Alcohol Use Disorder Displays Trait-Related Reductions in Prosocial Decision Making

Simon Jangard, Björn Lindström, Lotfi Khemiri, Philip Pärnamets, Nitya Jayaram-Lindström, and Andreas Olsson

ABSTRACT

BACKGROUND: Alcohol use disorder (AUD) is associated with deficits in social cognition, but the relationship between harmful alcohol use and the processes underlying interactive social behavior is still unknown. We hypothesized that prosocial decision making is reduced in AUD and that individual differences in the underlying processes are key to better understanding these reductions.

METHODS: In one laboratory study (Swedish participants, n = 240) and one confirmatory online study (American participants, n = 260), we compared young adults with AUD with age-, gender-, and education-matched healthy control subjects on 6 facets of prosocial decision making. We used standardized behavioral economic tasks, namely the dictator game, ultimatum game, trust game, and third-party game. To better understand the expected differences in prosociality, we evaluated attention by tracking eye gaze, decision response time, clinical symptoms, and social cognition.

RESULTS: Altruism (lab study: p = .007; online study: p < .001), fairness (lab study: p = .003; online study: p = .007), and reciprocal trust (lab study: p = .007; online study: p = .039) were reduced in individuals with AUD compared with healthy control subjects, whereas trust and third-party punishment and compensation were comparable in both studies. Reduced prosociality was associated with attending to the selfish response option, faster response time, and moral attitudes, while being dissociated from both psychiatric symptoms and drinking history in AUD.

CONCLUSIONS: Individuals with AUD have trait-related reductions in prosocial decision making that do not vary with drinking history or psychiatric symptom load. These reductions were confined to one-to-one interactions accompanied by differences in attention, decision time, and moral attitudes.

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The study of social interaction in the initiation and maintenance of alcohol use disorder (AUD) has been highlighted as one of the most pressing concerns in current addiction research (1). Despite this, research on social cognition in AUD (2,3) has largely omitted the study of prosocial behavior, which is key to a healthy social life (4) and could aid in contributing to the reduction of harmful alcohol use (1). We addressed this gap in existing research by applying a social decision-making framework to understand the processes underlying trade-offs between prosocial and selfish choices in AUD.

To date, the majority of research on social behavior in AUD has used self-report measures, and studies using objective measures during experimental social interactions are scarce (2,3). This is a limitation, because self-report measures fail to capture important aspects of actual social behavior, such as real-time markers of attention, response time, and decision outcomes with relevance to others and self (5–7). Objective measures of social decision making (e.g., tasks in behavioral economics) examine social behaviors by quantifying the ability to evaluate and select a prosocial course of action from multiple alternatives during social interaction (e.g., altruistic, fairness, and trust behavior) (8,9). To our knowledge, only 3 studies to date have used a social decision-making task in individuals with AUD (10–12). These studies showed that individuals with AUD compared with healthy control (HC) subjects more often rejected unfair offers from others. However, no prior work has extended these findings to examine whether individuals with AUD are more unfair themselves.

Social decision-making tasks have previously been successfully applied to understand deficits in other psychiatric disorders, such as cocaine use disorder (13) and attention-deficit/hyperactivity disorder (ADHD) (14), which display similar characteristics to AUD in terms of increased impulsivity. These studies have shown reduced altruistic behavior in comparison with healthy individuals using the dictator game (14) or a combined dictator/distribution game (13). In contrast, studies on other psychiatric disorders, such as autism (15) and schizophrenia (16), found no alterations using the dictator game. These applications across different psychiatric diagnostic groups reveal the relevance of deficits on prosocial tasks beyond conventional diagnostic boundaries, suggesting their usefulness also in AUD. Moreover, this approach resonates well with the Research Domain Criteria initiative, recommending the application of behavioral economic tasks in...
the search for more ecologically valid social biomarkers in psychiatric disorders (17). In light of these considerations, we used a set of standardized behavioral economic tasks to investigate prosocial decision making in individuals with AUD.

