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RESEARCH ARTICLE

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Competitive Bias in Severe Alcohol Use Disorder: An Exploration Through the Prisoner's Dilemma Paradigm

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ABSTRACT

Background: Biased social decision-making might play a critical role in interpersonal difficulties and relapse among individuals with severe alcohol use disorder (SAUD), but its exploration remains scarce. We measured social decision-making in SAUD through an ecological iterated prisoner's dilemma paradigm, measuring cooperative versus competitive tendencies during social interactions.

Methods: Forty detoxified patients with SAUD (16 females, mean age = 50.40 years, SD = 9.82) and 40 matched control participants (17 females, mean age = 44.48 years, SD = 12.87) played six iterated prisoner's dilemma games in a laboratory setting, varying according to the type of opponent (computer/human being) and the strategy followed by this opponent (competitive/cooperative/random). We measured the competition rates of participants in each condition as well as their social cognition performance (hostile attribution bias/empathy) and psychological measures [depression/(social) anxiety/impulsivity/interpersonal difficulties]. We assessed relapse at 6-month follow-up.

Results: Patients displayed a competitive bias during prisoner's dilemma games (resulting in higher outcomes) and a less efficient adaptation to their opponent's strategy. Both patients and controls were more competitive toward a computer than a human. We observed no link between the competitive bias of patients with SAUD and their social cognition difficulties. We observed that patients' competitive bias was associated with relapse rates at 6 months.

Conclusions: SAUD is characterized by a competitive bias during social decision-making. Such bias, despite leading to more advantageous decisions at the economic level, suggests difficulties in understanding others' intentions and behaving accordingly in social situations, which could favor social difficulties and relapse.

1 | Introduction

Beyond its established physical and psychological consequences (Grant et al. 2015; WHO 2018), severe alcohol use disorder (SAUD) is related to social impairments (e.g., conflicts, stigmatization, social isolation; Kilian et al. 2021; Maurage et al. 2017; Mowbray et al. 2014). However, the mechanistic predictors of these interpersonal difficulties are still poorly understood. A potential explanation is that deficits in socioemotional information processing would generate biased social decision-making, ending up in nonadaptive interpersonal behaviors promoting social impairments (Brevers et al. 2013; Gautier et al. 2021). There is thus a need to understand whether patients with SAUD display biased decision-making in social contexts, and how such biases relate to social cognition deficits.

We capitalized on Game Theory to deepen the understanding of social decision-making. This framework allows us to explore social decision-making through ecological and experimentally controlled paradigms (Robson et al. 2020) where players make

decisions affecting both their own economic outcomes and those of their opponent. These tasks measure actual social behavior rather than hypothetical decisions or intentions (Balliet et al. 2011) and are useful to assess transdiagnostic processes, notably following the Research Domain Criteria (RDoC) approach (NIMH 2016; Robson et al. 2020). To date, while several economic games have been tested in individuals with moderate-to-severe alcohol use disorder (Jangard et al. 2022, 2025), the Ultimatum Game remains the only task used in a clinical population of patients with SAUD, with three studies evidencing biased social decision-making (Brevers et al. 2013, 2015; Tsukue et al. 2015, but see Cortes et al. 2018; Gautier et al. 2025). While offering preliminary insights on fairness sensitivity, such focus on the Ultimatum Game hampered the exploration of other components of social decision-making, and centrally the tendency toward cooperative/competitive behaviors. The Prisoner's Dilemma (PD), another validated economic game, allows such exploration. Indeed, the PD examines the balance between cooperation and self-interest. It evaluates trust and cooperation when facing individual incentives to defect, mimicking everyday life where we constantly choose between common good and personal profit.

In the economic version of the PD, two participants are presented with a matrix of possible outcomes (usually translatable into money). Both must simultaneously and independently decide to cooperate or defect, and the combination of their choices determines the outcomes. It can be played in a one-shot (a single trial against one opponent) or iterated (multiple trials with the same opponent) format. In a one-shot PD, the more utility-maximizing strategy is to defect, as it brings the highest payoff regardless of the opponent's choice (Kümmerli et al. 2007; Robson et al. 2020; Sorgi and van 't Wout 2016; Viola et al. 2019). However, a behavior which is optimal for oneself in a one-shot game with a stranger (i.e., defecting) is not always optimal in repeated games (Camerer and Fehr 2004). In an iterated Prisoner's dilemma (iPD), it is more strategic to (partly) cooperate as joint cooperative choices bring the highest total outcomes for both players (Jurišić et al. 2012; Kümmerli et al. 2007; Lave 1962). This format therefore better reflects real-life interpersonal relationships, where social decision-making is often informed by prior knowledge of the other's behavior, and where flexibility between cooperation and competition optimizes social outcomes (Baggio and Benning 2022).

