough in advance if appointments cannot be met, room-sharing code of conduct…) may also be beneficial. Finally, although this may seem obvious, practitioners should aim at adopting warm, considerate and empathic attitudes towards patients. More specifically, our findings suggest that they should also strive to minimize ambiguity in their behaviour, notably by providing clear explanations for decisions or acts that may be interpreted as malevolent (e.g., cancellation of a therapy session, refusal to provide a given medication).

3.2.2 Assessment

Our findings of broader social cognition alterations than previously documented at a group level, combined with our and others' evidence of heterogeneity among patients (Maurage et al., 2021; Schmid et al., 2021b), further call for the inclusion of hostile attributional biases and social perception and knowledge in patients' evaluations, and for the systematic assessment of each patient individually. Indeed, given the links between social cognition alterations and interpersonal problems (which we also found in this thesis) and relapse (Hoffman et al., 2019a; Kornreich et al., 2002; Rupp et al., 2017), and indications that social cognition does not naturally recover over the first months of abstinence (Foisy et al., 2007a; Rupp et al., 2021a), it is essential to identify patients with alterations in this domain, and to specify which alterations they display, to provide tailored intervention. A comprehensive assessment of all four components, performed in the context of a larger neuropsychological evaluation, is therefore desirable as it would be maximally informative (Maurage et al., 2023). However, this may prove unfeasible in practice. In these cases, we would propose focusing on those components for which evidence of functional relevance among patients with SAUD has been provided, namely emotion recognition and hostile attributional biases.

Based on our findings, we recommend the use of the Word-Sentence Association Paradigm-Hostility, which we have validated in French (Pabst et al., 2023c) for the assessment of hostile attributional biases. It is a short (<5 minutes) evaluation that is easy to administer and score,

and we have provided evidence supporting its validity and reliability in both healthy individuals and patients with SAUD (see Chapter 6). It therefore currently constitutes the most suitable instrument for measuring this component in this population in clinical practice. One downside of this instrument is that we currently have only limited normative data from individuals matching typical SAUD patient sociodemographics (i.e., our control group in Chapter 6). As highlighted in a previous section, there are currently no other social cognition tasks with evidence of satisfactory psychometric properties in patients with SAUD that would qualify them as the tasks of choice. Until future research sheds light on those tasks, practitioners may resort to available batteries, tapping into the domains of the four-component model, to assess the remaining components. These include the battery from the SCOPE (Social Cognition Psychometric Evaluation) initiative in schizophrenia (Pinkham et al., 2018), which however comprises no social perception and knowledge task, as these were found to be inadequate for clinical use, or the ClaCoS battery (Brénugat et al., 2023), which is available in French, and comprises the tasks that were previously used by our group to investigate emotion recognition (Maurage et al., 2021), Theory of Mind (Maurage et al., 2016), and social perception and knowledge (Chapter 4). This battery has a larger set of normative data, but the general psychometric properties of its emotion recognition and social perception and knowledge tasks remain to be thoroughly investigated.

3.2.3 Interventions

Once patients with social cognition alterations have been identified, they should at least receive psychoeducational interventions informing them about their specific social cognitive profile (which can be illustrated on the basis of their test results compared to normative data), and about the functional consequences of their alterations. Such interventions may be beneficial in increasing patients' insight regarding their social cognition difficulties, which is known to be poor (Le Berre, 2019), and serve as a basis to discuss patient-initiated strategies to mitigate their effect on everyday social functioning (e.g., informing their entourage about these difficulties). Additional low-intensity interventions, notably derived from the Metacognitive Training protocol (Hotte-Meunier et al., 2023; Moritz & Woodward, 2007) may also be proposed to raise awareness of problematic situations, promote the withholding of spontaneous social judgments until sufficient evidence is gathered, encourage the consideration of alternative interpretations for social situations, and emphasize the importance of carefully considering context.

In terms of remediation (i.e., interventions aimed at reducing impairments or biases rather than simply mitigating their consequences), our findings from our second line of studies, while offering interesting perspectives, are currently too preliminary to indicate that acting on any of the purported mechanisms we shed light on will have positive impacts in SAUD. Nevertheless, informing patients of our results and discuss the importance of attending to positive social information and central facial cues, as well as raising awareness on potential tendencies to more easily access negative compared to positive social memories, may lead to improvements. For severely impaired patients, clinicians may wish to resort to adaptations of remediation protocols that have yielded positive results in other populations, some of which align with the recommendations that would flow from corroborations of our findings. For instance, emotion recognition may be rehabilitated using repeated training in the identification of subtle expressions with instructions to attend to salient facial features (e.g., Drusch et al., 2014; Marsh et al., 2012), which have been shown to increase both performance

and attention allocation. Similarly, hostile attributional biases may be decreased through repeated training to generate positive interpretations for socially ambiguous situations (Smith et al., 2018). Theory of Mind performance has been shown to be improved following exercises in which patients are asked to gather a maximum of relevant cues in social videos or pictures, and to identify both literal and potential hidden meanings of characters' interventions, as well as their likelihood given the evidence (Bechi et al., 2013). Unfortunately, we are not aware of specific social perception and knowledge treatments, but our findings indicate that similar exercises systematically encouraging patients to seek relevant cues about the context, and the relationships among individuals in social situations may be helpful.

Assessment and interventions should ideally occur as soon as possible during the detoxification period given that social cognition alterations may interfere with treatment completion and favor post-treatment relapse. They should further be repeated/ continued during post-detoxification treatment in patients attending such programs to monitor longer-term changes and maximize efficacy. Most low-intensity interventions (e.g., psychoeducation) could be offered to all patients with relevant alterations but the more demanding remediation protocols require minimal cognitive functioning and should therefore be adapted/ delayed on the basis of their more general impairment profile. Finally, assessments and interventions could be proposed in non-abstinence-focused settings to improve patients' social functioning and long-term recovery (i.e., controlled drinking). However, the level of consumption should be taken into account when interpreting test results and determining the feasibility and usefulness of treatments.

Together, social cognition interventions may further increase patients' adherence to treatment, and increase their interpersonal functioning post-discharge, in turn maximizing their own and their entourage's quality of life as well as the long-term maintenance of treatment benefits (Hunter-Reel et al., 2009).

3.3 General limitations

In addition to the specific limitations highlighted in the discussion sections focusing on each line of studies, our thesis also comprises general limitations that need to be considered.

A first set of limitations pertains to the characteristics and sizes of the samples we included in our studies. Indeed, our patients were treatment-seeking, recently detoxified (abstinent for eight days to three months) individuals with SAUD that were either inpatients in detoxification centres or outpatients in post-detoxification centres. This represents a relevant population for several reasons. It ensures that the observed effects cannot be attributed to the acute effects of alcohol (Baltariu et al., 2023) or withdrawal. Furthermore, treatment-seekers obviously represent the population of patients that can most readily be helped. Finally, identifying and intervening on relevant (social cognition) alterations early after detoxification is critical given that most relapses occur shortly thereafter (Hunt et al., 1971). However, these sample characteristics preclude generalizations to non-treatment seeking individuals with SAUD, who may have a distinct social cognitive profile. On the one hand, it is conceivable that they may have less social cognition difficulties, as they have been shown to report fewer interpersonal problems (Chapman et al., 2015). On the other hand, individuals with SAUD and more social cognition difficulties may also be less likely to seek others' help (Pabst et

al., 2023a; Schomerus et al., 2011). Future studies should disentangle these possibilities and investigate social cognition in these individuals. These characteristics also preclude generalizations to patients with SAUD who have achieved longer periods of abstinence.

Relatedly, the issue of comorbidity warrants commenting. The patients we included were screened upon admission into the treatment centers by a trained psychiatrist to ensure that alcohol consumption was currently their primary problem and that they did not present major comorbidities necessitating preliminary intervention. Furthermore, we included only patients reporting no history of problematic use of other substances (except nicotine) or psychiatric or neurological disorders besides depressive and anxiety disorders (we also controlled for depression, anxiety, and social anxiety symptoms in our analyses). This is a strength, from a fundamental perspective, as it minimizes the possibility that our observed group differences reflect the effect of other disorders (Cotter et al., 2018) and lends confidence to the idea that there is a relatively specific or "true" relationship between SAUD and social cognition impairments (future studies aiming at determining the specificity of this relationship may nevertheless consider alternative, more direct approaches to controlling for frequent comorbidities e.g., including clinical control groups). It also importantly suggests that social cognition impairments can be observed in relatively "pure" cases of SAUD and calls for systematic clinical consideration of these difficulties during SAUD treatment. However, this also restricts the generalizability of our findings to a subset of patients that does not represent a substantial proportion of cases. Indeed, in practice, patients with SAUD often present with other comorbid diagnoses. For instance, the lifetime prevalence of other substance use disorders (excluding nicotine) in patients with SAUD is estimated to be around 40%, while the current prevalence of personality disorders lies around 20% (Castillo-Carniglia et al., 2019). Ulterior work should therefore consider including patients with other frequent comorbidities or recruiting larger, unselected samples that are subsequently subtyped based on comorbidity status.

Finally, although we strove to base our recruitment on a priori power analyses (except in Chapters 4 and 5), our samples were generally small, which could explain why we did not detect hypothesized group effects (e.g., in Chapter 8, where the expected effect size may have been overestimated), and constrained our ability to observe significant correlations in our exploratory analyses.

A second set of limitations pertains to our designs. Indeed, our studies were exclusively cross-sectional. This notably prevented us from establishing important directional or causal relationships between alterations in social cognition components and interpersonal problems in our first line of studies (Chapters 5 and 6), and between our purported mechanisms and their corresponding social cognitive impairment (which were both assessed in Chapter 7). The absence of follow-up assessments further precluded examinations of the temporal evolution of social cognition alterations over abstinence, which are essential to verify the assumption that, like other components (Rupp et al., 2021a), those we investigated here remain relatively stable and therefore represent credible contributors to interpersonal problems in the months following treatment, and relevant intervention targets. The absence of follow-up also prevented assessments of the predictive relationship between social cognition and clinical outcomes such as drop-out or relapse. Finally, our cross-sectional designs did not allow us to determine whether social cognition and social information processing alterations preceded and/ or followed SAUD onset. While this was not an essential question in our specific context, as we aimed at better documenting alterations and underlying

mechanisms that could contribute to the maintenance of SAUD once established (and stable social cognition alterations may do so regardless of when or why they arose), it will be important to qualify the directional relation between social cognition and SAUD to better understand its origins and develop effective primary and secondary prevention strategies.

A final set of limitation pertains to our experimental material and setting. Indeed, our studies generally relied on social cognition tasks comprising simplistic, often static, decontextualized, and never encountered, social stimuli that, while providing increased experimental control, can be criticized for lacking ecological validity and hence offering only modest insight into patients' real-life difficulties (although the relations we and others evidenced between these tasks and interpersonal problems provide some support their relevance) (Barrett et al., 2019a; Osborne-Crowley, 2020; Spreng & Mar, 2012). In addition, in our task-settings, participants were placed in the position of third-person observers. Such tasks cannot capture the individual engagement, interactivity and reciprocity that characterize much of social situations in which everyday social cognition occurs, and which have been suggested to influence the processes engaged during social cognitive judgments (Osborne-Crowley, 2020; Quesque & Rossetti, 2020; Schilbach et al., 2013). Finally, we aggregated data from patients in different treatment centres in Belgium to attain our desired sample sizes. These sites may differ with regard to important variables, and notably access to, type, and frequency of, social activities patients had the opportunity to engage in, that may have influenced our social cognition outcomes.

3.4 An outlook for SAUD research

As a central avenue to help the field of social cognition in SAUD move forward, future studies should aim at overcoming the above-mentioned general limitations by 1) expanding the present investigations toward other populations of individuals with SAUD such as those not seeking treatment (in whom assessments of relations between social cognition and reluctance to seek help would be relevant), and those presenting with comorbidities including problematic polysubstance use (Lewis et al., 2020); 2) conducting longitudinal studies examining when social cognition alterations emerge and characterizing their temporal stability over abstinence and their prospective relationships with indicators of interpersonal functioning and clinical outcomes; 3) increasing the ecological validity of tasks assessing both social cognition components (e.g., using emotion recognition tasks with dynamic, non-posed, and/ or contextualized stimuli, Theory of Mind tasks in which participants directly interact with another individual; or tasks assessing social judgments about already encountered individuals; Chen & Whitney, 2019; Murty et al., 2016; van der Schalk et al., 2011; Wu & Keysar, 2007; Yitzhak et al., 2017), and potential social information processing mechanisms (e.g., by assessing participants' attention to important social features during an actual interaction; Clin & Kissine, 2023).

We would also like to highlight the potential of two broader and novel fields of investigations that may complement and build upon the acquired knowledge on social cognition to 1) clarify the implications of the inclusion of this component in current SAUD models, and 2) extend our understanding of the processes contributing to interpersonal dysfunction in SAUD.

3.4.1 Assessment of the relations between social cognition alterations and other systems

We already mentioned that the inclusion of social cognition alterations within current conceptualizations would foster investigations on the interrelations that are likely to exist between the various components of these conceptualizations. We would like to insist on the value of such research, both for clarifying the extent of social cognition effects on SAUD symptoms other than interpersonal problems, as well as for the renewed understanding of other relevant processes. To illustrate our point, we focus on the specific relationship between social cognition alterations and biased processing of substance related cues (a central process in current SAUD models).

Given the previously described link between social stress and rejection and increased motivational salience of alcohol cues (Bach et al., 2024; Heilig et al., 2016) on the one hand, and the fact that social cognition alterations are likely to increase perceived or actual social rejection and social stress on the other hand, it can be hypothesized that patients with greater social cognition alterations may show increased biases toward alcohol cues in social situations, particularly ambiguous and objectively stressing ones. This could be tested, for example, by examining the moderating role of patients' social cognition alterations on differences in alcohol attentional bias indices (e.g., Bollen et al., 2021) between social and non-social conditions.

If confirmed, this relationship may provide answers to important questions such as: "How do social cognition and interpersonal problems maintain problematic consumption or increase the risk of relapse?" (e.g., in part by increasing biases to substance cues in social situations), "What are at-risk situations in which biases to alcohol are most likely to manifest?" (e.g., at least in patients with social cognition alterations, social situations), "How to best assess and train those biases?" (e.g., at least in patients with social cognition alterations, assessments in social contexts may be more revealing, and training in social contexts may be most effective).

Hence, establishing relationships between social cognition alterations and other processes relevant to SAUD bears major fundamental and clinical implications. In our example, the evidenced link would provide one explanatory account for the link between social cognition and relapse (Rupp et al., 2017), clarify interactions between patient and situational characteristics predicting biased processing of substance cues, offer perspectives for improving clinical assessment based on patient characteristics, point to adaptations (patient selection and social contextualization) of substance bias modification procedures that may renew interest in this technique, and support social cognition remediation and substance bias modification as complementary interventions to maximize long-term abstinence in at-risk patients. Clarifying such relationships should therefore be the focus of a comprehensive research program.

3.4.2 Beyond social cognition: toward a comprehensive investigation of social processes in SAUD

While it is undeniable that social cognition alterations contribute to deteriorate interpersonal functioning, they may not constitute the only relevant individual-level factor in that regard in SAUD. In interpersonal situations, involved parties successively endorse the roles of

perceiver and emitter of social information. Hence, misunderstandings and ensuing tensions and conflicts (i.e., interpersonal problems) may result from failures to adequately process (i.e., social cognition alterations), but also emit/ express/ communicate social information (i.e., social *production* alterations). In support of this, a growing literature in both healthy and psychiatric populations denotes the negative interpersonal consequences (for both perceivers and emitters) associated with difficulties in accurately and clearly conveying one's mental states (Brüne et al., 2007; Gregory et al., 2023; Human & Biesanz, 2013; Troisi et al., 2007; Zaki et al., 2008). Whether patients with SAUD, like other disorders, show difficulties in social production that hamper others' understanding of what they think or feel, however, is unknown, as research has up to now failed to consider their active contribution to the social communicative situation. Nevertheless, there are indications that they might. As mentioned in Chapter 1, SAUD is associated with motor impairments and preliminary evidence suggests that these extend to reduced facial expressiveness (Dethier et al., 2014; Dethier & Blairy, 2012). The reduced attention to the eyes that we documented in Chapter 7 may further lead to difficulties in making oneself understood, as eye-contact serves both an information-gathering and a communicative/ signalling function (Risko et al., 2016). Finally, social cognition, and notably Theory of Mind alterations, which are present in SAUD (Bora & Zorlu, 2017), were found to be related to social production alterations, supporting a role of understanding others in the effective communication of social information (Achim et al., 2023; Brüne et al., 2009). Empirically determining whether patients with SAUD show social production alterations is therefore warranted. This may be initiated using a similar paradigm to Gregory et al. (2023), where participants are asked to describe negative and positive life events while being video-recorded and subsequently provide continuous ratings of their own affect while viewing their video. These ratings are then correlated with those of external viewers to yield an index of social production accuracy: the higher the correlation the more accurately external viewers perceived participants' affect. Links between this index and measures of facial of prosodic expressiveness, gaze behaviour, or language specificities can then be investigated to identify sources of potential reductions in production accuracy.

In a similar vein, research on social cognition (which is focused on the perception and interpretation of social information) should be complemented by more thorough investigations of social decision-making (the concrete choices with outward consequences that participants implement in social settings) in SAUD. Such investigations may shed light on additional independent processes (e.g., limited response repertoire, sensitivity to moral norms or to the consequences of decisions, tendency for inaction) to understand interpersonal difficulties and/ or point to potential bridges between social cognition alterations and relational problems at behavioural and social network levels (Gautier et al., 2021; Gawronski et al., 2017). For instance, reduced social perception and knowledge may lead to decreases in choices congruent with norms. To date, very few studies with important methodological shortcomings have investigated patients' performance in this domain, but interesting suggestions have been made to address this gap using ecological paradigms (e.g., participants have to make decisions affecting interacting counterparts that they see before starting the computer task and hence believe to be real) coupled with physiological measures (e.g., eye-tracking to measure potential attentional underpinnings of patients' decision-making) that are anchored in clear conceptual and statistical frameworks and hence allow identifying underlying processes (Gautier et al., 2021).

All in all, in order to reach a comprehensive understanding of the range of individual-level factors compromising interpersonal functioning in SAUD (i.e., social processes), and

consequently enrich our arsenal of therapeutic levers, investigations of social cognition alterations in SAUD (how they perceive and interpret social information) should be extended to social production (how they express/ convey social information) and social decision-making (how they make choices affecting others in social contexts).

4. Conclusion

In this thesis, we made two main contributions to the SAUD literature. First, we provided evidence that SAUD is associated with a broader range of social cognition difficulties than previously documented. Indeed, whereas earlier research established the presence of emotion recognition and Theory of Mind impairments in this disorder, we showed here that patients also displayed hostile attributional biases and impairments in social perception and knowledge, which represent other central but neglected components of social cognition highlighted in an influential model.

Second, we identified basic social information processing alterations that could underpin some of the social cognition difficulties displayed by patients. Specifically, at the attentional level, we showed that patients attended less to the eye region of facial expressions and lacked the attentional bias to positive vs. neutral social information that was evident in healthy individuals. At the memory level, we evidenced subtle difficulties in the initial encoding of novel facial identities, as well as greater access to negative compared to positive memories of previously experienced social interactions.

These findings 1) yield a more comprehensive description of the individual-level, social cognitive, difficulties that may contribute to patients' interpersonal problems, which remain largely overlooked despite their considerable influence on the course and severity of SAUD, and 2) offer a preliminary mechanistic conceptualization of these difficulties by shedding light on precise and actionable processes that may underlie them. By introducing and supporting the relevance of novel frameworks, our results further lay the foundations for a more structured investigation of social cognition difficulties and their underpinnings in SAUD.

At a more general fundamental level, this thesis suggests that current models of SAUD should be expanded to incorporate a social cognition system, and we outline some of the benefits that can be expected from this inclusion. At a clinical level, our findings point to practical recommendations to minimize treatment drop-out in SAUD improve the assessment of social cognition. They also offer interesting perspectives in terms of social cognition rehabilitation interventions.

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Appendices

Appendix 1. Socio-demographic, psychopathological, interpersonal problems, and alcohol-related measures in patients with severe alcohol-use disorder (SAUD) and healthy controls (HC): Mean (SD), separately by gender (Chapter 6).

	SAUD (*n*=56)		HC (*n*=66)		Group effect (*p*)	Gender effect (*p*)	Interaction (*p*)	Decomposition
	Women (*n*=28)	Men (*n*=28)	Women (*n*=27)	Men (*n*=39)				
Age	52.71 (8.88)	46.89 (10.25)	48.74 (10.81)	45.79 (12.12)	0.200	0.028	0.467	
Education level (in years)	14.21 (2.11)	14.14 (2.30)	15.04 (2.55)	14.33 (2.82)	0.270	0.398	0.491	
BDI[a]	11.73 (6.09)[2]	9.67 (6.22)[4]	3.82 (4.46)	2.51 (2.19)	<.001	0.063	0.671	
STAI[b]-State	29.43 (7.48)	35.21 (11.60)	30.89 (7.17)	27.15 (6.30)	0.030	0.497	0.002	Men HC < Women HC = Women SAUD < Men SAUD
STAI-Trait	53.78 (9.44)[1]	51.26 (8.81)[4]	41.11 (9.00)	36.66 (8.85)[1]	<0.001	0.042	0.571	
LSAS[c]	56.54 (31.41)[2]	45.33 (26.88)[4]	44.81 (27.50)	32.46 (25.34)	0.020	0.026	0.913	

Total IIP[d]	101.11 (32.87)	87.90 (32.47)[1]	70.41 (29.91)	61.05 (35.19)[1]	<0.001	0.064	0.750	
Domineering	7.18 (3.06)	7.22 (3.08)	5.44 (3.26)	5.42 (3.72)	0.005	0.987	0.957	
Self-centered	8.61 (5.13)	8.57 (4.94)	5.59 (3.63)	6.00 (4.24)	0.001	0.822	0.791	
Cold/Distant	10.14 (6.58)	9.30 (7.76)	6.33 (4.32)	5.55 (5.12)	<0.001	0.464	0.976	
Socially Inhibited	12.25 (9.72)	11.08 (8.86)	9.37 (6.83)	6.55 (6.95)	0.015	0.184	0.582	
Nonassertive	17.00 (8.26)	11.93 (8.74)	12.52 (6.48)	9.21 (7.32)	0.013	0.004	0.536	
Overly accomodating	17.14 (7.50)	12.19 (6.61)	13.44 (5.68)	10.24 (6.47)	0.022	0.001	0.473	
Self sacrificing	18.96 (6.99)	16.70 (5.93)	13.48 (5.85)	11.37 (6.72)	<0.001	0.068	0.951	
Intrusive	11.75 (8.08)	12.77 (5.76)	5.92 (4.20)	6.39 (5.88)	<0.001	0.492	0.800	
AUDIT[e]	32.04 (5.03)[4]	29.87 (5.69)[5]	2.48 (1.95)	3.67 (2.33)	<0.001	0.504	0.025	Women HC < Men HC < Men SAUD = Women SAUD
Number of abstinence days	30.63 (24.18)[1]	19.22 (10.85)[1]	/	/	0.032	/	/	
Number of previous detoxifications	1.71 (2.32)	1.04 (1.62)	/	/	0.210	/	/	
Duration of SAUD (in years)	19.43 (16.03)	19.68 (18.37)	/	/	0.956	/	/	

Number of alcohol units per day[f]	14.55 (6.71)	19.50 (12.87)	/	/	0.079	/	/
Number of DSM-5 SAUD symptoms	9.07 (1.63)	8.37 (1.76)[1]	/	/	0.131	/	/

[a] Beck Depression Inventory (Beck & Steer, 1987).
[b] State/Trait Anxiety Inventory (Spielberger & Gorsuch, 1983).
[c] Liebowitz Social Anxiety Scale (Liebowitz, 1987).
[d] Inventory of Interpersonal Problems (Horowitz et al., 2003)
[e] Alcohol Use Disorder Identification Test (Babor et al., 2001.
[f] Before detoxification (an alcohol unit corresponds to 10 gr of ethanol).
Note = Superscript numbers indicate the number of missing data.

Appendix 2. Correlations between benign and hostile attribution scores, psychopathological symptoms and interpersonal problems in the whole SAUD sample, as well as in men and women separately (Chapter 6).

	Benign						Hostile					
	Whole sample		Women		Men		Whole sample		Women		Men	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
	-0.11	0.427	-.35[2]	.077	.05[4]	.804	0.11	0.457	.12[2]	.557	.24[4]	.263
BDI[a]												
STAI[b]-State	-0.13	0.346	-.20	.318	-.02	.907	**0.26**	**0.050**	.20	.296	.18	.367
STAI-Trait	0.00	0.999	-.19[1]	.340	.16[4]	.467	0.05	0.719	.07[1]	.723	.15[4]	.491
LSAS[c]	0.03	0.862	-.06[2]	.783	.05[4]	.825	0.07	0.615	.14[2]	.510	.19[4]	.367
	-0.16	0.202	-.18	.350	.08[1]	.688	0.22	0.113	.37	.054	.24[1]	.234
Total IIP[d]												
Domineering	0.01	0.910	-.00	.962	-.26	.189	**0.38**	**0.004**	**.38**	**.044**	**.41**	**.034**
Self-centred	-0.14	0.252	-.32	.102	.10	.063	**0.30**	**0.025**	**.41**	**.030**	.23	.252
Cold/Distant	-0.23	0.071	**-.45**	**.016**	.06	.754	**0.34**	**0.010**	.37	.053	**.40**	**.042**
Socially Inhibited	-0.14	0.253	-.24	.230	.10	.616	0.20	0.143	.29	.131	.17	.391
Nonassertive	-0.16	0.204	-.15	.448	.19	.346	0.02	0.904	.17	.383	.07	.718
Overly accomodating	-0.08	0.534	.32	.100	-.04	.842	- 0.12	0.395	.04	.847	-.07	.742
Self sacrificing	-0.07	0.590	.00	.973	.17	.391	0.04	0.755	.16	.426	.05	.809
Intrusive	-0.04	0.734	-.12	.551	.01	.948	0.17	0.202	.14	.466	.19	.340

[a] Beck Depression Inventory (Beck & Steer, 1987).
[b] State/Trait Anxiety Inventory (Spielberger & Gorsuch, 1983).
[c] Liebowitz Social Anxiety Scale (Liebowitz, 1987).
[d] Inventory of Interpersonal Problems (Horowitz et al., 2003)
Note = Bold lines indicate a significant correlation. Superscript numbers indicate the number of missing data.

Appendix 3. Reliability estimates obtained using Spearman-Brown-corrected averages of 5000 permutations of random split-half correlations (Chapter 7).

		First fixation prop.		*Dwell-time proportion*		*Total fixations proportion*	
		SAUD	HC	SAUD	HC	SAUD	HC
Across emotions	Eyes	0.99	0.99	0.99	0.99	0.99	0.99
	Mouth	0.97	0.99	0.99	0.99	0.99	0.99
	Nose	0.97	0.99	0.99	0.99	0.99	0.99
Anger	Eyes	0.93	0.92	0.97	0.98	0.97	0.97
	Mouth	0.90	0.93	0.97	0.97	0.96	0.97
	Nose	0.89	0.94	0.94	0.97	0.95	0.97
Contempt	Eyes	0.94	0.95	0.97	0.98	0.97	0.97
	Mouth	0.87	0.94	0.96	0.97	0.95	0.97
	Nose	0.88	0.95	0.94	0.97	0.94	0.97
Disgust	Eyes	0.93	0.94	0.97	0.97	0.96	0.97
	Mouth	0.91	0.91	0.96	0.96	0.95	0.95
	Nose	0.84	0.95	0.93	0.95	0.93	0.96
Fear	Eyes	0.93	0.94	0.97	0.97	0.97	0.97
	Mouth	0.87	0.96	0.97	0.98	0.97	0.97
	Nose	0.87	0.95	0.94	0.97	0.94	0.96
Sadness	Eyes	0.92	0.93	0.97	0.97	0.97	0.97
	Mouth	0.81	0.97	0.97	0.97	0.97	0.96
	Nose	0.86	0.94	0.94	0.97	0.93	0.97

Appendix 4. Proportions of correct emotion recognition trials [Mean (SE)] in patients with SAUD and HC across all trials (Total) and as a function of intensity class, emotional expression, and the interaction between intensity class and emotion recognition (Chapter 7).

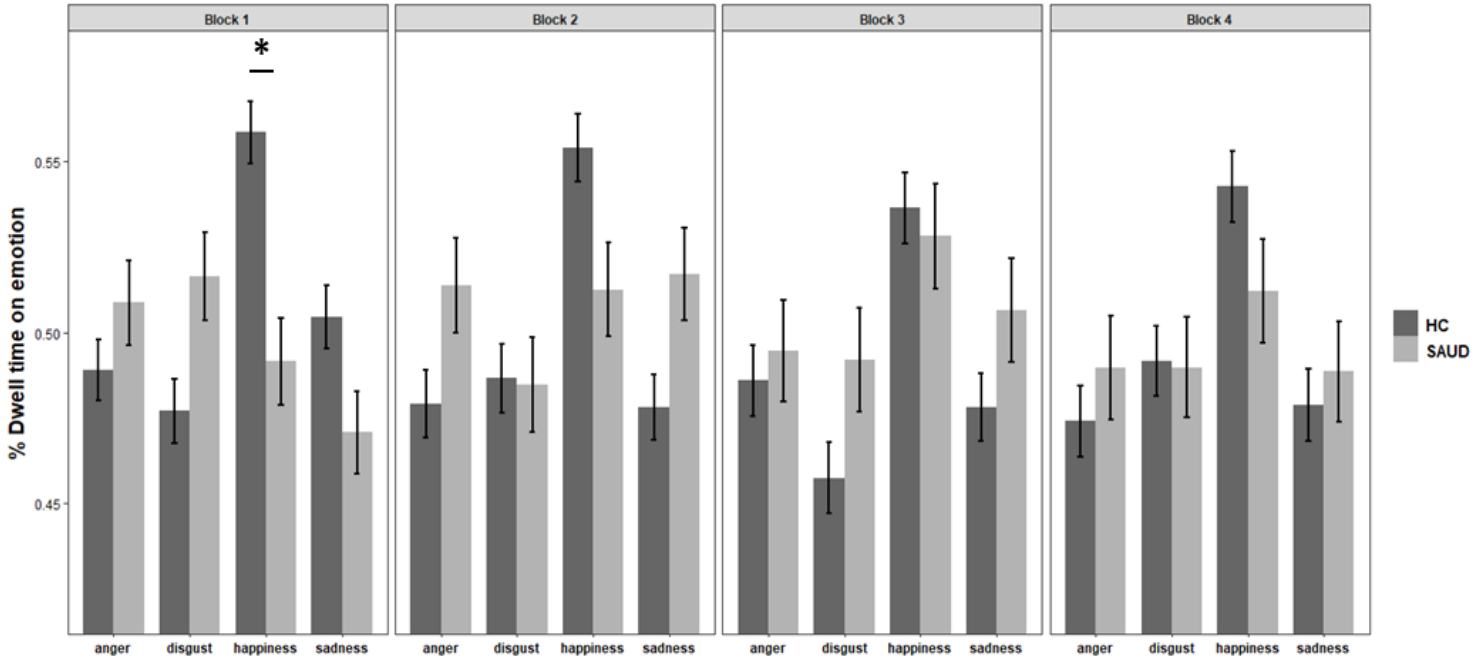
		SAUD	HC
Total		0.723 (0.012)	0.749 (0.011)
Intensity			
	High	0.899 (0.010)	0.913 (0.010)
	Medium	0.831 (0.012)	0.851 (0.012)
	Low	0.439 (0.018)	0.482 (0.018)
Emotion			
	Anger	0.638 (0.029)	0.666 (0.027)
	Contempt	0.799 (0.018)	0.821 (0.020)
	Disgust	0.739 (0.026)	0.756 (0.025)
	Fear	0.658 (0.031)	0.731 (0.029)
	Sadness	0.779 (0.020)	0.772 (0.019)
High			
	Anger	0.905 (0.015)	0.898 (0.018)
	Contempt	0.850 (0.028)	0.873 (0.036)
	Disgust	0.927 (0.021)	0.945 (0.016)
	Fear	0.907 (0.025)	0.973 (0.010)
	Sadness	0.905 (0.020)	0.880 (0.020)
Medium			
	Anger	0.747 (0.031)	0.775 (0.033)
	Contempt	0.848 (0.024)	0.847 (0.034)
	Disgust	0.895 (0.021)	0.913 (0.016)
	Fear	0.830 (0.025)	0.895 (0.015)
	Sadness	0.832 (0.025)	0.825 (0.025)
Low			
	Anger	0.262 (0.028)	0.325 (0.028)
	Contempt	0.700 (0.035)	0.742 (0.023)
	Disgust	0.395 (0.027)	0.410 (0.028)
	Fear	0.237 (0.022)	0.325 (0.027)
	Sadness	0.600 (0.034)	0.610 (0.033)

Appendix 5. Proportions of trials in which each emotion was incorrectly selected [Mean (SE)] in patients with SAUD and HC (Chapter 7).

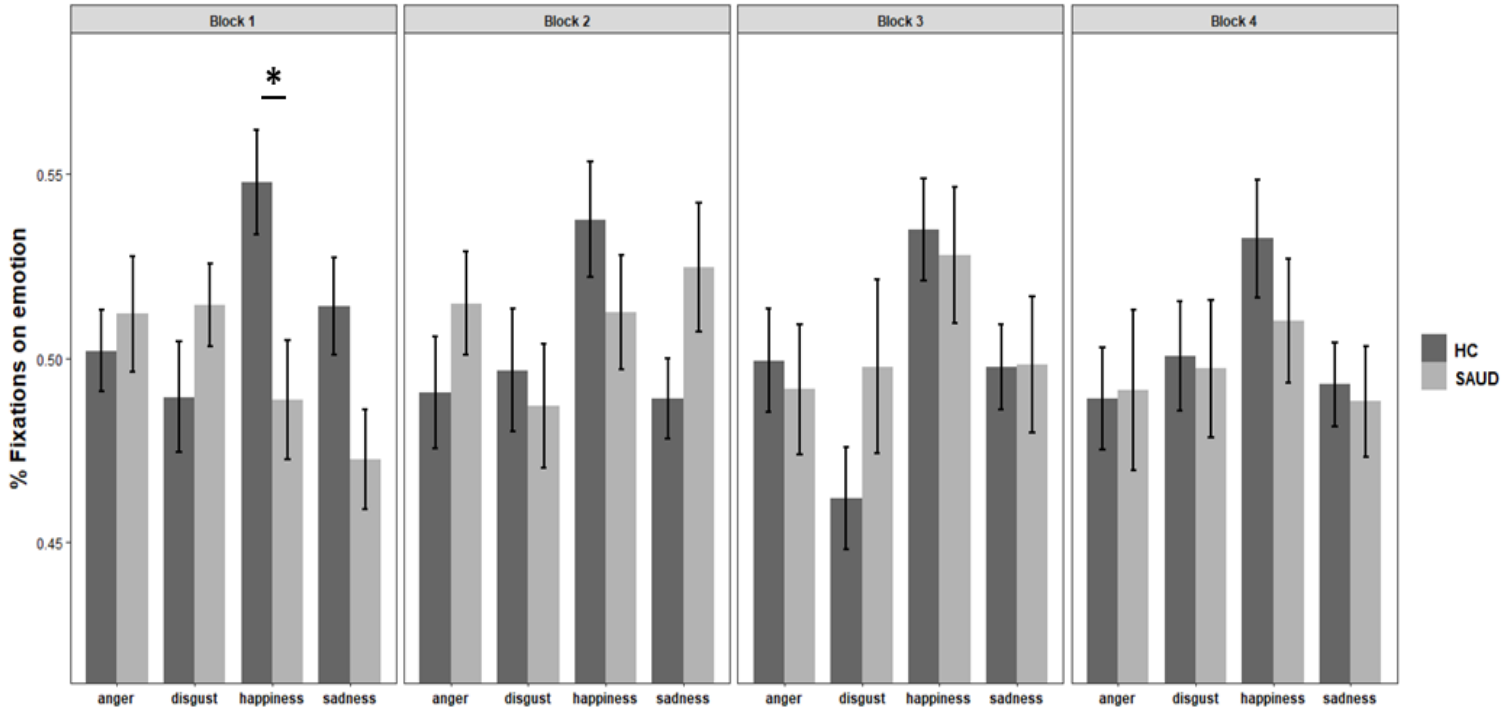
	SAUD	HC
Anger	0.101 (0.014)	0.102 (0.018)
Contempt	0.413 (0.023)	0.415 (0.023)
Disgust	0.105 (0.014)	0.096 (0.014)
Fear	0.067 (0.009)	0.077 (0.012)
Sadness	0.300 (0.021)	0.301 (0.024)

Appendix 6. Reliability estimates obtained using Spearman-Brown-corrected averages of 5000 permutations of random split-half correlations (Chapter 8).

		Reaction time difference		*First fixation.*		*First fixation latency difference*		*Dwell-time proportion*		*Total fixations proportion*	
		SAUD	HC	SAUD	HC	SAUD	HC	SAUD	HC	SAUD	HC
Across blocks	Anger	0.00	-0.39	-0.23	-0.11	-0.19	-0.64	0.90	0.95	0.88	0.91
	Disgust	-0.46	-0.11	-0.30	-0.25	0.26	-0.38	0.90	0.92	0.89	0.87
	Happiness	0.29	-0.13	-0.31	-0.21	-0.06	-0.62	0.87	0.93	0.85	0.91
	Sadness	-0.40	-0.42	0.01	0.08	-0.16	-0.59	0.89	0.91	0.87	0.82
Block1	Anger	0.22	0.04	0.13	0.10			0.38	0.70	0.35	0.49
	Disgust	-0.21	0.32	-0.35	0.06			0.39	0.72	0.15	0.67
	Happiness	0.46	0.43	-0.33	-0.39			0.43	0.75	0.39	0.68
	Sadness	0.34	-0.13	0.29	0.05			0.57	0.76	0.41	0.64
Block2	Anger	0.05	-0.30	-0.41	-0.17			0.42	0.79	0.31	0.67
	Disgust	0.44	-0.11	-0.27	-0.14			0.61	0.83	0.47	0.78
	Happiness	0.49	-0.30	-0.21	-0.23			0.42	0.79	0.39	0.75
	Sadness	-0.02	0.12	0.11	-0.44			0.43	0.72	0.51	0.47
Block3	Anger	0.30	0.24	-0.12	-0.17			0.66	0.78	0.61	0.63
	Disgust	0.46	0.20	-0.10	-0.18			0.73	0.75	0.73	0.68
	Happiness	0.71	0.05	-0.30	-0.22			0.75	0.71	0.69	0.62
	Sadness	-0.28	0.54	-0.22	-0.48			0.39	0.59	0.43	0.46
Block4	Anger	0.57	0.21	0.12	-0.22			0.62	0.80	0.57	0.57
	Disgust	-0.30	-0.11	0.35	0.12			0.65	0.86	0.64	0.71
	Happiness	0.04	0.10	-0.35	-0.01			0.61	0.73	0.55	0.68
	Sadness	0.49	-0.21	-0.19	-0.02			0.58	0.57	0.40	0.13



***Appendix 7**. Percentages of dwell time on the emotional vs neutral expression according to group, emotion, and block (Chapter 8).*



Appendix 8 *Percentages of dwell time on the emotional vs neutral expression according to group, emotion, and block (Chapter 8).*

Appendix 9. Correlations between (A) the percentage of dwell-time on the happy vs. neutral face in the first block of stimuli or (B) the percentage of number of fixations on the happy vs. neutral face in the first block of stimuli, and sociodemographic, psychopathology, alcohol consumption and interpersonal problems variables in the SAUD and HC groups [r(p)] (Chapter 8).

	A		B	
	SAUD	HC	SAUD	HC
Sociodemographics				
Education level	0.29 (0.15)	0.09 (0.40)	0.30 (0.12)	0.16 (0.40)
Psychopathology				
BDI[1]	-0.11 (0.60)	0.01 (0.96)	-0.07 (0.72)	0.01 (0.96)
STAI-A[2]	-0.04 (0.86)	0.14 (0.46)	-0.08 (0.70)	0.23 (0.22)
STAI-B[2]	0.10 (0.63)	-0.10 (0.60)	0.11 (0.59)	-0.14 (0.46)
LSAS[3]	-0.25 (0.21)	-0.15 (0.42)	-0.26 (0.21)	-0.11 (0.56)
Alcohol consumption				
Number of previous detoxifications	-0.19 (0.35)	/	-0.04 (0.84)	/
Age of SAUD onset	0.41 (0.03)	/	0.40 (0.04)	/
Number of alcohol units per day	-0.08 (0.70)	/	0.04 (0.87)	/
AUDIT	0.27 (0.19)	0.24 (0.21)	0.28 (0.17)	0.24 (0.22)
Interpersonal problems				
Total	-0.13 (0.50)	0.05 (0.79)	-0.14 (0.48)	0.08 (0.68)
Domineering	-0.15 (0.44)	0.08 (0.67)	-0.11 (0.59)	0.11 (0.56)
Self-centered	-0.04 (0.85)	-0.17 (0.37)	-0.10 (0.61)	-0.10 (0.59)
Cold/distant	-0.34 (0.08)	0.12 (0.54)	-0.34 (0.08)	0.15 (0.45)
Socially inhibited	-0.16 (0.41)	-0.13 (0.50)	-0.16 (0.43)	-0.09 (0.63)
Nonassertive	0.09 (0.64)	0.07 (0.70)	0.06 (0.78)	0.11 (0.58)
Overly accomodating	0.00 (0.99)	0.15 (0.44)	-0.02 (0.91)	0.14 (0.47)
Self-sacrificing	-0.03 (0.87)	0.11 (0.59)	-0.02 (0.91)	0.11 (0.55)
Intrusive/needy	-0.24 (0.22)	0.05 (0.80)	-0.20 (0.31)	0.02 (0.90)

[1]BDI = Beck Depression Inventory (Beck and Steer, 1987).
[2]STAI = State (A) and Trait (B) Anxiety Inventory (Spielberger et al., 1983)
[3]LSAS = Liebowitz Social Anxiety Scale (Liebowitz, 1987)

Appendix 10. Socio-demographic, psychopathological, interpersonal problems, and alcohol consumption measures in the subsample of patients with severe alcohol use disorder (SAUD) and healthy controls (HC) that completed the memory accessibility task: Mean (SD) (Chapter 9).

	SAUD (n=29)	HC (n=30)	t/χ^2	p
Gender ratio (M/F)	16/13	16/14	0.00	1.00
Age	48.83 (10.06)	47.10 (11.32)	0.62	0.54
Education level (in years)	15.03 (2.28)	14.33 (2.28)	1.18	0.24
BDI[a]	**10.53 (4.73)**	**2.20 (1.73)**	**8.93**	**<0.001**
STAI[b]-State	**33.00 (8.18)**	**26.70 (6.43)**	**3.28**	**0.002**
STAI-Trait	**53.69 (7.84)**	**36.57 (9.21)**	**7.70**	**<0.001**
LSAS[c]	**53.25 (29.70)**	**34.50 (22.60)**	**2.69**	**0.01**
Total IIP[d]	**99.04 (34.98)**	**52.63 (27.75)**	**5.57**	**<0.001**
Domineering	**7.11 (3.36)**	**4.30 (3.31)**	**3.20**	**0.002**
Self-centered	**8.57 (5.59)**	**4.33 (3.41)**	**3.46**	**0.001**
Cold/Distant	**10.29 (8.33)**	**4.23 (3.44)**	**3.57**	**0.001**
Socially Inhibited	**13.18 (11.05)**	**5.47 (5.57)**	**3.32**	**0.002**
Nonassertive	**14.82 (9.16)**	**7.97 (6.12)**	**3.33**	**0.002**
Overly accomodating	**16.25 (7.18)**	**10.00 (5.92)**	**3.60**	**<0.001**
Self sacrificing	**19.50 (5.82)**	**10.50 (6.47)**	**5.58**	**<0.001**
Intrusive	**12.53 (7.42)**	**5.63 (4.03)**	**4.36**	**<0.001**
AUDIT	**30.46 (5.14)**	**2.70 (2.39)**	**25.27**	**<0.001**
Number of abstinence days	22.68 (13.74)			
Number of previous detoxifications	1.69 (2.32)			
Duration of SAUD (in years)	10.45 (7.62)			
Number of alcohol units per day[3]	19.74 (10.95)			

[1] Beck Depression Inventory (Beck & Steer, 1987).
[2] State/Trait Anxiety Inventory (Spielberger & Gorsuch, 1983).
[3] Before detoxification (an alcohol unit corresponds to 10 gr of ethanol).
[4] Inventory of Interpersonal Problems (Horowitz et al., 2003)
Note = Bold lines indicate a significant difference between groups.

Appendix 11. Mean (SD) proportions of hits and false alarms (FA) in both groups [patients with severe alcohol use disorder (SAUD) and healthy controls (HC)] (1) across emotions and awareness levels (Grand Total), and (2) separately for angry and happy emotions and each awareness level (Chapter 9).

			SAUD	HC
Grand Total		Hits	0.65 (0.12)	0.68 (0.14)
		FA	0.33 (0.16)	0.29 (0.16)
	Remember	Hits	0.28 (0.16)	0.30 (0.16)
		FA	0.11 (0.11)	0.07 (0.08)
	Know	Hits	0.20 (0.14)	0.20 (0.12)
		FA	0.08 (0.09)	0.10 (0.10)
	Guess	Hits	0.18 (0.15)	0.18 (0.10)
		FA	0.13 (0.15)	0.13 (0.10)
Angry	Total	Hits	0.62 (0.15)	0.65 (0.16)
	Remember	Hits	0.24 (0.16)	0.27 (0.18)
	Know	Hits	0.20 (0.14)	0.20 (0.14)
	Guess	Hits	0.18 (0.16)	0.18 (0.13)
Happy	Total	Hits	0.69 (0.14)	0.72 (0.15)
	Remember	Hits	0.33 (0.20)	0.33 (0.20)
	Know	Hits	0.19 (0.16)	0.21 (0.15)
	Guess	Hits	0.18 (0.17)	0.18 (0.11)

Appendix 12. Mean (SD) proportions of correctly recalled emotions in both groups [patients with severe alcohol use disorder (SAUD) and healthy controls (HC)] (1) across emotions and awareness levels (Grand Total), and (2) separately for angry and happy emotions and each awareness level (Chapter 9).

		SAUD	HC
Grand Total		0.59 (0.12)	0.62 (0.11)
	Remember	0.18 (0.15)	0.19 (0.13)
	Know	0.19 (0.13)	0.17 (0.10)
	Guess	0.22 (0.15)	0.27 (0.13)
Angry	Total	0.56 (0.21)	0.59 (0.19)
	Remember	0.17 (0.19)	0.18 (0.18)
	Know	0.18 (0.20)	0.16 (0.13)
	Guess	0.21 (0.19)	0.25 (0.21)
Happy	Total	0.63 (0.14)	0.65 (0.17)
	Remember	0.20 (0.18)	0.20 (0.15)
	Know	0.20 (0.15)	0.17 (0.15)
	Guess	0.23 (0.19)	0.29 (0.18)

Appendix 13. Correlations between identity recognition scores as well as the difference between valid negative and positive memories reported, and psychopathological symptoms, interpersonal problems, and alcohol consumption measures in the SAUD sample (Chapter 9).

	Identity recognition scores	Nr of negative – Nr of positive memories reported
Psychopathological measures		
BDI[a]	0.08	-0.18
STAI[b]-State	-0.01	-0.01
STAI-Trait	0.02	0.11
LSAS[c]	-0.10	0.05
Interpersonal Problems		
Total IIP[d]	0.09	-0.07
Domineering	-0.02	0.01
Self-centered	0.30	0.06
Cold/Distant	**0.38***	-0.14
Intrusive	0.11	0.35
Overly accomodating	-0.15	-0.05
Socially inhibited	-0.01	-0.34
Self sacrificing	0.01	-0.04
Nonassertive	-0.03	-0.07
Alcohol consumption measures		
AUDIT[e]	-0.13	**0.41**
Number of abstinence days	0.17	-0.16
Number of previous detoxifications	-0.08	-0.33
Duration of SAUD (in years)	-0.15	-0.24
Number of alcohol units per day[f]	-0.19	-0.32
Number of SAUD symptoms	0.30	0.05

[a] Beck Depression Inventory (Beck & Steer, 1987).
[b] State/Trait Anxiety Inventory (Spielberger & Gorsuch, 1983).
[c] Liebowitz Social Anxiety Scale (Liebowitz, 1987).
[d] Inventory of Interpersonal Problems (Horowitz et al., 2003)
[e] Alcohol Use Disorder Identification Test (Babor et al., 2001.
[f] Before detoxification (an alcohol unit corresponds to 10 gr of ethanol).
*The coefficient of the robust percentage bend correlation is shown instead of Pearson's correlation coefficient, as the two methods yielded different results
Note = Bold lines indicate a significant correlation. Superscript numbers indicate the number of missing data.