Given that prosocial behavior is influenced by numerous state- and trait-related factors at the individual level, it is of key importance to go beyond simple group differences (e.g., individuals with AUD vs. healthy individuals) to understand underlying individual differences within the groups themselves (18). For instance, visual attention is informative for prosocial decisions in being associated with an increased attendance toward stimuli representing prosocial (compared with selfish) choices (7,19). Visual attention has also been shown to be trait related in consistently influencing individual choice behavior across social and nonsocial task domains (20,21). Response time is another individual-level factor with relevance to prosocial decisions in which a slower decision in general results in a more prosocial choice (7,22). Collectively, the influence of both increased attention and response time on altered prosociality has been suggested to operate through modulating the subjective value attributed to prosociality at the individual level (19,22).

Individual variability in drinking history for individuals with AUD (e.g., days of abstinence, recent consumption level, and duration of harmful drinking) may also inform whether there is a relationship between alcohol use patterns and altered prosociality. Such a relationship would suggest that altered prosociality in individuals with AUD primarily depends on state-related fluctuations in drinking history. Conversely, a nonrelation would suggest that the prosocial alterations are mainly trait related in that they are independent of differences in drinking history, and are instead indicative of some other underlying process (e.g., processes of social cognition or impulsivity). In sum, information on drinking history in individuals with AUD might help us to understand the role of prosocial deficits as a state- or trait-related factor of the disorder.

In the present study, we investigated 6 key facets of prosocial decision making (altruism, fairness, trust, reciprocal trust, third-party punishment, and third-party compensation) in young adults with AUD compared with a matched population of HC subjects. To achieve this goal, we conducted 2 separate experiments (n = 240 and n = 260), including standardized behavioral economic tasks in 2 separate samples. Additionally, we investigated individual differences by assessing measures of attention, response time, clinical variables, and socio-cognitive variables. We proposed 2 main hypotheses. First, we hypothesized that young adults with AUD would exhibit reduced prosociality across all 6 facets of prosocial decision making. Second, we hypothesized that reduced prosociality in AUD would 1) be associated with increased attention toward selfish stimuli and faster response times, 2) be associated with reduced empathy and moral attitudes, and 3) be dissociated from drinking history in AUD.

METHODS AND MATERIALS

Participants

Participants were young adults (18–24 years of age) with AUD, and age-, gender-, and education-matched HC subjects for comparison. They were recruited as part of 2 separate studies: a Swedish laboratory study conducted at Karolinska Institutet comprising 120 participants with AUD (50% females) and 120 HC participants (50% females), and an American online study comprising 124 participants with AUD (47% females) and 136 HC participants (59% females) using the Prolific Research Platform (www.prolific.co). Details regarding power estimation, recruitment, and selection process are provided in Supplemental Methods.

We screened individuals in both study samples by carefully assessing a range of inclusion and exclusion criteria (including exclusion of other substance use disorder, neuropsychiatric disorder, and severe psychiatric disorder; see the Supplemental Methods for details). The AUD group fulfilled a minimum of 4 DSM-5 criteria of AUD (corresponding to moderate or severe AUD), while the HC group fulfilled a maximum of 1 DSM-5 criterion of AUD (corresponding to no AUD). For the laboratory study, assessment of the clinical criteria was done by a licensed psychologist or a medical doctor using the Mini-International Neuropsychiatric Interview (23), while for the online study assessment was self-rated by the participants using an established questionnaire (24). Additionally, the laboratory study assessed IQ scores using the Wechsler Adult Intelligence Scale (25).

All participants were compensated for their participation with 3 movie vouchers (lab study) or $16 (online study), and an additional bonus compensation based on their decisions (see the Supplemental Methods and Supplemental Discussion for details).

All participants provided informed consent, and the procedures were in accordance with the Declaration of Helsinki. The laboratory study was approved by the Swedish Ethical Review Authority (Dnr: 2019-05123). No ethical approval was required for the online study, as the Swedish Act concerning the Ethical Review of Research Involving Humans (2003:460) states that approval is needed only when personal data are handled. A preregistration of the study, including a general plan for analysis and collected measures that will be reported elsewhere, can be found online (https://osf.io/uvhmg).

