Journal of Affective Disorders 323 (2023) 778–787

Contents lists available at ScienceDirect

Journal of Affective Disorders

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

Research paper

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

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ARTICLE INFO

Keywords:
Social cognition
Alcohol use disorder
Alcohol dependence
Social functioning
Attentional bias

ABSTRACT

Background: Social cognition impairments in severe alcohol use disorder (SAUD) are increasingly established. However, fundamental aspects of social cognition, and notably the attentional processing of socio-affective information, remain unexplored, limiting our understanding of underlying mechanisms. Here, we determined whether patients with SAUD show attentional biases to specific socio-affective cues, namely emotional faces.
Method: In a modified dot-probe paradigm, 30 patients with SAUD and 30 demographically matched healthy controls (HC) were presented with pairs of neutral-emotional (angry, disgusted, happy, sad) faces while having their eye movements recorded. Indices of early/automatic (first fixations, latency to first fixations) and later/controlled (number of fixations, dwell-time) processes were computed.
Results: Patients with SAUD did not differ from HC in their attention to angry/disgusted/sad vs. neutral faces. However, patients with SAUD fixated/dwelled less on happy vs. neutral faces in the first block of stimuli than HC, who presented an attentional bias to happy faces.
Limitations: Sample-size was determined to detect medium-to-large effects and subtler ones may have been missed. Further, our cross-sectional design provides no explanation as to whether the evidenced biases precede or are a consequence of SAUD.
Conclusions: These results extend the social cognition literature in SAUD to the attentional domain, by evidencing the absence of a controlled attentional bias toward positive social cues in SAUD. This may reflect reduced sensitivity to social reward and could contribute to higher order social cognition difficulties and social dysfunction.

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 related lack of social support are, in turn, associated with elevated internalized symptoms (Akerlind and 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 and 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 et al., 2021). Moreover, such impairments have been associated with interpersonal problems and poor SAUD prognosis (Hoffman et al., 2019;

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https://doi.org/10.1016/j.jad.2022.12.027
Received 11 October 2021; Received in revised form 7 November 2022; Accepted 10 December 2022
Available online 16 December 2022
0165-0327/

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 and 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 and 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 and 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 in 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 others' 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) activations 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 and Olatunji, 2012; Maurage et al., 2019), and (3) present improved psychometric properties (Bollen et al., 2021; Christiansen et al., 2015; 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. We recruited HC via social media, University participant pools and study flyers. They were free of lifetime psychiatric disorders, except for nicotine use disorder. They reported drinking <10 units (1unit = 10 g of ethanol) per week and <3 units per day, had an Alcohol Use Disorder Identification Test (AUDIT; Babor et al., 2001) score <8, and reported no first degree family history of SAUD. They were asked to abstain from alcohol during the 72 h 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 and Anastasi, 2012). Each trial started with a drift correction phase through a central fixation cross that remained on screen until a 1000 ms 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 2000 ms (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 5.4 cm. 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 1080 × 1920p; 120 Hz refresh rate). The eye-screen distance was approximatively 57 cm. 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 1) and completed the state form of the State-Trait Anxiety Inventory (STAI; Spielberger and Gorsuch, 1983). They then performed the dot-probe task, lasting about 40 min 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 and 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 and 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., 2009, 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

Table 1
Sociodemographic, alcohol consumption, psychopathology and interpersonal problems variables in patients with SAUD and HC [Mean (SD)].

Full sample	SAUD (N = 30)	HC (N = 30)	t/Chi^2	p-Value
Sociodemographics				
Age	48.23 (10.67)	47.87 (10.67)	−0.14	0.89
Gender, N(%) of females	13 (43.33)	14 (46.66)	2.07	0.36
Education (in years since starting primary school)	13.93 (3.05)	15.37 (2.63)	1.95	0.056
Alcohol consumption variables				
Number of previous detoxifications	1.67 (2.93)	/	/	/
Age at SAUD onset	36.83 (10.70)	/	/	/
Number of alcohol units per day	17.27 (6.68)	/	/	/
AUDIT score	32.11 (6.39)	2.77 (1.99)	−23.66	<0.001
Psychopathology				
BDI[a]	8.37 (6.16)	2.40 (3.51)	−4.61	<0.001
STAI[b]-State	33.92 (10.62)	28.70 (8.25)	−2.12	0.04
STAI-Trait	50.40 (9.71)	35.47 (11.44)	−5.45	<0.001
LSAS[c]	48.52 (27.06)	31.70 (23.87)	−2.53	0.014
Interpersonal problems				
Total	90.35 (36.38)	56.37 (36.58)	−3.61	<0.001
Domineering	8.44 (5.21)	4.40 (3.68)	−3.46	0.001
Self-centered	8.99 (5.15)	4.17 (3.68)	−4.18	<0.001
Cold/distant	9.00 (6.46)	4.57 (5.41)	−2.88	0.006
Socially inhibited	11.34 (6.32)	7.17 (7.34)	−2.36	0.02
Non-assertive	12.82 (8.18)	8.53 (7.82)	−2.07	0.04
Overly accommodating	13.95 (7.50)	10.63 (6.09)	−1.88	0.065
Self-sacrificing	14.70 (6.38)	11.07 (6.98)	−2.10	0.04
Intrusive/needy	11.12 (5.17)	5.73 (4.83)	−4.17	<0.001

Non-starers	SAUD (N = 27)	HC (N = 29)	t/Chi^2	p-Value
Sociodemographics				
Age	48.22 (10.83)	47.72 (10.83)	−0.17	0.86
Gender, N(%) of females	13 (48.15%)	14 (48.28%)	2.30	0.32
Education	13.93 (3.19)	15.48 (2.60)	2.01	0.049
Alcohol consumption variables				
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)	−21.64	<0.001
Psychopathology				
BDI	8.46 (5.88)	2.31 (3.54)	−4.70	<0.001
STAI-State	34.83 (10.66)	28.69 (8.40)	−2.40	0.02
STAI-Trait	50.00 (9.14)	35.31 (10.61)	−5.23	<0.001
LSAS	50.81 (26.25)	31.86 (24.28)	−2.93	0.005

(continued on next page)

Table 1 (*continued*)

Non-starers	SAUD (N = 27)	HC (N = 29)	t/Chi[2]	p-Value
Interpersonal problems				
Total	93.71 (36.49)	55.72 (37.06)	−3.86	<0.001
Domineering	8.56 (5.30)	4.28 (3.68)	−3.53	<0.001
Self-centered	9.37 (4.94)	4.03 (3.67)	−4.63	<0.001
Cold/distant	9.04 (6.24)	4.34 (5.36)	−3.02	0.003
Socially inhibited	11.75 (6.32)	7.10 (7.47)	−2.51	0.015
Non-assertive	13.72 (8.07)	8.59 (7.96)	−2.40	0.02
Overly accommodating	14.76 (7.43)	10.69 (6.19)	−2.23	0.03
Self-sacrificing	14.96 (6.55)	10.82 (6.98)	−2.28	0.03
Intrusive/needy	11.52 (5.20)	5.76 (4.92)	−4.26	<0.001

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

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 200 ms (no trial) or higher than 2000 ms (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 >50 % of trials (van Ens et al., 2019). Sample characteristics of non-starers are displayed in Table 1. Fixations were defined according to the Eyelink DataViewer's default settings. Fixations separated by <1° of visual angle were merged and those lasting <100 ms were deleted (Manor and 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 ($ps < 0.002$).

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 and 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 at SAUD onset, number of units consumed per day prior to detoxification, AUDIT score) and interpersonal problems using bivariate Pearson correlations within each group.

3. Results

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

The characteristics of the full and of the "non-starers" samples are displayed in Table 1. In the full sample, groups did not statistically differ on age, gender or successfully completed education years. Patients with SAUD however reported higher state anxiety (STAI-state), trait anxiety (STAI-trait), social anxiety (LSAS) and depression symptoms than HC. Patients also logically had higher AUDIT scores and reported more interpersonal problems, as indexed by the total score and every subscore (besides "Overly accommodating") of the IIP. Similar results were found in the "non-starers" sample with the exceptions that patients with SAUD had higher scores at the "Overly accommodating" subscale of the IIP and completed fewer education years. Exploratory analyses therefore also encompassed correlations between attentional bias indices and education.

3.2. Main analyses

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

Regarding dwell-time, there was a significant main effect of emotion ($F(1.48, 80.04) = 4.50$, $p = 0.02$, $\eta_p^2 = 0.08$) and, more relevant to the study's aims, there was a significant group x emotion x block interaction ($F(6.90, 372.74) = 2.05$, $p = 0.049$, $\eta_p^2 = 0.04$), see Fig. 1. All other main or interaction effects were nonsignificant (all $ps > 0.11$). 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 ($F(2.07, 111.58) = 6.01$, $p_{BC} = 0.01$, $\eta_p^2 = 0.10$). 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 Fig. 1 and Supplementary Material 1).

Regarding the number of fixations, there was again a main effect of emotion ($F(1.71, 92.426) = 3.11$, $p = 0.057$, $\eta_p^2 = 0.05$), as well as a group x emotion x block interaction ($F(6.70, 361.870) = 1.99$, $p = 0.058$, $\eta_p^2 = 0.04$), both falling just below the significance threshold (all other $ps > 0.13$), see Fig. 2. 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 ($F(2.361, 127.5) = 4.67$, $p_{BC} = 0.03$, $\eta_p^2 = 0.08$). 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 %.

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 emotional vs neutral face in block 1. As shown in Table 2, within the SAUD group, age at 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 toward 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., 2007; Freeman et al., 2018; Frigerio et al., 2002; Maurage et al., 2009; Philippot et al., 1999) 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 and 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., 2021), 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 until larger 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 and 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 and 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 and 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 and Abramson, 1979; Armstrong and 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

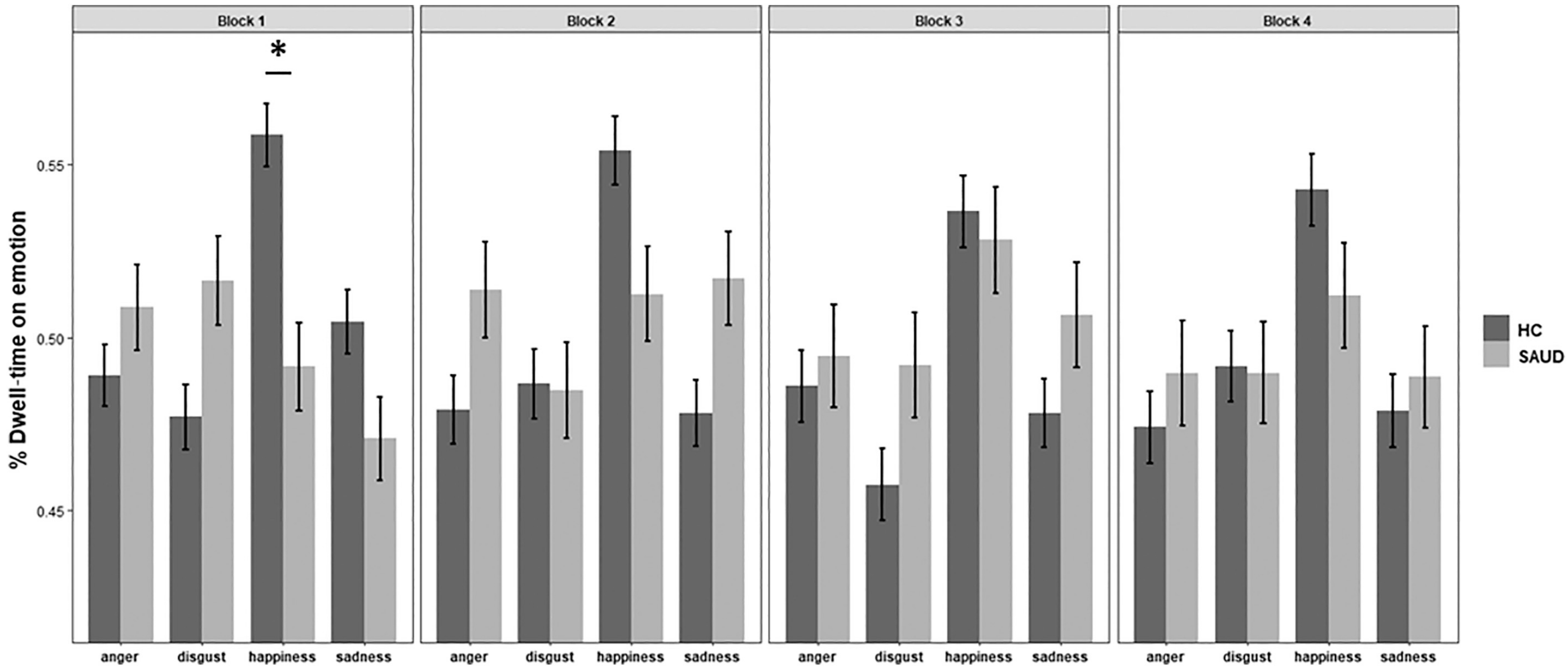

Fig. 1. Percentages of dwell time on the emotional vs neutral expression according to group, emotion, and block.

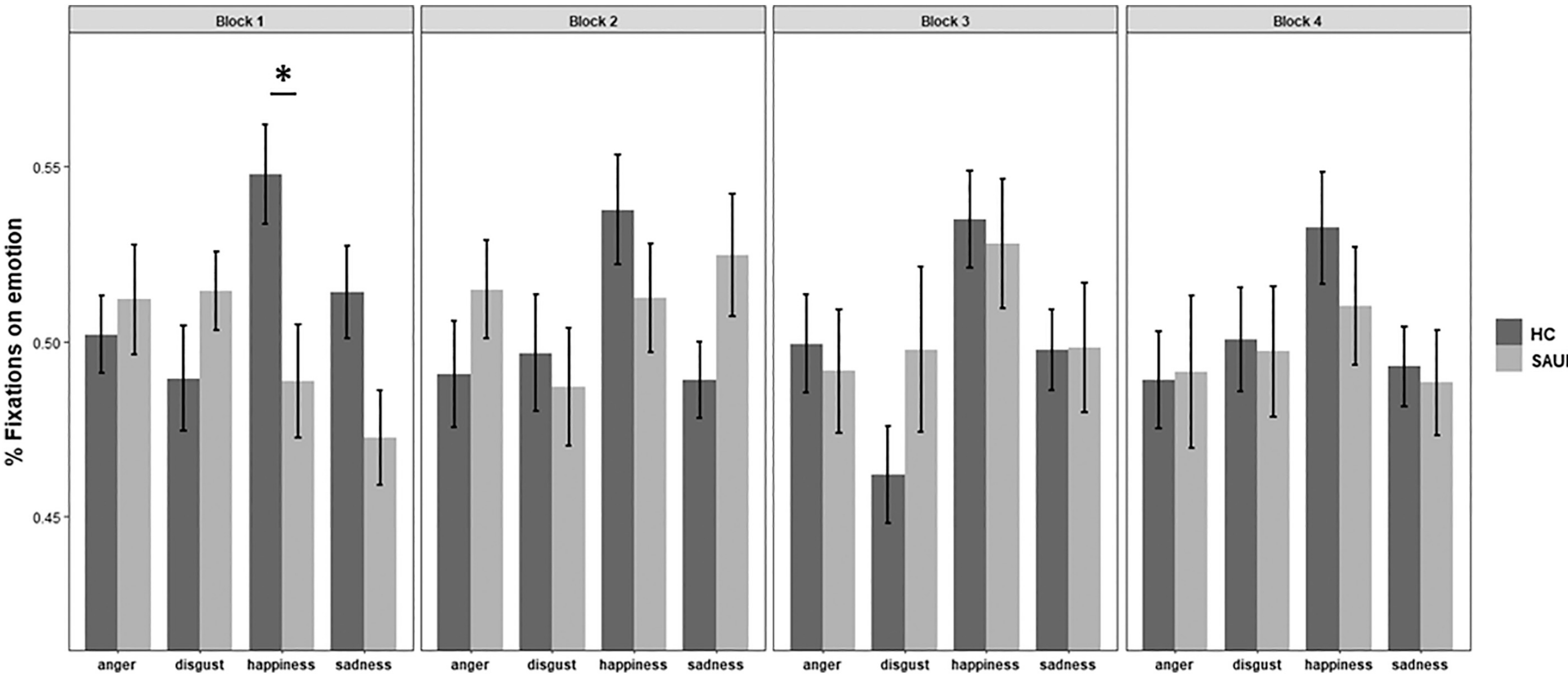

Fig. 2. Percentages of number of fixations on the emotional vs neutral expression according to group, emotion, and block.

Table 2
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)].

	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[a]	−0.11 (0.60)	0.01 (0.96)	−0.07 (0.72)	0.01 (0.96)
STAI-A[b]	−0.04 (0.86)	0.14 (0.46)	−0.08 (0.70)	0.23 (0.22)
STAI-B[b]	0.10 (0.63)	−0.10 (0.60)	0.11 (0.59)	−0.14 (0.46)
LSAS[c]	−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 at 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)
Non-assertive	0.09 (0.64)	0.07 (0.70)	0.06 (0.78)	0.11 (0.58)
Overly accommodating	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)

[a] BDI = Beck Depression Inventory (Beck and Steer, 1987).
[b] STAI = State (A) and Trait (B) Anxiety Inventory (Spielberger and Gorsuch, 1983).
[c] LSAS = Liebowitz Social Anxiety Scale (Liebowitz, 1987).

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 at 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 thus have been missed. Second, 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 toward 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.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jad.2022.12.027.

Funding

This work benefitted from financial support allocated by the Belgian Fund for Scientific Research (F.R.S.-FNRS) to PM (Senior Research Associate), NM (grant PDR- T.0047.18), ZB (Junior Research Associate), and AP (FRESH grant holder). N.M. is also funded by the research grant FNR-INTER/FNRS/17/1178524 from the National Research Fund of Luxembourg (FNR, Luxembourg).

CRediT authorship contribution statement

Arthur Pabst: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft. **Zoé Bollen:** Conceptualization, Methodology, Writing – review & editing. **Nicolas Masson:** Methodology, Formal analysis, Writing – review & editing. **Pauline Billaux:** Investigation, Writing – review & editing. **Philippe de Timary:** Resources, Writing – review & editing. **Pierre Maurage:** Conceptualization, Supervision, Project administration, Writing – review & editing.

Conflict of Interest

None.

Acknowledgements

None.

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