We thus employed an iPD paradigm to investigate competitivity/strategic adaptation in social decision-making in SAUD, and its links with social cognition. We applied two improvements to the iPD. First, we controlled the opponents' strategies and made it vary (i.e., cooperative, competitive, random behavior) to explore whether patients with SAUD can adapt their decision to their opponent's strategy (Baggio and Benning 2022). Second, we manipulated the social aspect of the situation by having participants play against presumed human opponents or a computer. We centrally hypothesized that patients with SAUD will: (1) present more competitive behaviors than controls in an iPD (main hypothesis); (2) adapt less efficiently and more slowly their strategy to the opponent's one compared to controls, namely present a weaker adjustment of their "cooperate/defect" choices to match the other player's cooperative or competitive strategy. We also predicted that (3) higher competition rates would be associated with impaired social cognition (i.e., increased hostility bias and decreased empathy), greater interpersonal problems, and higher relapse rates at 6-month follow-up. This hypothesis is based on evidence showing social cognition and interpersonal difficulties in SAUD (Kumar et al. 2022; Maurage et al. 2017; Pabst et al. 2024) and the idea that altered social decision-making may deteriorate social support and hence promote relapse risk (Hunter-Reel et al. 2009; Shafiei et al. 2014; Sliedrecht et al. 2019). Last, we expected that (4) participants will present higher competition rate when playing against a computer than a human, this difference being reduced among patients, potentially less sensitive to the social component of the game.

2 | Methods

2.1 | Participants

Based on an a priori power analysis, we recruited 80 participants: 40 patients with SAUD and 40 healthy controls. We recruited patients with SAUD in detoxification units of four Belgian hospitals. They were diagnosed with SAUD according to DSM-5 criteria (i.e., the presence of 6 or more symptoms), and had an abstinence duration between 9 and 72 days at testing time. We recruited healthy controls through social media, participants pool and flyers. They had a low alcohol consumption as indexed by (1) a score lower than 8 at the Alcohol Use Disorders Identification Test (AUDIT; Saunders et al. 1993) and (2) a consumption lower than 10 alcohol units/week and 4 units/day, a unit corresponding to 10 g of ethanol. They did not present a family history of SAUD (i.e., first-degree parent with present/past SAUD) and we matched them with the SAUD group on sex and education (i.e., assessed by the number of years of successful schooling since first grade).

Exclusion criteria for both groups included (1) past/present neurological/psychiatric disorder (except mild depression/anxiety for patients), (2) history of head injury with prolonged loss of consciousness, (3) other substance abuse (except nicotine), (4) psychotropic medication with significant cognitive impact, (5) gambling disorder (i.e., score >2 at the Canadian Problem Gambling Index; Ferris and Wynne 2001), (6) lack of fluency in French and (7) uncorrected poor vision.

2.2 | Procedure

We performed the study protocol in accordance with the Declaration of Helsinki and it was approved by the Ethics Committee of the Saint-Luc-UCLouvain Clinics and the local committee of each hospital. All participants provided a written informed consent.

Before the experiment, participants completed the State Anxiety Inventory (STAI-A; Spielberger and Gorsuch 1983). Participants played two iPD games: one against a simulated human, considered a real human by participants (i.e., an actor appearing in a prerecorded webcam video at the beginning of the game; see Supporting Information) and one against a computer. The task built on E-Prime 2 is available online for research purpose (https://osf.io/cyg9n/?view_only=ae6b617752