Social Decision-Making Tasks

Participants’ prosocial behavior was estimated by 6 behavioral economic tasks of social decision making, namely altruism using the dictator game (9,26), fairness using the ultimatum game (14,27), trust and reciprocal trust using the trust game (9,28), and third-party punishment and compensation using the third-party game (9,28). Each task consisted of 2 to 5 trials and was implemented in PsychoPy (lab study) and jsPsych (online study) (29,30). Participants were informed that they would play online with a different and allegedly real interaction partner for each trial in each of the tasks [i.e., a series of independent “one-shot” games (8)], see the Supplemental Methods for instructions and details]. The tasks had a similar design and setup in which individuals decided regarding the distribution of points for oneself and/or another participant (see Figure 1 and the Supplemental Methods for illustrations). For each task, prosocial behavior was operationalized as the per-trial number of points transferred to the other participant.

Attention

Attention was assessed during the social decision-making tasks in the lab study by recording eye gaze using an SMI RED 250 tracking (iMotions) at 250 Hz running on a dedicated platform (www.proli.com). Details regarding power estimation, recruitment, and selection process are provided in Supplemental Methods.
We used the proportion of fixations during choice and defined areas of interest in relation to the social stimuli of the screen, namely the selfish and prosocial response option (i.e., “min” and “max” on the response bar) (see Figure 1), and the silhouettes representing each respondent (i.e., “self” and “other”). For details regarding data preprocessing and operational procedure, see the Supplemental Methods.

**Response Time**

As a measure of deliberation during choice, we recorded trial-by-trial response time data during the 6 tasks in both studies (22). The recording occurred from the start of choice in which the response bar was shown, to the end of choice, when the participant clicked the “continue” button following a desired response (see Figure 1).

**Self-Report Measures**

Alcohol and drug use were assessed with the Alcohol Use Disorders Identification Test (31) and the Drug Use Disorders Identification Test (32), respectively. Abstinence duration and alcohol use in the past 30 days were assessed using the timeline follow-back method (33), while alcohol craving was assessed using a single-item visual analog scale (ranging from 0 to 100 and asking, “How much craving for alcohol do you experience right now?”) (34) presented in conjunction to starting the first behavioral task (i.e., dictator game). Duration of harmful drinking was assessed using the single-item visual analog scale (ranging from 0 to 100 and asking, “For how long (years; months) would you consider that you have been drinking too much?”) (34) presented in conjunction to starting the first behavioral task (i.e., dictator game).

**Statistical Analysis**

All models were estimated in R (version 4.0.4; R Foundation for Statistical Computing) using the lme4-package (version 1.1-26) (see the Supplemental Methods for details) (40). In our main analyses, we investigated group differences by conducting separate multilevel linear regression analyses for each of the 6 social decision-making tasks. For all tasks, the task response was our outcome variable that we modeled as a function of group (AUD group vs. control group, fixed effect), while variation across trials for each participant was modeled using a random intercept:

\[
\text{TaskResponse} \sim \text{Group} + (1 \mid \text{Participant})
\]

Moreover, in the tasks measuring reciprocal trust, third-party punishment, and compensation, an initial response was given by the other participant before the participant responded. We therefore included the other participant’s response in the models as an additional fixed effect and as a random slope (because the magnitude of the response varied across trials):

\[
\text{TaskResponse} \sim \text{Group} + \text{OtherResponse} + (1 + \text{OtherResponse} \mid \text{Participant})
\]
All models were fitted separately for the lab and online samples because our main interest was to identify group differences that were replicated in both samples. Given group differences in task performance across samples, we assessed individual differences by investigating the unique contribution of attention, response time, and clinical and sociocognitive variables by conducting one additional multilevel linear regression analysis per relevant task.

**RESULTS**

**Demographics**

The demographics and clinical characteristics of the study groups are presented in Table 1. The groups did not differ regarding matching variables of age, gender, and education, with the exception for the online study, in which participants with AUD were slightly older and more educated, but these differences had no effect on the main results (Supplemental Results S2–S3). The lab and online study samples were similar in terms of the mean number of fulfilled AUD criteria as well as in terms of the self-reported Alcohol Use Disorders Identification Test score. That alcohol had been the main drug of choice during the past year was (apart from the clinical evaluation in the lab study) also confirmed by the low Drug Use Disorders Identification Test scores in both samples (41).

**Group Differences in Prosocial Decision Making**

We found, across samples, evidence for a significant reduction of prosocial decision making in AUD (see Table 2 for effect estimations, and Figure 2 and Supplemental Results S1 for details). Specifically, the AUD group exhibited reduced altruistic (lab study: $B = 3.17, p = .007$; online study: $B = 4.53, p < .001$), fairness (lab study: $B = 1.61, p = .003$; online study: $B = 2.30, p = .007$), and reciprocal trust (lab study: $B = 2.00, p = .007$; online study: $B = 2.50, p = .039$) decisions. However, we did not find any across-sample reduction in trust, third-party punishment, or third-party compensation. Given that the distribution of the response variable across tasks was not normal (Figure 2), we verified the robustness of our results in an additional set of analyses using square root and logarithmic transformations of the response variables (Supplemental Results S8). Moreover, we validated the group differences in each task by controlling for the responses in the other tasks that replicated the key results (Supplemental Results S9). Individuals were also consistently faster in making decisions on subsequent trials within the same task, but crucially this had no effect on decision outcomes (Supplemental Results S10). Finally, we exchanged the group variable in the main models to a continuous self-report measure on harmful drinking (Supplemental Results S16, S19, and S22). We found no effect of alcohol craving at the time of testing or of symptoms of anxiety, depression, and stress in the past week.

**Clinical Variables.** In the AUD group, drinking history had no effect on prosocial decisions in terms of abstinence duration, alcohol use in the past 30 days, and duration of harmful drinking (Supplemental Results S16, S19, and S22). We found no effect of alcohol craving at the time of testing or of symptoms of anxiety, depression, and stress in the past week.

**Response Time.** Response time showed a negative effect on prosocial decisions across all 3 tasks, such that individuals with faster response time trials had a stronger reduction in prosociality (Figure 4; Supplemental Results S15, S18, and S21). In particular, this reduction for the lab study was stronger for individuals in the AUD group compared with the HC group subjects, as shown by interaction effects (altruism: $B = -1.49, p = .076$; fairness: $B = -1.79, p = .012$; reciprocal trust: $B = -1.95, p = .002$), whereas the negative effect was comparable for both groups, as shown by main effects in the online study (altruism: $B = 1.39, p = .052$; fairness: $B = 1.51, p = .051$; reciprocal trust: $B = 1.95, p = .023$).

**Sociocognitive Variables.** We found a negative effect for moral attitudes of impartiality for others in the lab study (altruism: $B = 2.86, p < .001$; fairness: $B = 1.16, p = .034$; reciprocal trust: $B = 1.33, p = .014$) (Figure 2; Supplemental Results S15, S18, and S21), such that individuals disfavoring impartiality also showed a stronger reduction in prosocial decisions. Although all measures in the online study pointed in the same direction (altruism: $B = 1.52, p = .11$; fairness: $B = 0.16, p = .80$), only reciprocal trust was marginally significant ($B = 1.67, p = .061$). In contrast, neither moral...
AUD Displays Reductions in Prosocial Decision Making

DISCUSSION

In the present study, we report differences in prosocial decision making in young adults with AUD in comparison with HC subjects in 2 separate samples: one laboratory sample in Sweden and one U.S. confirmatory online sample. Our study yielded 3 major findings. First, using standardized behavioral economical tasks, we found that altruistic, fairness, and reciprocal trust decisions were reduced in individuals with AUD compared with HC subjects. In contrast, trust, third-party punishment, and third-party compensation decisions did not differ between the 2 groups. Specifically, individuals with AUD kept more economically incentivized points for themselves in a

Table 1. Demographics and Clinical Characteristics

| Characteristics                                      | Alcohol Use Disorder Group, n = 120 | Healthy Control Group, n = 120 | p* | Alcohol Use Disorder Group, n = 124 | Healthy Control Group, n = 136 | p* |
|-----------------------------------------------------|------------------------------------|--------------------------------|----|------------------------------------|-------------------------------|----|
| Age, Years                                          | 21.4 (2.0)                         | 21.0 (2.0)                     | .083| 21.8 (1.7)                         | 20.8 (2.1)                    | <.001|
| Gender, Male                                        | 60 (50.0%)                         | 60 (50.0%)                     | 1.000| 64 (51.6%)                         | 55 (40.4%)                    | .086|
| Socioeconomic Status, Education                     |                                    |                                |    |                                    |                               |    |
| Undergraduate degree or higher                      | 43 (35.8%)                         | 30 (25.0%)                     | .092| 87 (70.2%)                         | 60 (44.1%)                    | <.001|
| Don’t meet basic expenses                           | 4 (4.5%)                           | 3 (2.5%)                       |    | 9 (7.3%)                           | 12 (8.8%)                     |     |
| Just meet basic expenses                            | 8 (9.1%)                           | 9 (7.5%)                       |    | 36 (29.0%)                         | 23 (16.9%)                    |     |
| Meet needs with a little left                       | 48 (54.5%)                         | 67 (55.8%)                     |    | 48 (38.7%)                         | 52 (38.2%)                    |     |
| Live comfortably                                     | 28 (31.8%)                         | 41 (34.2%)                     |    | 31 (25.0%)                         | 49 (36.0%)                    |     |
| Nonverbal IQ Score<sup>a</sup>                      | 26.4 (4.4)                         | 25.9 (4.0)                     | .435| NA                                 | NA                            |     |
| Verbal IQ Score<sup>b</sup>                         | 21.7 (7.6)                         | 21.8 (7.5)                     | .939| NA                                 | NA                            |     |
| Psychiatric Attributes and Substance Use            |                                    |                                |    |                                    |                               |    |
| Adult ADHD Self-Report Scale                        | 12.0 (3.9)                         | 9.4 (3.6)                      | <.001| 9.3 (4.1)                         | 7.5 (3.8)                     | <.001|
| Depression Anxiety Stress Scales                    |                                    |                                |    |                                    |                               |    |
| Anxiety                                             | 3.5 (3.3)                          | 1.2 (1.6)                      | <.001| 4.7 (3.7)                          | 2.1 (2.6)                     | <.001|
| Stress                                              | 6.6 (4.5)                          | 2.7 (2.4)                      | <.001| 7.9 (5.3)                          | 4.4 (4.3)                     | <.001|
| Alcohol Use Disorder Identification Test            | 17.3 (4.5)                         | 1.7 (1.8)                      | <.001| 17.9 (6.2)                         | 1.0 (1.4)                     | <.001|
| Alcohol Use Disorder Criteria                       | 6.2 (1.8)                          | NA<sup>c</sup>                 |    | 6.5 (2.1)                          | 0.1 (0.3)                     | <.001|
| Drinking Too Much, No. Months                       | 29.4 (26.6)                        | 1.0 (3.9)                      | <.001| 27.5 (25.3)                        | 0.8 (6.7)                     | <.001|
| Alcohol Binges, Past 6 Months                       | 22.8 (19.1)                        | NA<sup>c</sup>                 |    | 19.1 (21.6)                        | 0.1 (0.3)                     | <.001|
| Alcohol Consumption, Past 30 Days, No. Drinks       | 51.5 (25.4)                        | 1.4 (3.0)                      | <.001| 65.1 (40.1)                        | 2.3 (4.6)                     | <.001|
| Alcohol Abstinence, No. Days                        | 3.4 (2.3)                          | 23.4 (10.0)                    | <.001| 3.1 (4.4)                          | 23.1 (12.4)                   | <.001|
| Alcohol Craving at Time of Testing                  | 18.5 (18.5)                        | 1.0 (7.2)                      | <.001| 45.3 (26.8)                        | 2.1 (6.9)                     | <.001|
| Drug Use Disorders Identification Test              | 3.6 (4.5)                          | 0.2 (0.8)                      | <.001| 1.6 (2.2)<sup>d</sup>             | 0.3 (0.9)<sup>e</sup>         | <.001|
| Cognitive Attributes                                |                                    |                                |    |                                    |                               |    |
| Oxford Utilitarianism Scale                         |                                    |                                |    |                                    |                               |    |
| Impartial beneficence                               | 20.2 (6.9)                         | 20.2 (6.2)                     | .958| 19.4 (6.2)                         | 20.0 (5.8)                    | .441|
| Instrumental harm                                   | 16.1 (4.7)                         | 14.9 (4.9)                     | .057| 14.9 (4.6)                         | 14.7 (4.9)                    | .695|
| Questionnaire of Cognitive and Affective Empathy    |                                    |                                |    |                                    |                               |    |
| