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Unfairness sensitivity and equity in severe alcohol use disorder: Insights from the ultimatum game

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ABSTRACT

Objectives: Severe alcohol use disorder (SAUD) is characterized by social interaction difficulties that play a key role in the persistence of this addictive state. Biased social decision-making might underpin such interpersonal problems. Previous studies exploring social decision-making in SAUD used the ultimatum game – an economic game evaluating sensitivity to unfairness (for the responder) and equity (for the proposer) – and showed increased unfairness sensitivity in SAUD. However, these studies used one-shot designs that are not representative of real-life interactions and focused only on responders, letting much of the phenomenon unexplored.
Methods: Thirty-five recently detoxified patients with SAUD and 34 matched control participants played four iterated ultimatum games, with variations according to the role (responder *vs.* proposer) and strategy used by their virtual opponent (fair/easy *vs.* unfair/difficult). Participants then completed social cognition tasks and psychopathological questionnaires.
Results: As responders, patients with SAUD did not reject fair or unfair offers more often than controls, which contradicts the unfairness sensitivity previously highlighted in one-shot ultimatum games. As proposers, patients with SAUD made more generous offers than controls and did not adapt to their opponent's strategy, which resulted in poorer economic outcomes.
Conclusions: Patients with SAUD do not display an unfairness sensitivity but are less able to adapt to their opponent, which has detrimental consequences, namely poorer outcomes. They behave differently during one-shot and repeated interactions, probably because – due to their social cognition impairments – they need more time to understand their opponent and overcome their *a priori* social biases.

1. Introduction

Social decision-making, the ability to make efficient choices in interpersonal situations, is key for adapted social life (Hinterbuchinger et al., 2018) and its impairment could be involved in the continuum of alcohol use disorders, globally defined as problematic patterns of alcohol use leading to clinically significant impairment or distress (American Psychiatric Association, 2013). Such social decision-making deficits could be particularly involved in the persistence of the most serious form of alcohol use disorder, namely severe alcohol use disorder (SAUD, corresponding to the presence of six or more diagnosis criteria of the DSM-5). A wide range of studies have demonstrated major cognitive impairments in SAUD (e.g., Bernardin et al., 2014; Stavro et al., 2013). More recently, an interest has emerged regarding social cognition abilities in SAUD, namely the mental processes that allow the perception and interpretation of social signals. Indeed, deficits in social cognition are known to affect social functioning (Fett et al., 2011) and, in turn, interpersonal difficulties are relapse risk factors (Sliedrecht et al., 2019). A large number of studies has documented that patients with SAUD present widespread difficulties to identify and interpret emotional and interpersonal signals from others (Bora & Zorlu, 2016; Pabst et al., 2022). However, social decision-making, namely the way people with SAUD behave during social interactions (beyond their impaired social cognition abilities) remain poorly understood. Social decision-making might constitute the missing link between social cognition alterations and real-life maladaptive social behaviors (Gautier et al., 2021). There is thus an urgent need to better document these abilities in SAUD.

Economic games, derived from the Game Theory, are highly suitable

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to study social decision-making as they mimic real-life social interactions where participants make choices affecting others (Hinterbuchinger et al., 2018). Among them, the ultimatum game (UG) is particularly suited to assess how people perceive and react to fairness. It is a take-it-or-leave-it game with two players (proposer/responder) where the proposer receives money and has to split it between themselves and the responder. If the responder accepts the deal, the money is split as agreed upon but if they reject the offer, no player receives any money. This game examines sensitivity to unfairness (responder) or fairness/equity (proposer) (Brevers et al., 2013; Jangard et al., 2022). From a purely economic/rational level, the responder should accept any offer as any gain is better than losing it all (Hinterbuchinger et al., 2018), and the proposer should propose the smallest amount likely to be accepted (Tisserand et al., 2015). However, previous results showed that proposers usually offer around 40 % of the money (Hinterbuchinger et al., 2018; Tisserand et al., 2015) and that offers lower than 20 % are rejected half of the time (Houser & McCabe, 2014). The current interest for economic games, and centrally for the UG, is also illustrated by its inclusion in the recommendations made by Research Domain Criteria approaches (RDoC, aiming to describe disorders in terms of observable behaviors rather than diagnoses) to study social biomarkers in psychiatric disorders (NIMH, 2016; Robson et al., 2020). For example, rejecting more unfair offers in UG may index a reduced reward sensitivity that falls under the *Reward Responsiveness* RDoC construct. Conversely, accepting more unfair offers may translate conflict avoidance that falls under the *Affiliation and Attachment* construct (Robson et al., 2020). Social decision-making biases observed in the UG might thus constitute transdiagnostic processes, as two systematic reviews highlighted such biases across psychiatric disorders. However, they also documented a variability across diagnoses by identifying different patterns of UG behaviors among various populations with mental health conditions (Hinterbuchinger et al., 2018; Robson et al., 2020).

The UG has also been used to explore social decision-making in several substance use disorders, leading to globally mixed results and limited consistency across studies: some researchers found no difference in UG performance between individuals with cocaine use disorder and matched healthy controls (Verdejo-Garcia et al., 2017) while others showed that females with cocaine use disorder accepted significantly more often than controls the first unfair offer only (Viola et al., 2019). Acute MDMA users presented higher offer acceptance rates (as responders) and made fairer offers (as proposers) than controls (Stewart et al., 2014). Individuals with heroin use disorder were inclined to have a more complex response pattern: when compared to controls, they simultaneously presented higher rejection rates for unfair offers when the amount of money involved was low, but conversely lower rejection rates when the amount was high (Hou et al., 2016). Four studies have used the UG in SAUD. Three suggested that patients with SAUD reject more often unfair offers than controls, this increased unfairness sensitivity being related to impulsivity and emotion regulation difficulties (Brevers et al., 2013; 2015; Tsukue et al., 2015 but see Cortes et al., 2018). However, these studies presented limitations. First, patients only acted as responders, leaving the "proposer" part unexamined in SAUD, although populations with subclinical alcohol use disorder tend to be less fair as proposers (Jangard et al., 2022). Second, all previous studies used one-shot designs, despite the mechanisms involved in single versus multi-shot games differ: in an iterated UG (iUG), the responder can reject an unfair offer to pressure the proposer to increase subsequent offers, such strategy being irrelevant in single-shot games where the proposer varies across trials (Xue et al., 2010). An optimal behavior in a one-shot game (e.g., accept low offers) could be maladaptive in iUG. Third, previous studies did not measure the link between impaired social cognition and social decision-making, despite the former influences the latter. For example, reduced emotional regulation (e.g., difficulties to regulate the anger generated by unfair offers) or hostile attributional bias (e.g., leading to attribute malevolent intentions to the proposer after receiving an unfair offer) could lead the responder to reject unfair offers more frequently. Social cognition deficits could thus underlie impaired social decision-making in SAUD.

To overcome these limitations, we explored social decision-making in SAUD through an iUG (encompassing both responder and proposer roles), and its links with social cognition. We hypothesized that patients with SAUD will (1) reject more unfair offers than healthy controls (HC) when acting as responders (Brevers et al., 2013; 2015; Tsukue et al., 2015); (2) offer smaller amounts than HC when playing as proposers (as reported in subclinical alcohol use disorders; Jangard et al., 2022); (3) adapt less efficiently their strategy to the opponent's strategy than HC, leading to poorer money outcomes; (4) show links between social-decision making deficits and impulsivity, ToM, hostility bias as well as interpersonal problems.

2. Materials and Method

2.1. Pre-registration

We pre-registered the hypotheses, design, sample size rationale and analysis plan of the study on the Open Science Framework: https://doi.org/10.17605/OSF.IO/V6QPW. We describe and justify departures from this original plan in the corresponding sections.

2.2. Participants

An *a priori* power analysis in G*Power 3.1.9.7 based on a repeated-measures ANOVA with a significance level of 0.05 and a desired power of 0.8 indicated that a sample size of 35 participants per group was required. We recruited recently detoxified patients (mean abstinence duration: 19.49 days), diagnosed with SAUD according to DSM-5 criteria, in Belgian detoxification centers. HC had an Alcohol Use Disorders Identification Test (AUDIT, Saunders et al., 1993) score lower than 8, consumed less than ten alcohol units/week and no more than three units/day. They had no family history of SAUD and were free from any psychotropic medication. Exclusion criteria for both groups included (1) past/present neurological/psychiatric disorder, (2) history of head injury with prolonged loss of consciousness, (3) other substance abuse (except nicotine), (4) psychotropic medication affecting cognition, (5) gambling disorder (i.e., score $>$ 2 at the Canadian Problem Gambling Index; Ferris & Wynne, 2001), (6) limited fluency in French, (7) uncorrected poor vision.

2.3. Pretest on offers fairness

The UG literature is inconsistent regarding fair/unfair offers classification [e.g., offering 40 % is considered unfair in Beadle et al. (2012), but fair in Marchetti et al. (2011); 30 % is fair in Cortes et al. (2018) but unfair in Girardi et al. (2018)]. We thus based our classification on a pretest on 24 University students. Over the 432 trials, offers of 4–5–6€ out of 10€ were accepted 94.44–100–100 % of the time respectively, while offers of 1–2-3€ were accepted 9.72–11.11–40.28 % of the time respectively. We therefore classified 1–2–3€ as unfair and 4–5–6€ as fair offers according to the gap in acceptance rates between these groups of offers.

2.4. Iterative ultimatum game (iUG)

Participants played four 12-trial iUG: two as responder and then two as proposer. To avoid biases caused by opposite-sex dyads, we used single-gender games (Ortmann & Tichy, 1999) by creating two identical versions (male/female) of each iUG (Marchetti et al., 2011). All choices were computer-generated but the cover story led participants to believe that they indeed played against a human opponent, through an actor appearing in a pre-recorded and standardized webcam video at the beginning of the game. We fixed the amount to 10€ throughout the trials to avoid adding a cognitive cost to the tasks. When acting as responder,

participants were confronted with a fair (proposing 4–5–6€) and an unfair (proposing 1–2–3€) proposer. As proposers, in each trial, participants had to make an offer between 1 and 9€ and were confronted with two responders: an easy one (who accepted all offers except 1€) and a difficult one (who accepted all offers from 4€). In both roles, a feedback of the responder's choice appeared after each trial with the total money earned by each player. We randomized the strategies' order within a role (responder/proposer) as well as the video attributed to each fictitious opponent. We used money as incentives to maximize emotional engagement during the UG (Brevers et al., 2015): participants were told that one offer will be selected randomly at the end of the task to determine their payoff (Wei et al., 2022).

2.5. Procedure

Participants first filled-out the State Anxiety Inventory (STAI-A; Spielberger, 1983), then played the two iUG as responders (Fig. 1) followed by the two iUG as proposers. Participants then completed a hostility bias measure, the Word Sentence Association Paradigm - Hostility (WSAP-H; Dillon et al., 2016, Pabst et al., 2023) and a Theory of Mind (ToM) measure related to UG (adapted from Chang et al., 2023), which is an adapted version of the classic false-belief task where participants observed interactions between agents in an UG and were subsequently asked to infer the agents' beliefs. Participants also responded to questionnaires evaluating emotional regulation (DERS; Gratz & Roemer, 2004), impulsivity (UPPS; Billieux et al., 2012), interpersonal problems (IIP-64; Horowitz et al., 2003), depression (BDI; Beck et al., 1961), trait anxiety (STAI-B; Spielberger, 1983) and social anxiety (LSAS; Liebowitz, 2015). We then debriefed participants about the study's objectives and procedure, and they received a financial compensation. The study protocol was performed in accordance with the Declaration of Helsinki and was approved by the Biomedical Ethics Committee of the University.

2.6. Statistical analyses

2.6.1. Preliminary analyses

We excluded one participant from analyses because he accepted all offers. We performed *t*-tests to investigate group differences in the underlying mechanisms of social decision-making (hostility bias, ToM, emotional regulation, impulsivity) and the psychological variables explored.

2.6.2. iUG–responders

For each participant, we computed the proportion of acceptance for fair/unfair offers and the sum of money earned in each game. We analyzed all UG runs together by conducting a repeated-measures analysis of variance (ANOVA), with offer type as within-subjects factor (unfair/fair), group as between-subjects factor (HC/SAUD) and the acceptance rate as dependent variable. However, due to the violation of the model's residuals normality assumption, we performed Mann–Whitney U tests to examine between-groups differences on the proportion of acceptance according to the type of offers. As this assumption violation prevented us from introducing the hypothesized underlying processes variables in the model, we deviated from the preregistration and performed Spearman correlations between the acceptance rate of fair/unfair offer, and hostility bias, emotion regulation, impulsivity and interpersonal problems. We then ran a repeated measures ANOVA with the money earned (i.e., performance at the game) as dependent variable and the opponent's strategy (within) and group (between) as independent variables. We next introduced the hypothesized underlying mechanisms (hostility bias/ToM) as covariates.

2.6.3. iUG–proposers

We performed a linear mixed model (to account for all offers made and the variability across participants) with the offer made at each trial as dependent variable, the opponent's strategy (within) and group (between) as fixed effects, as well as a random intercept and a random slope for the opponent's strategy (to allow the model to account for the variability in how participants adjust their offers in response to the opponent's strategy). As there is no consensus regarding effect-size estimation for linear mixed models, we report unstandardized beta-coefficients, along with 95 % confidence intervals, which provide an easy-to-interpret measure of the association strength between our variables. We also conducted a correlational analysis between the average offer made and interpersonal problems. We then ran a repeated measures ANOVA with the money earned as dependent variable and the opponent's strategy and group as independent variables. We next introduced hostility bias and ToM as covariates.

2.6.4. Exploratory analyses

We explored whether the poorer adaptation of patients with SAUD to the opponent's strategy (i.e., amount of money earned) was associated with their emotion regulation difficulties and impulsivity through Pearson correlations. Finally, we performed per group Pearson correlations to test the links between our dependent variables and psychopathological measures.

3. Results

3.1. Demographic, psychopathological, alcohol-related, and social cognition measures

As shown in Table 1, groups did not differ for sex, age, education, state anxiety and ToM, but patients showed higher scores for AUDIT, depression, social anxiety, trait anxiety, impulsivity and interpersonal problems, as well as lower emotion regulation abilities. At the WSAP-H, groups did not differ regarding benign attributions but patients' hostile attributions were marginally higher and patients presented a higher hostile interpretation bias [computed following Kuckertz et al. (2013) by subtracting the benign attribution score from the hostile attribution

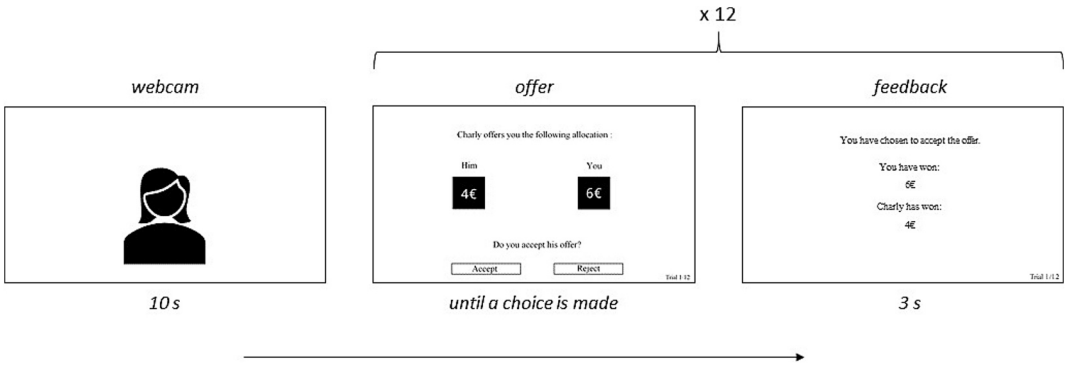

Fig. 1. Experimental timeline of a game as responder.

Table 1
Sample characteristics regarding sociodemographic variables, psychopathological symptoms, interpersonal problems, alcohol consumption and SAUD related variables.

	Patients (N = 35) M (SD)	**Controls (N = 34)** M (SD)	***t* / χ^2**	***p*-value**	**cohen's *d***
Demographic measures					
Age	45.26 (11.38)	46.68 (10.41)	−0.54	0.591	−0.13
Education	13.74 (3.39)	15.09 (2.63)	−1.84	0.071	−0.44
Sex ratio (female/ male)	18/17	24/10	2.66	0.103	
Alcohol consumption measures					
AUDIT [a]	32.77 (5.26)	2.68 (2.18)	30.79	**<0.001**	7.47
Number of units per day	18.68 (8.14)	–			
Number of previous detoxifications	1.43 (1.99)	–			
Psychopathological measures					
BDI [a]	10.31 (7.61)	2.97 (3.05)	5.22	**<0.001**	1.27
STAI-A	31.86 (10.32)	28.56 (6.99)	1.56	0.124	0.38
STAI-B [a]	52.50 (12.63)	40.53 (8.50)	4.58	**<0.001**	1.11
LSAS [a]	54.82 (30.80)	36.82 (22.60)	2.75	**0.008**	0.67
Anxiety	28.94 (17.55)	19.00 (13.51)	2.62	**0.011**	0.63
Avoidance	25.88 (14.97)	17.82 (11.50)	2.49	**0.016**	0.60
UPPS [a]	47.23 (11.10)	41.06 (8.04)	2.62	**0.011**	0.64
Negative urgency	10.30 (3.40)	8.35 (2.50)	2.70	**0.009**	0.65
Positive urgency	10.65 (2.87)	10.18 (2.36)	0.74	0.462	0.18
Lack of premeditation	8.78 (3.67)	6.97 (2.14)	2.48	**0.016**	0.60
Lack of perseverance	8.32 (3.19)	6.50 (2.58)	2.59	**0.012**	0.63
Sensation seeking	9.18 (3.27)	9.06 (2.63)	0.16	0.871	0.04
DERS [a]	102.12 (25.22)	80.09 (17.55)	4.18	**<0.001**	1.02
Non-acceptance	15.41 (6.48)	11.97 (4.93)	2.46	**0.017**	0.60
Goal-directed behaviors	16.06 (5.38)	13.29 (4.19)	2.36	**0.021**	0.57
Impulse control	15.94 (5.46)	11.21 (3.37)	4.30	**<0.001**	1.04
Lack of emotional awareness	18.38 (5.29)	17.65 (4.09)	0.64	0.524	0.16
Emotion regulation strategies	23.44 (7.35)	16.18 (5.21)	4.70	**<0.001**	1.14
Lack of emotional clarity	12.90 (4.12)	9.79 (3.52)	3.34	**0.001**	0.81
Interpersonal problems					
IIP-64 total [a]	97.28 (34.61)	62.91 (26.12)	4.62	**<0.001**	1.12
Domineering	8.35 (5.49)	4.50 (3.27)	3.52	**<0.001**	0.85
Self-centered	9.32 (5.46)	5.03 (3.25)	3.94	**<0.001**	0.96
Cold / Distant	9.90 (6.42)	5.09 (4.24)	3.64	**<0.001**	0.88
Socially inhibited	12.65 (8.05)	8.50 (5.78)	2.44	**0.017**	0.59
Non-assertive	14.97 (8.06)	10.65 (6.88)	2.38	**0.020**	0.58
Overly accommodating	13.97 (6.31)	11.06 (6.04)	1.94	0.056	0.47
Self-sacrificing	17.35 (5.68)	11.88 (6.23)	3.78	**<0.001**	0.92
Intrusive / Needy	10.85 (5.92)	6.03 (3.80)	4.00	**<0.001**	0.97
Social cognition					
ToM	10.06 (2.06)	10.38 (1.88)	−0.67	0.495	−0.16
WSAP-H - Hostile attributions	3.34 (0.82)	2.96 (0.78)	1.98	0.052	0.48
WSAP-H - Benign attributions	3.82 (0.57)	4.08 (0.62)	−1.82	0.074	−0.44
Interpretation bias	−0.49 (1.06)	−1.13 (1.22)	2.33	**0.023**	0.56

Note: [a] = 1 missing data.

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3.2. Ultimatum game

3.2.1. Responders

The results of the repeated-measures ANOVA – with offer type as within-subjects factor (unfair *vs*. fair) and group as between subjects' factor (HC *vs*. SAUD) – revealed no significant group difference on acceptance rate [$F(1,67) = 0.00$, $p = 0.992$, $\eta_p^2 = 0.00$] nor group*offer type interaction [$F(1,67) = 1.34$, $p = 0.251$, $\eta_p^2 = 0.02$], but a main effect of offer type [$F(1,67) = 632.58$, $p < 0.001$, $\eta_p^2 = 0.90$]. Due to the non-normality of the data, we confirmed this result by performing Mann-Whitney U tests to examine between-groups differences on the percentage of acceptance according to offer type. There was no significant difference between patients with SAUD (average rank = 35.69 for unfair offers; 33.90 for fair offers) and controls (average rank = 34.29 for unfair offers; 36.13 for fair offers) for unfair (Mann–Whitney U statistic = 571.00, $p = 0.766$, $r = 0.04$) nor fair offers (Mann–Whitney U statistic = 556.50, $p = 0.628$, $r = 0.06$), indicating that patients and HC did not significantly differ in their acceptance rate in the iUG [median = 8.33 for unfair offers; 91.67 for fair offers in both groups; median difference for unfair offers = 0 (95 % CI: 0.00 to 8.33) and median difference for fair offers = 0 (95 % CI: −8.33 to 0.00)].

Per group correlational analyses revealed a positive correlation between acceptance rate of unfair offers and the *lack of premeditation* facet of impulsivity [$r = 0.41$, $p = 0.015$] and a negative association between acceptance rate of fair offers and the *lack of emotional clarity* facet of emotional regulation [$r = -0.46$, $p = 0.006$] for patients only. In HC, we only found a positive correlation between acceptance rate of unfair offers and the *negative urgency* facet of impulsivity [$r = 0.38$, $p = 0.026$]. We found no link between acceptance rate of unfair offers and interpersonal problems or hostility bias.

Regarding the amount of money earned as responder, the mixed model revealed a main effect of opponent's fairness [$F(1,68) = 1903.62$, $p < 0.001$, $\eta_p^2 = 0.97$], with higher outcomes when facing a fair opponent, but no group effect nor opponent fairness*group interaction. When included in the model as covariate, we showed a main effect of ToM [$F(1,65) = 4.08$, $p = 0.048$, $\eta_p^2 = 0.06$] and a strategy*ToM interaction [$F(1,65) = 6.04$, $p = 0.017$, $\eta_p^2 = 0.08$], higher ToM abilities being associated with higher outcomes, especially when facing a fair opponent. We found no effect of hostility bias.

3.2.2. Proposers

The linear mixed model showed a main effect of group [$F(1,67.04) = 4.77$, $b = 0.325$ (95 % CI: 0.033 to 0.617), $p = 0.032$], opponent's strategy [$F(1,123.85) = 18.55$, $b = -0.345$ (95 % CI: −0.501 to −0.188), $p < 0.001$] and a group*strategy interaction [$F(1,123.85) = 5.77$, $b = 0.384$ (95 % CI: 0.071 to 0.698), $p = 0.018$] on the mean offer made as proposer, with higher mean offer made to a difficult opponent, and higher mean offer made by the SAUD group. Holm-corrected post-hoc analyses revealed that patients with SAUD offered higher amounts as proposers than HC, only when facing an easy opponent [$t(67) = -2.62$, $p = 0.044$] with no group difference against a difficult opponent [$t(67) = -0.99$, $p = 0.651$]. Post-hoc analyses also revealed that patients with SAUD did not differ in their mean offer made to an easy or difficult opponent [$t(67) = -1.36$, $p = 0.538$] while HC made a distinction between the two opponents' strategies [$t(67) = -4.71$, $p < 0.001$]. Per group correlational analyses showed no link between the average offer made in each strategy and interpersonal problems.

Regarding the amount of money earned as proposer, the mixed model showed a main effect of opponent's strategy [$F(1,68) = 164.37$, $p < 0.001$, $\eta_p^2 = 0.71$], with more money earned against an easy opponent, and a marginally significant group effect [$F(1,67) = 3.98$, $p = 0.05$, $\eta_p^2 = 0.06$], with more money earned by HC. ToM and hostility bias had no effect when included as covariates.

3.3. Exploratory analyses

Per group Pearson correlations revealed no link between the amount of money earned at the games and emotion regulation difficulties nor impulsivity. Pearson correlations revealed no link between acceptance rate of fair/unfair offers as responder and mean offers made against an easy/difficult opponent as proposer, and the psychopathological measures, which were therefore not included as covariates.

4. Discussion

We explored social decision-making in SAUD through an iUG where recently detoxified patients and matched controls played two games as responders against two different opponents (i.e., fair *vs.* unfair) and two games as proposers against two other opponents (i.e., easy *vs.* difficult). This unique approach allowed to address three main goals. First, we investigated behaviors during repeated social interactions, which is more representative of real-life relations. Second, we explored for the first time how patients with SAUD perform as proposers during an iUG. Third, we measured the underlying processes of social decision-making, by indexing social cognition markers widely impaired in SAUD, namely ToM (Onuoha et al., 2016), emotional regulation (Stellern et al., 2022) and hostile attributional bias (Pabst et al., 2024).

In contrast with the unfairness sensitivity reported in one-shot UG (Brevers et al., 2013; 2015; Tsukue et al., 2015), our results revealed that patients with SAUD did not reject more fair/unfair offers than controls as responders in an iUG and earned as much money as HC. Impulsivity and emotional processing were only marginally associated with social decision-making. These contradictory findings might be explained by methodological discrepancies. First, Brevers et al. (2013, 2015) used a variable sum of money to be split, while we used a fixed amount to limit cognitive load. Second, the UG literature is inconsistent regarding offers classification: Brevers et al. (2013, 2015) and Tsukue et al. (2015) used three classifications (unfair/medium-fair/fair) while we used only two (fair/unfair, based on our pretest). Studies also differ in what should be considered as fair/unfair: we classified the split of 3€/7€ as unfair while it was classified as fair in Cortes et al. (2018) and as medium-fair in Brevers et al. (2013, 2015) and Tsukue et al. (2015). Third, the contradictory results might also be explained by the iterative aspect of our UG. Specifically, one-shot and iterated paradigms involve different processes (Xue et al., 2010), notably regarding strategies. An iUG better captures real-life interpersonal relationships, where social decision-making is often based on the previous elaboration of knowledge regarding the opponent's behavior. Finally, although our failure to replicate previous results indicating an unfairness sensitivity in SAUD may be attributed to methodological differences across studies, such an outcome further points to the lack of robustness or practical significance of this effect. Indeed, we note that effect sizes in our study (r between 0.04 and 0.06), but also in previous studies showing a significant difference (r between 0.04 and 0.28; Brevers et al., 2013; 2015; Tsukue et al., 2015), are in the range of small/weak effects. Compared to other social cognition measures, the effect sizes related to social decision-making biases in SAUD appear weaker as meta-analyses (Bora & Zorlu, 2016) revealed medium effect size for emotion recognition [d = 0.65; 95 % CI:0.42–0.89] and Theory of Mind (d = 0.58; 95 % CI:0.36–0.81) deficits, the two most studied social cognition impairments in SAUD. Social cognition tasks, based on accuracy and hence measuring performance deficits, might thus generate stronger group differences than the UG, designed to explore subtle biases in social behaviors rather than accuracy/performance indexes. Beyond these differences with previous explorations, our results clearly revealed that patients adaptively respond to repeated social interactions, leading to the proposal that they might tend to be sensitive to unfairness in new social interactions (when they do not know their opponent as in one-shot UG), but might conversely be able to adapt and learn about their opponent during repeated interactions (i.e., iUG) where they did not differ from HC. Patients with SAUD, potentially due to their affective and cognitive deficits, might need more information about others and thus repeated interactions before acting adaptively. Our results thus suggest that when patients with SAUD acquire relevant information about others, they can overcome their initial increased sensitivity to unfairness observed by studies using one-shot UG.

We also showed that higher ToM abilities were associated with higher amount of money earned as responder, which supports the idea that ToM is required to understand the opponent's strategy and adapt to it to maximize outcomes. In the UG, a proposer with a good ToM will understand faster and more efficiently that a too low offer will upset the responder, who will refuse it to punish the proposer, and the proposer should thus infer what is the minimum offer to be accepted by the responder to maximize their own benefit. Moreover, a responder with good ToM abilities should understand that proposers want to maximize their own payoff and will therefore accept offers lower than an equal distribution. ToM is therefore necessary to understand the opponent' behaviors and to adapt oneself efficiently in the role of proposer or responder. In this context, patients with SAUD – because of their ToM difficulties – might need more time to understand their opponent's behavior and thus initially behave according to *a priori* biases in one-shot games, resulting in inefficient behaviors (i.e., less money earned). However, when they progressively learn about their opponent in an iUG, their behaviors can adapt efficiently.

Another key observation from our study relates to the offers made by patients with SAUD as proposers. Contrary to our hypothesis, patients with SAUD offered higher amounts than HC when facing an easy opponent (i.e., who accepted every offer except 1€). This pattern might reflect that, when patients with SAUD feel socially accepted (i.e., here after several trials in an iterated game), they tend to be more generous toward their opponent than during one-shot interactions. Patients with SAUD also present a high sensitivity to social exclusion with difficulties to regulate these feelings (Maurage et al., 2012). They thus might be afraid of being misunderstood or rejected by others, leading them to offer higher amount of money to please their opponent and be socially accepted. However, this proposal would have led patients to accept more unfair offers as well, which we did not observe. Finally, patients with SAUD did not adapt their offers regarding their opponent's strategy contrary to HC, which generated suboptimal behaviors. As a proposer in the UG, the most rational choice is to propose the smallest amount likely to be accepted by the responder (Tisserand et al., 2015). This last result underlines the difficulty for patients to adapt to their opponent to

maximize their benefits when they are initiating the social interaction, probably related to cognitive or ToM difficulties hampering to consider others' behaviors to adapt their offers. As a result, patients with SAUD earned marginally less money as proposers.

The comparison of our results with previous ones in substance use disorders beyond SAUD is hampered by the fact that the available data are scarce and lack consistency. Indeed, some studies documented unmodified UG performance (in cocaine users, Verdejo-Garcia et al., 2017) or conversely an increased tendency to accept unfair offers [in women with cocaine use disorders (Viola et al., 2019) and MDMA users (Stewart et al., 2014)], particularly when the amount of money involved is high (in heroin users, Hou et al., 2016). This trend towards a reduced unfairness sensitivity in substance use disorders contrasts with previous results obtained in SAUD, suggesting that excessive alcohol consumption might lead to a different social decision-making pattern than other substance use disorders. However, in view of the very few studies currently available and of the variability of the results obtained, future work, potentially capitalizing on transdiagnostic explorations including populations with different substance use disorders, should disentangle the effects of substance-specific impairments and contextual influences on decision-making in substance use disorders. When considering our results more broadly in relation with social decision-making impairments in psychiatric disorders, Robson et al. (2020) concluded that there are two areas under the RDoC framework in which there is consistency across psychiatric disorders: (1) impaired ToM and reduced integration of social/cognitive processes, which result in less effective and flexible decision-making. This is in line with our result showing that higher ToM abilities were associated with higher amount of money earned as responder, but also in the lack of flexibility of patients with SAUD as proposer; (2) Increased risk avoidance (of negative social interactions) and reduced reward sensitivity, which results in reduced profit-seeking. This is in line with our result showing that patients with SAUD made higher offers as proposers, possibly to be socially accepted. Our results are thus in line with the transdiagnostic impairments observed for social decision-making. Conversely, psychiatric states appear to generate various results regarding cooperative/altruistic behaviors, some patients (e.g., with depression or bipolar disorder) rejecting more unfair offers, others accepting more unfair offers (e.g., in anxiety; Robson et al., 2020). As results are inconsistent in SAUD, more studies are needed to understand how SAUD stands in the transdiagnostic approach of social decision-making.

5. Conclusion

Taken together, our findings suggest that patients with SAUD are sensitive to the development of positive social interactions. As proposers, patients with SAUD were more generous toward opponents and were less influenced than HC by their opponent's readiness to accept small offers. Whereas in new interactions like one-shot games they are prone to retaliation (by rejecting unfair offers more often as responders), this initial hostile responding dissipates with prolonged interactions like an iUG, presumably due to social learning.

The present results stress the need for social processing research in SAUD to embrace the complexity of real-life interactions and to go beyond classical approaches focusing on passive perception or reactions to single events emitted by unknown others. Considering patients in an active, initiating role with counterparts with whom they repeatedly interact offers novel and ecological insights into their social decision-making profile. From a clinical perspective, we suggest that the unfairness sensitivity observed in one-shot paradigms could be toned down through developed interactions. We further points to the possibility that patients may invest more resources than necessary into preserving social relationships (i.e., offering higher amounts as proposers), which may ultimately have detrimental consequences for themselves.

6. Author agreement

All authors have seen and approved the final version of the manuscript being submitted. They warrant that the article is the authors' original work, has not received prior publication and is not under consideration for publication elsewhere.

CRediT authorship contribution statement

Mado Gautier: Writing – original draft, Visualization, Software, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Damien Brevers:** Writing – review & editing. **Arthur Pabst:** Writing – review & editing, Formal analysis. **Christophe Geus:** Writing – review & editing, Project administration. **Pierre Maurage:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Conceptualization.

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Declaration of competing interest

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

Data availability

Data will be made available on request.

References

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (5th ed.). doi: 10.1176/appi.books.9780890425596.

Beadle, J. N., Paradiso, S., Kovach, C., Polgreen, L., Denburg, N. L., & Tranel, D. (2012). Effects of age-related differences in empathy on social economic decision-making. *International Psychogeriatrics, 24*(5), 822–833. https://doi.org/10.1017/s1041610211002547

Beck, A. T., Ward, C. H., Mendelson, M., Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. *Archives of general psychiatry, 4*, 561–571.

Bernardin, F., Maheut-Bosser, A., & Paille, F. (2014). Cognitive impairments in alcohol-dependent subjects. *Frontiers in Psychiatry, 5*, 78. https://doi.org/10.3389/fpsyt.2014.00078

Billieux, J., Rochat, L., Ceschi, G., Carré, A., Offerlin-Meyer, I., Defeldre, A., Khazaal, Y., Besche-Richard, C., & Van Der Linden, M. (2012). Validation of a short French version of the UPPS-P Impulsive Behavior Scale. *Comprehensive Psychiatry, 53*(5), 609–615. https://doi.org/10.1016/j.comppsych.2011.09.001

Bora, E., & Zorlu, N. (2016). Social cognition in alcohol use disorder : A meta-analysis. *Addiction, 112*(1), 40–48. https://doi.org/10.1111/add.13486

Brevers, D., Noël, X., Ermer, E., Dabiri, D., Verbanck, P., & Kornreich, C. (2013). Unfairness sensitivity and social decision-making in individuals with alcohol dependence : A preliminary study. *Drug And Alcohol Dependence, 133*(2), 772–775. https://doi.org/10.1016/j.drugalcdep.2013.08.013

Brevers, D., Noël, X., Hanak, C., Verbanck, P., & Kornreich, C. (2015). On the relationship between emotional state and abnormal unfairness sensitivity in alcohol dependence. *Frontiers In Psychology, 6*. https://doi.org/10.3389/fpsyg.2015.00983

Chang, L., Armaos, K., Warns, L., De Sousa, A. Q. M., Paauwe, F., Scholz, C., & Engelmann, J. B. (2023). Mentalizing in an economic games context is associated with enhanced activation and connectivity in the left temporoparietal junction. *Social Cognitive And Affective Neuroscience, 18*(1). https://doi.org/10.1093/scan/nsad023

Cortes, C. R., Grodin, E. N., Mann, C. L., Mathur, K., Kerich, M., Zhu, X., Schwandt, M., Diazgranados, N., George, D. T., Momenan, R., & Heilig, M. (2018). Insula Sensitivity to Unfairness in Alcohol Use Disorder. *Alcohol And Alcoholism, 53*(3), 201–208. https://doi.org/10.1093/alcalc/agx115

Dillon, K. H., Allan, N. P., Cougle, J. R., & Fincham, F. D. (2016). Measuring hostile interpretation bias. *Assessment, 23*(6), 707–719. https://doi.org/10.1177/1073191115599052

Fett, A. K., Viechtbauer, W., Dominguez, M. D., Penn, D. L., van Os, J., & Krabbendam, L. (2011). The relationship between neurocognition and social cognition with functional outcomes in schizophrenia: A meta-analysis. *Neuroscience & Biobehavioral Reviews, 35*(3), 573–588. https://doi.org/10.1016/j.neubiorev.2010.07.001

Ferris, J., & Wynne, H. (2001). The Canadian Problem Gambling Index: Final report. Ottawa: Canadian Centre on Substance Abuse.

Gautier, M., Pabst, A., & Maurage, P. (2021). Social decision making in severe alcohol use disorder : Scoping review and experimental perspectives. *Alcoholism Clinical And Experimental Research, 45*(8), 1548–1559. https://doi.org/10.1111/acer.14664

Girardi, A., Della Sala, S., & MacPherson, S. E. (2018). Theory of mind and the Ultimatum Game in healthy adult aging. *Experimental Aging Research, 44*(3), 246–257. https://doi.org/10.1080/0361073x.2018.1449590

Gratz, K. L., & Roemer, L. (2004). Difficulties in Emotion Regulation Scale (DERS) [Database record]. *APA PsycTests*. https://doi.org/10.1037/t01029-000

Hinterbuchinger, B., Kaltenboeck, A., Baumgartner, J. S., Mossaheb, N., & Friedrich, F. (2018). Do patients with different psychiatric disorders show altered social decision-making ? A systematic review of ultimatum game experiments in clinical populations. *Cognitive Neuropsychiatry, 23*(3), 117–141. https://doi.org/10.1080/13546805.2018.1453791

Horowitz, L., Alden, L., Wiggins, J., & Pincus, A. (2003). Inventory of interpersonal problems manual. Mind. *Garden.*

Hou, Y., Zhao, L., Yao, Q., & Ding, L. (2016). Altered economic decision-making in abstinent heroin addicts: Evidence from the ultimatum game. *Neuroscience Letters, 627*, 148–154. https://doi.org/10.1016/j.neulet.2016.06.002

Houser, D., & McCabe, K. (2014). Experimental Economics and Experimental Game Theory. Dans Elsevier eBooks (p. 19–34). doi: 10.1016/b978-0-12-416008-8.00002-4.

Jangard, S., Lindström, B., Khemiri, L., Pärnamets, P., Jayaram-Lindström, N., & Olsson, A. (2022). Alcohol use disorder displays trait-related reductions in prosocial decision making. *Biological Psychiatry Cognitive Neuroscience And Neuroimaging, 7*(9), 925–934. https://doi.org/10.1016/j.bpsc.2022.05.002

Liebowitz, M. R. (2015). Social phobia. *Modern Problems Of Pharmacopsychiatry/Modern Trends In Pharmacopsychiatry, 141–173*. https://doi.org/10.1159/000414022

Marchetti, A., Castelli, I., Harlé, K. M., & Sanfey, A. G. (2011). Expectations and outcome : The role of Proposer features in the Ultimatum Game. *Journal Of Economic Psychology, 32*(3), 446–449. https://doi.org/10.1016/j.joep.2011.03.009

Maurage, P., Joassin, F., Philippot, P., Heeren, A., Vermeulen, N., Mahau, P., Delperdange, C., Corneille, O., Luminet, O., & De Timary, P. (2012). Disrupted Regulation of Social Exclusion in Alcohol-Dependence : An fMRI Study. *Neuropsychopharmacology, 37*(9), 2067–2075. https://doi.org/10.1038/npp.2012.54

National Institute of Mental Health (NIMH) (2016): Behavioral assessment methods for RDoC constructs: A report by the National Advisory Mental Health Council Workgroup on Tasks and Measures for Research Domain Criteria (RDoC). Available at: https://www.nimh.nih.gov/sites/default/files/documents/about/advisory-boards-and-groups/namhc/reports/rdoc_council_workgroup_report.pdf.

Onuoha, R. C., Quintana, D. S., Lyvers, M., & Guastella, A. J. (2016). A Meta-analysis of Theory of Mind in Alcohol Use Disorders. *Alcohol And Alcoholism, 51*(4), 410–415. https://doi.org/10.1093/alcalc/agv137

Ortmann, A., & Tichy, L. K. (1999). Gender differences in the laboratory : Evidence from prisoner's dilemma games. *Journal Of Economic Behavior & Organization, 39*(3), 327–339. https://doi.org/10.1016/s0167-2681(99)00038-4

Pabst, A., De Eulate, N. G., Dillon, K. H., & Maurage, P. (2023). French adaptation and further validation of the word sentence association paradigm to assess hostile attributional biases. *Canadian Journal Of Behavioural Science/Revue Canadienne des Sciences du Comportement*. https://doi.org/10.1037/cbs0000385

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), 999–1011. https://doi.org/10.1037/adb0000874

Pabst, A., Gautier, M., & Maurage, P. (2024). Hostile attributional biases in severe alcohol use disorder : Replication, gender specificity, and mechanistic insights. *Alcohol And Alcoholism, 59*(2). https://doi.org/10.1093/alcalc/agae010

Robson, S. E., Repetto, L., Gountouna, V. E., & Nicodemus, K. K. (2020). A review of neuroeconomic gameplay in psychiatric disorders. *Molecular Psychiatry, 25*(1), 67–81. https://doi.org/10.1038/s41380-019-0405-5

Saunders, J. B., Aasland, O. G., Babor, T. F., De la Fuente, J. R., & Grant, M. (1993). Development of the Alcohol Use Disorders Identification Test (AUDIT) : WHO Collaborative Project on Early Detection of Persons with Harmful Alcohol Consumption-II. *Addiction, 88*(6), 791–804. https://doi.org/10.1111/j.1360-0443.1993.tb02093.x

Sliedrecht, W., De Waart, R., Witkiewitz, K., & Roozen, H. G. (2019). Alcohol use disorder relapse factors : A systematic review. *Psychiatry Research, 278*, 97–115. https://doi.org/10.1016/j.psychres.2019.05.038

Spielberger, C. D., & Gorsuch, R. L. (1983). State-Trait Anxiety Inventory for adults: Sampler set: Manual, test, scoring key. Mind. *Garden.*

Stavro, K., Pelletier, J., & Potvin, S. (2013). Widespread and sustained cognitive deficits in alcoholism : A meta-analysis. *Addiction Biology, 18*(2), 203–213. https://doi.org/10.1111/j.1369-1600.2011.00418.x

Stellern, J., Xiao, K. B., Grennell, E., Sanches, M., Gowin, J. L., & Sloan, M. E. (2022). Emotion regulation in substance use disorders : A systematic review and meta-analysis. *Addiction, 118*(1), 30–47. https://doi.org/10.1111/add.16001

Stewart, L. H., Ferguson, B., Morgan, C. J., Swaboda, N., Jones, L., Fenton, R., Wall, M. B., & Curran, H. V. (2014). Effects of ecstasy on cooperative behaviour and perception of trustworthiness: A naturalistic study. *Journal of Psychopharmacology, 28*(11), 1001–1008. https://doi.org/10.1177/0269881114544775

Tisserand J.C., Cochard F. & Le Gallo J. (2015) Altruistic or strategic considerations: A meta-analysis on the ultimatum and dictator games. Besançon: CRESE, Université de Franche Comté. Retrieved from: https://www.semanticscholar.org/paper/Altruistic-or-strategic-considerations-%3A-A-on-the-%E2%88%97-Tisserand-Cochard/6d0ad9a29c60bfca3bdeb11a3a56d454acbaf85f.

Tsukue, R., Okamoto, Y., Yoshino, A., Kunisato, Y., Takagaki, K., Takebayashi, Y., Tanaka, K., Konuma, K., Tsukue, I., & Yamawaki, S. (2015). Do Individuals with Alcohol Dependence Show Higher Unfairness Sensitivity ? The Relationship Between Impulsivity and Unfairness Sensitivity in Alcohol-Dependent Adults. *Alcoholism Clinical And Experimental Research, 39*(10), 2016–2021. https://doi.org/10.1111/acer.12832

Verdejo-Garcia, A., Verdejo-Román, J., Albein-Urios, N., Martínez-González, J. M., & Soriano-Mas, C. (2017). Brain substrates of social decision-making in dual diagnosis: Cocaine dependence and personality disorders. *Addiction Biology, 22*(2), 457–467. https://doi.org/10.1111/adb.12318

Viola, T. W., Niederauer, J. P. O., Kluwe-Schiavon, B., Sanvicente-Vieira, B., & Grassi-Oliveira, R. (2019). Cocaine use disorder in females is associated with altered social decision-making: A study with the prisoner's dilemma and the ultimatum game. *BMC Psychiatry, 19*(1), 211. https://doi.org/10.1186/s12888-019-2198-0

Wei, Z., Li, Q., Liang, C., & Liu, H. (2022). Cognitive process underlying ultimatum game : An eye-tracking study from a dual-system perspective. *Frontiers In Psychology, 13*. https://doi.org/10.3389/fpsyg.2022.937366

Xue, G., Chen, C., Lu, Z., & Dong, Q. (2010). Brain imaging techniques and their applications in decision-making research. *Acta Psychologica Sinica, 42*(1), 120–137. https://doi.org/10.3724/sp.j.1041.2010.00120