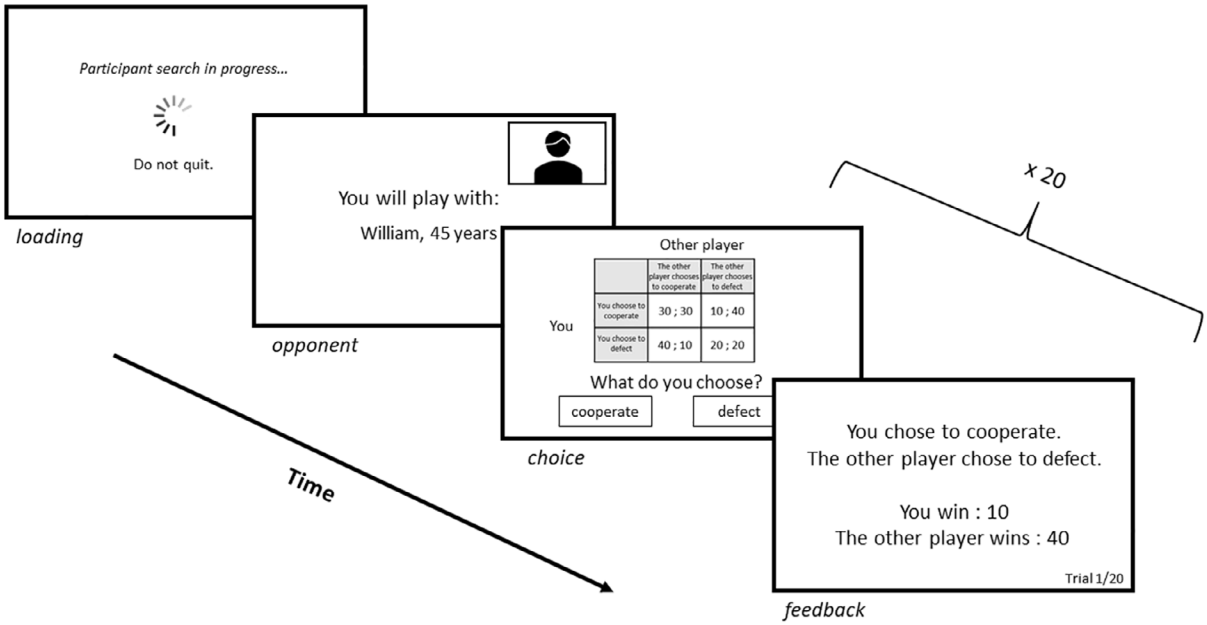

FIGURE 1 | Experimental timeline of a block in the "human" condition. Participants saw a webcam video of their opponent during 20 s, with his/her name and age, together with a screen indicating that the computers were currently connecting. Each block comprised 20 trials during which the participant had to decide to cooperate or defect. The matrix was displayed on the screen during each trial, so that participants were free to refer to it for every decision and did not have to memorize it. A feedback of their own and the other player's choices appeared after each trial, with the number of points earned by each player.

TABLE 1 | Prisoner's dilemma outcomes matrix used in the study, depending on both players' choice to cooperate (C) or to defect (D). In each cell, the comma separates the payoffs of the two players.

	C	D
C	30, 30	10, 40
D	40, 10	20, 20

824cef994142451bb75ad6). In both games, the opponent was actually computerized with predetermined responses. Each game consisted of three blocks of 20 trials during which the participant decided to cooperate/defect, varying regarding the opponent's strategy (Figure 1): the first block was random, the second competitive, and the last cooperative (see Supporting Information for a detailed description of the task). The within-subject design allowed the participants to accumulate, throughout the successive trials against the same opponent, information about the opponent's strategy and to adapt their own accordingly (Bitsch et al. 2018). As the probability of competitive behavior in the PD is strongly influenced by the payoff matrix (Scodel 1962; Scodel et al. 1959), we controlled for the choice of payoff values (Ashlock et al. 2010): the matrix (Table 1) was selected based on a pretest (see Supporting Information). We told participants before the task that, depending on the points earned, they could earn between 0 and 10 euros. We decided to use real money incentives to increase engagement (Brevers et al. 2015). Since previous research indicates that, despite sex effects on decisions in the iPD, cooperation rates are comparable in single-sex games (Ortmann and Tichy 1999), two identical versions of each iPD were created so that participants only played with same-sex opponents (Sorgi and van 't Wout 2016).

After the two iPDs, participants completed the Word Sentence Association Paradigm Hostility Scale (WSAP-H; Dillon et al. 2016; Pabst et al. 2023), a measure of hostile interpretation bias. They completed measures of empathy (Empathy Quotient, EQ; Baron-Cohen and Wheelwright 2004) and interpersonal problems (Inventory of Interpersonal Problems, IIP-64; Horowitz et al. 2003). Then, they filled out questionnaires assessing depression (Beck Depression Inventory, BDI; Beck et al. 1961), trait anxiety (Trait Anxiety Inventory, STAI-B; Spielberger and Gorsuch 1983), social anxiety (Liebowitz Social Anxiety Scale, LSAS; Liebowitz 1987), and impulsivity (Urgency, lack of Premeditation, lack of Perseverance, Sensation seeking Scale, UPPS; Billieux et al. 2012). We finally debriefed participants, and they received a fixed financial compensation (independent of their performance at the game and greater than the maximum amount they could possibly have earned).

2.3 | Statistical Analyses

We preregistered the hypotheses, design, sample size rationale and analysis plan of the study on the Open Science Framework on November 17, 2022: https://doi.org/10.17605/OSF.IO/Q4YD6. We describe and justify departures from this original plan in the corresponding sections. We performed all analyses using the software Jamovi 2.3.28.

2.3.1 | Sample Size Computation

An a priori power analysis using G*Power 3.1.9.7 was performed to determine the sample size, based on between factors effect in

a repeated measures ANOVA (our main hypothesis being a difference between groups in the PD), with a significance level of 0.05, a desired power of 0.8, and a medium effect size expected (as no study has the PD in SAUD before). We deviated from the preregistration as the sample size rationale in the preregistration was based on the wrong analysis. We calculated a new sample size based on the correct preregistered main analysis (i.e., a repeated measures ANOVA) that lead to a smaller but almost similar sample size. This analysis leads to a total sample size of 76 that we increased to 80.

2.3.2 | Group Comparison

We first performed *t*-tests (or chi-squared test for two proportions when applicable) to compare our two groups on (1) sociodemographic variables (i.e., age, sex, and education), (2) psychological variables (i.e., anxiety, social anxiety, depression, alcohol consumption, and interpersonal problems), and (3) social cognition variables (i.e., hostile attributional bias, empathy).

2.3.3 | Competitive Behavior at the Game

To test Hypotheses 1 and 4, we performed a repeated measures ANOVA with competition rate (i.e., percentage of competitive choices) as the dependent variable and strategy (cooperative vs. random vs. competitive; within), opponent (human vs. computer; within), and group (patients with SAUD vs. controls; between) as independent variables to investigate the competitive behaviors of participants across conditions. We then performed post hoc analyses corrected for multiple comparisons on the significant effects.

2.3.4 | Performance at the Game

To investigate the consequences of decision-making and strategy optimization, we also ran a repeated measures ANOVA with the number of points earned per block (i.e., performance at the game) as dependent variable and the strategy (within), opponent (within), and group (between) as independent variables.

2.3.5 | Adaptation to Strategy

To test Hypothesis 2, related to the ability to adapt one's strategy to opponent's strategy changes, we ran two mixed effect binary logistic regression (i.e., respectively based on data from the competition/cooperation conditions), with fixed effects on Group, Opponent, Time, and Group × Opponent, Group × Trial, and Opponent × Trial interactions; and random effects for the subject on the intercept and the opponent variable's slope. The dependent variable was participants' choice to defect on each trial (1/0). We conducted complementary nonpreregistered analyses as we used difference scores to investigate in more detail participants' adaptation to the different strategies according to Hypothesis 2. For each participant, we computed a difference score in competition rate between opponent's strategies. We then compared groups on these three difference scores (i.e., competition minus random, competition minus cooperation, random minus cooperation) using independent sample *t*-tests.

2.3.6 | Correlational Analyses

Regarding the correlational analyses testing Hypothesis 3, we performed Pearson correlations between the competition rate and the WSAP-H (hostility bias), EQ (empathy), and IIP-64 (interpersonal problems) scores, respectively, and between the WSAP-H score and the competition rate in the third block (cooperative ones) and the number of points earned respectively. In our exploratory analyses, we performed Pearson's correlational analyses Bonferroni-corrected for multiple comparison to test the links between the competition rate and psychopathological measures, as well as abstinence duration, to include them as covariates if linked. As groups were not matched on age, we also performed Pearson correlations between age and our dependent variables to include age as covariate if linked.

2.3.7 | Link With Relapse

Finally, we explored the link between social decision-making and relapse (defined as at least one re-consumption episode, our "relapse" measure therefore including both lapse and relapse) by performing a unilateral *t*-test with the competition rate as dependent variable and the two groups of patients as independent variable [i.e., patients still abstinent at 6 months ($n = 17$) versus patients who relapsed ($n = 15$)]. This analysis was not preregistered as we did not know what would be the drop-out rate for follow-up (usually high in this population) and whether this analysis would be possible. We also performed *t*-tests to compare relapsers and nonrelapsers on key clinical variables e.g., depression, (social) anxiety, impulsivity, and interpersonal problems.

3 | Results

3.1 | Demographic, Psychopathological, Alcohol-Related, and Social Cognition Measures

Patients with SAUD and controls did not differ for sex, education, state anxiety, social anxiety and empathy ($p > 0.05$). Patients showed higher scores for depression [$t(56.97) = 5.61$, $p < 0.001$, Cohen's d (d) = 1.29], trait anxiety [$t(75) = 4.52$, $p < 0.001$, $d = 1.03$], and AUDIT [$t(48.28) = 33.50$, $p < 0.001$, $d = 7.66$]. Patients reported more impulsivity [$t(76) = 3.89$, $p = < 0.001$, $d = 0.88$] and interpersonal problems [$t(77) = 2.02$, $p = 0.046$, $d = 0.46$]. Patients displayed a hostility bias compared to controls, with higher scores on the WSAP-H hostile attribution subscale [$t(78) = 2.55$, $p = 0.013$, $d = 0.57$] but not on the benign attribution subscale. These exploratory analyses are presented in Table 2.

3.2 | Prisoner's Dilemma

3.2.1 | Competitive Behavior at the Game

The first model revealed a main Group effect, which confirms our first hypothesis: patients with SAUD (M = 68.3% of competitive choices, SD = 15.2) are more competitive than controls (M = 59.4%, SD = 17.1) [$F(1,78) = 5.99$, $p = 0.017$, $\eta^2_p = 0.071$]. We also observed a main effect of Opponent, participants being

TABLE 2 | Sociodemographic, psychopathological, interpersonal problems, and alcohol consumption variables in patients with SAUD and controls.

	Patients with SAUD ($N=40$)	Controls ($N=40$)			
	M (SD)	M (SD)	t/χ^2	p	Cohen's d
Demographic measures					
Age*	50.40 (9.82)	44.48 (12.87)	2.32	0.023	0.52
Education[ns]	14.02 (3.05)	15.32 (2.79)	1.99	0.050	0.44
Sex ratio (female/male)[ns]	16/24	17/23	0.052	0.820	—
Alcohol consumption measures					
AUDIT***[,2]	32.02 (4.93)	3.22 (1.99)	33.50	<0.001	7.66
Number of units per day before detoxification[2]	16.46 (10.25)	—	—	—	—
Number of previous detoxifications	1.56 (2.56)	—	—	—	—
Psychopathological measures					
BDI***[,3]	9.35 (5.86)	3.15 (3.42)	5.61	<0.001	1.29
STAI-A[ns]	30.69 (10.26)	29.14 (7.31)	0.78	0.437	0.18
STAI-B***[,3]	50.78 (10.69)	40.00 (10.21)	4.52	<0.001	1.03
LSAS[ns,4]	50.17 (31.80)	38.98 (27.94)	1.63	0.107	0.38
Anxiety[ns,3]	24.50 (17.03)	20.72 (15.57)	1.02	0.313	0.23
Avoidance*[,4]	25.67 (16.48)	18.25 (15.57)	2.04	0.045	0.47
UPPS***[,2]	47.98 (6.90)	42.25 (6.12)	3.89	<0.001	0.88
Negative urgency***	10.50 (2.39)	8.30 (2.56)	3.91	<0.001	0.89
Positive urgency***	11.50 (2.28)	9.68 (1.67)	4.05	<0.001	0.92
Lack of premeditation*	8.47 (2.91)	7.00 (2.11)	2.55	0.013	0.58
Lack of perseverance[ns]	7.90 (2.75)	7.05 (2.26)	1.50	0.138	0.34
Sensation seeking[ns]	9.60 (2.51)	10.22 (2.41)	1.11	0.270	0.25
Interpersonal problems					
IIP-64 total*[,1]	90.99 (30.84)	75.88 (35.30)	2.02	0.046	0.46
Domineering[ns]	7.15 (3.18)	6.30 (3.77)	1.09	0.281	0.24
Self-centered**	9.05 (4.66)	6.40 (3.90)	2.75	0.008	0.62
Cold/distant[ns]	8.64 (5.62)	6.90 (5.76)	1.36	0.178	0.31
Socially inhibited[ns]	12.08 (8.86)	9.50 (7.88)	1.37	0.175	0.31
Nonassertive[ns]	13.33 (8.67)	12.12 (7.63)	0.66	0.513	0.15
Overly accommodating[ns]	14.15 (6.88)	13.25 (6.28)	0.61	0.544	0.14
Self-sacrificing[ns]	15.94 (5.92)	13.98 (6.60)	1.39	0.168	0.31
Intrusive/Needy**	10.63 (5.30)	7.20 (4.82)	3.01	0.003	0.68
Social cognition					
EQ[ns,2]	40.49 (10.57)	40.70 (11.59)	0.08	0.932	0.02
Cognitive empathy[ns]	5.10 (2.36)	4.72 (2.62)	0.67	0.503	0.15
Emotional reactivity[ns]	5.92 (2.34)	6.02 (2.03)	0.21	0.834	0.05
Social skills[ns]	5.45 (2.25)	5.35 (2.33)	0.19	0.852	0.04

(Continues)

TABLE 2 | (Continued)

	Patients with SAUD ($N=40$)	Controls ($N=40$)			
	M (SD)	M (SD)	t/χ^2	p	Cohen's d
WSAP-H					
Hostile attributions*	3.36 (0.88)	2.90 (0.70)	2.55	0.013	0.57
Benign attributions	4.06 (0.72)	4.11 (0.52)	0.37	0.715	0.08

Note: *$p<0.05$, **$p<0.01$, ***$p<0.001$, superscript numbers indicate the number of missing data.
Abbreviations: AUDIT, Alcohol Use Disorders Identification Test (Saunders et al. 1993); BDI, Beck Depression Inventory (Beck et al. 1961); EQ, Empathy Quotient (Baron-Cohen and Wheelwright 2004); IIP-64, Inventory of Interpersonal Problems (Horowitz et al. 2003); LSAS, Liebowitz Social Anxiety Scale (Liebowitz 1987); STAI, State–Trait Anxiety Inventory (Spielberger and Gorsuch 1983); ns, nonsignificant; UPPS, urgency, lack of premeditation, lack of perseverance, Sensation seeking Scale (Billieux et al. 2012); WSAP-H, Word Sentence Association Paradigm Hostility Scale (Dillon et al. 2016; Pabst et al. 2023).

more competitive toward a computer (M = 66.0%, SD = 17.5) than a human (M = 61.6%, SD = 19.4) [$F(1,78)=5.94$, $p=0.017$, $\eta^2_p=0.071$], without Opponent × Group interaction, which only partly confirms our fourth hypothesis. We observed a main effect of Strategy [$F(1.68,130.87)=41.88$, $p<0.001$, $\eta^2_p=0.349$] as well as a Strategy × Group interaction [$F(1.68,130.87)=7.63$, $p=0.001$, $\eta^2_p=0.089$] and a Strategy × Opponent interaction [$F(2,156)=4.06$, $p=0.019$, $\eta^2_p=0.050$]. Post hoc analyses with Bonferroni correction revealed patients were more competitive than controls facing a cooperative opponent [$t(78)=2.99$, $p=0.012$, $d=0.67$] and an opponent with a random strategy [$t(78)=2.50$, $p=0.045$, $d=0.56$], but groups did not differ when facing a competitive opponent (Figure 2). This result confirms that patients tend to persist in competition after facing a competitive opponent as they presented more defection choices than controls in the cooperative block following the competitive one. Participants made a distinction in their competition rate between competitive strategy (M = 72.75%, SD = 15.03) and both random (M = 59.41, SD = 16.30) [$t(78)=10.53$, $p<0.001$, $d=1.18$] and cooperative ones (M = 59.34, SD = 24.22) [$t(78)=7.10$, $p<0.001$, $d=0.79$], but not between random and cooperative strategies [$t(78)=0.03$, $p>0.05$, $d=0.00$], as was confirmed for both groups. The Strategy × Opponent interaction corrected for multiple comparisons also revealed participants made a distinction between human and computer only in the cooperative strategy [$t(78)=3.38$, $p=0.003$], but not in the random/competitive strategies. We observed no Opponent × Strategy × Group triple interaction.

3.2.2 | Performance at the Game

The second model with the points earned during the game as dependent variable indicated a main Group effect [$F(1,78)=5.97$, $p=0.017$, $\eta^2_p=0.071$], with patients (M = 3219.00, SD = 181.88) having won more points than controls (M = 3113.25, SD = 204.63). We observed a main Opponent effect [$F(1,78)=5.88$, $p=0.018$, $\eta^2_p=0.070$] with more points won in the computer condition than in the human one, and a main Strategy effect [$F(1.68,131)=2011.53$, $p<0.001$, $\eta^2_p=0.963$], participants having won significantly more points in the cooperative strategy, followed by the random and finally the competitive one. Results showed a significant Strategy × Group interaction [$F(1.68,131)=7.58$, $p=0.002$, $\eta^2_p=0.089$]. The post hoc analyses (corrected for multiple comparisons) revealed that patients with SAUD won more points than controls in the cooperative [$t(78)=2.98$, $p=0.012$, $d=0.67$] and random strategies [$t(78)=2.50$, $p=0.045$, $d=0.56$]. The model also showed a Strategy × Opponent interaction [$F(2,156)=4.02$, $p=0.020$, $\eta^2_p=0.049$], indicating that participants won more points in the computer condition than in the human one only in the cooperative strategy [$t(78)=-3.37$, $p<0.001$].

3.2.3 | Adaptation to Strategy

The two mixed effect binary logistic regression in the competitive [$F(1,3193)=1.88$, $p=0.171$] and cooperative strategies [$F(1,3193)=1.13$, $p=0.288$] showed no significant group × trial interaction, indicating that patients did not significantly differ from controls in the time taken to adopt a competitive strategy in the competitive condition or a cooperative strategy in the cooperative condition.

3.2.4 | Correlational Analyses

Despite patients with SAUD displayed higher scores on the hostile attribution subscale of the WSAP-H, this hostility bias was not related to their higher competition rate (i.e., the number of "defection" choices through the six games) nor to their persistence in competition (i.e., the number of "defection" choices in the block following the competitive strategy), or the points earned at the games, contrary to our hypotheses. The higher competition rate displayed by patients was not linked with their empathy score (or subscores), nor with their reported interpersonal problems.

3.3 | Exploratory Analyses

We further explored the adaptation to the strategies through difference scores. We computed the difference in competition rate between each strategy and compared these scores between groups. Results indicated that controls made a higher distinction between competitive and random strategies [$t(78)=2.59$, $p=0.011$, $d=0.58$], and between competitive and cooperative strategies [$t(68.69)=-3.49$, $p<0.001$, $d=0.78$] than patients with SAUD. These results indicated that patients made less distinction between the different strategies of their opponents.

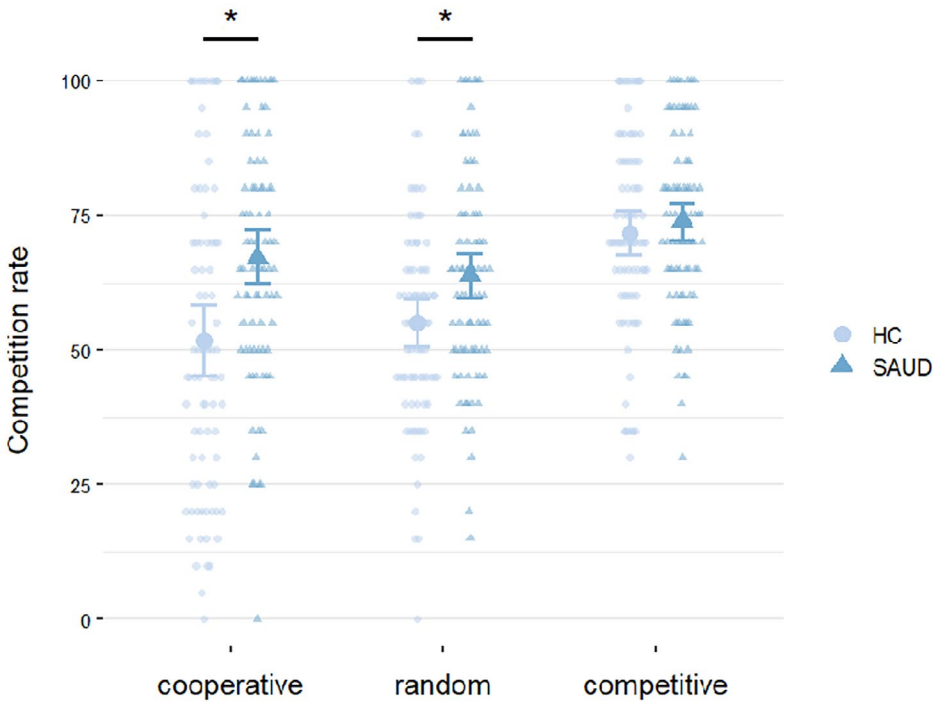

FIGURE 2 | Means and error bars of the competition rate (percentage of "defection" choices during the game) depending on strategies (cooperative, random, competitive) and groups [healthy controls (HC), patients with SAUD (SAUD)].

We performed Pearson's correlations corrected for multiple comparison to test the links between competition rate (i.e., number of "defection" choices through the six games) and the psychopathological measures and abstinence duration. As none of these correlations were significant, we did not add these variables as covariates. As our two groups were not matched on age, we performed correlations between age and the competition rates in the different conditions and none of them were significant. Therefore, we did not include age as covariate.

3.4 | Link With Relapse

We compared the competition rate at testing time of patients who had relapsed and patients who remained abstinent 6 months later and showed that patients who had relapsed were more competitive at baseline than the ones who remained abstinent [$t(30) = 1.75$, $p = 0.045$, $d = 0.62$]. Importantly, relapsers did not differ from nonrelapsers on depression [$t(29) = 1.40$, $p = 0.171$, $d = 0.50$], anxiety [$t(29) = 0.57$, $p = 0.575$, $d = 0.20$], social anxiety [$t(28) = 0.27$, $p = 0.787$, $d = 0.10$], impulsivity [$t(30) = 0.34$, $p = 0.735$, $d = 0.12$], nor interpersonal problems [$t(30) = 0.49$, $p = 0.629$, $d = 0.17$].

4 | Discussion

The exploration of social decision-making in SAUD and its underlying processes remains sparse and restricted to specific subprocesses (i.e., unfairness sensitivity), despite its potential role in the interpersonal difficulties and high relapse rates observed in this population. We explored direct social decision-making behaviors through the measurement of competitive tendencies in an ecological iPD paradigm simulating real social interactions.

First, in line with our first hypothesis, patients with SAUD exhibited a competitive bias, by defecting more frequently than controls in the iPD. This bias is particularly obvious when their opponents employed a cooperative/random strategy. The competitive bias of patients with SAUD was associated with a medium effect size, consistent with effect sizes typically reported in social cognition (Bora and Zorlu 2017) and classical cognitive domains (e.g., attention; Stavro et al. 2013). Importantly, in our iPD game with fixed conditions (where the opponents' strategies are predetermined and do not vary according to participant's choices), defecting is more advantageous (i.e., leads to higher points earned) than cooperating, as demonstrated by the second model where patients with SAUD won significantly more points than controls. From a utility-maximizing perspective, one could argue that patients with SAUD are more rational than controls during social decision-making, as they consistently choose the option maximizing their benefit. However, this higher performance was only possible because our iPD was based on fixed strategies with predetermined responses, not adapting with the participant's choices (e.g., in the competitive strategy, the opponent played 80% of competition and 20% of cooperation, no matter the participant's behavior), which differ from real-life situations. With real human opponents, the patients' competitive strategy would probably have prompted the opponent to—at least partially—adapt their strategy and become competitive too, which would be deleterious for both players. Indeed, in repeated social interactions, it seems more strategic to cooperate—at least to some extent—to preserve future social interactions and engage in long-term cooperation, beneficial for both protagonists (Jurišić et al. 2012;

Kümmerli et al. 2007; Lave 1962). Even though, at the strict economic level, maximizing their own benefits is the most rational behavior, human beings are first and foremost socially oriented, organized in societies where they are interdependent (Tomasello 2014). In this context, it seems adaptive to cooperate with your counterparts.

Second, both groups were more competitive toward a computer than a human opponent, indicating preserved social sensitivity in SAUD. Patients with SAUD are able to identify the nature of their interlocutor and to adapt their behavior when confronted with a supposed human versus computer. This knowledge of the social norms governing interactions might constitute a valuable clinical lever, by using it to restore deficient social relationships and thus reduce social isolation. However, if patients with SAUD are able to differentiate human/computer interactions, they also show less adaptation to their opponent's strategy, in addition to their overall competition bias. Even though groups had distinct competition rates between the competitive strategy compared to the random/cooperative ones, with no significant difference between the latter two, patients' smaller computed difference scores suggest that they adapt less efficiently to their opponent's strategy. Indeed, patients with SAUD showed less variability in their competition rate according to the strategy: they showed less difference in their competition rates between the competitive and the two other strategies compared to controls. The competitive bias presented by patients with SAUD in situations during which the opponent is behaving in a cooperative or neutral way might reflect difficulties in inferring others' intentions and in accurately adapting to them in real-life interactions. Being able to adapt to others is essential for navigating the social world and difficulties in adopting other's points of view can affect social relationships, which are of primary importance for patients' abstinence. A meta-analysis (Onuoha et al. 2016) notably showed that patients with SAUD display large deficits in mentalizing, namely the ability to accurately infer others' mental states (Quesque et al. 2024), an essential ability for social interactions (D'Hondt et al. 2021; Maurage et al. 2016; Uekermann et al. 2006) identified as a strong predictor of psychopathological states (Brüne 2005; Brüne et al. 2007; Roncone et al. 2002). As social skills and supportive social networks are strong protective parameters against relapse in SAUD (Hunter-Reel et al. 2009; Shafiei et al. 2014; Sliedrecht et al. 2019), mentalizing appears to play an important role in the disorder's prognosis.

Third, the competitive bias of patients was linked with their relapse rates at 6-month follow-up. This is the first evidence of the real-life impact of biased social decision-making in SAUD, which highlights the importance of social factors in the care process. Being more competitive might reduce the quality/quantity of social interactions, reducing social support and hampering the adapted interpersonal life needed to maintain abstinence (Hunter-Reel et al. 2009; Shafiei et al. 2014; Sliedrecht et al. 2019). This preliminary result suggests that social decision-making might constitute a valuable clinical target, through psychoeducation or by developing remediation programs specific to social decision-making, as already used for cognitive functions (Rupp et al. 2012), attentional bias (Schoenmakers et al. 2010), or social cognition (Peyroux and Franck 2014).

Our results showed no link between competitive bias and social cognition components (hostility bias and empathy) or interpersonal problems. It may imply that other mechanisms are at work in the relation between social cognition and social decision-making. However, attribution biases and empathy are two umbrella terms for complex affective and cognitive constructs, and their validated measures can be influenced by various factors, making it challenging to interpret a single score. In addition, self-reported measures can be subject to biases (e.g., over/under estimation of symptoms severity, social desirability) which may limit their validity to explore real-life social functioning, particularly in clinical populations (Podsakoff et al. 2003). In this context, social decision-making appears to be a better indicator of real-life behavior, and thus real-life difficulties, as indicated by the link with relapse. Despite this task is not normed and cannot yet be used in clinical settings, it seems necessary to go beyond social cognition exploration solely that are not reflective of real-life difficulties, to explore social behaviors directly involving participants. Future studies investigating the links between social cognition and interpersonal difficulties should therefore evaluate these aspects through ecologically valid tools. Of note, our cross-sectional design did not allow any causal inference between our variables. The competitive bias observed might also be linked with other variables commonly found in individuals with SAUD, such as antisocial traits (Goldstein et al. 2007; Helle 2019). These potential associations warrant further investigation.

Some limitations should also be acknowledged. First, although the experimental paradigm allowed for the controlled investigation of social decision-making, behaviors observed in the laboratory may not fully generalize to real-world social interactions, which are typically more complex, emotionally salient, and embedded in longer-term relationships. Future studies should therefore examine whether the competitive bias observed in individuals with SAUD extends to more ecologically valid or naturalistic social contexts. Second, groups were not matched for age. However, exploratory analyses revealed no significant associations between age and competition rates across any of the experimental conditions. Nevertheless, future studies should aim to recruit age-matched groups to further minimize the potential influence of demographic differences. Another limitation of the present study is the use of a fixed condition order, which may introduce potential order effects. Therefore, the interpretation of behavioral persistence following exposure to a competitive opponent should be considered in light of this design feature. Finally, to avoid excessive cognitive burden associated with a lengthy task in patients undergoing treatment, the number of trials was limited to 20 per condition. Although increasing the number of trials per condition could further improve the reliability and sensitivity of condition-specific estimates of competitive behavior, reliability analyses indicated good to excellent internal consistency of competitive choice rates across trials.

In conclusion, we revealed for the first time a competitive bias in SAUD, linked to relapse rates. We also showed patients with SAUD adapt themselves less efficiently to their opponent's strategy. Even if this higher competitiveness, potentially linked to difficulties to consider others' mental states, might be efficient during economic games by generating more outcomes, it can also be detrimental in everyday life, by deteriorating social relations, which could precipitate relapse.

Author Contributions

Mado Gautier: project administration (lead), conceptualization (lead), methodology (lead), software (lead), investigation (equal), formal analysis (lead), visualization (lead), writing – original draft preparation (lead). **Maxime Bertoux:** writing – review and editing (equal). **Damien Brevers:** writing – review and editing (equal). **Nicolas Vinsous:** investigation (equal), writing – review and editing (supporting). **Pierre Maurage:** supervision (lead), project administration (supporting), conceptualization (supporting), methodology (supporting), writing – original draft (supporting), writing – review and editing (equal).

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Table S1:** Prisoner's dilemma outcomes matrix model depending of both players' choice to cooperate (C) or to defect (D). In each cell, the comma separates the payoffs of the two players.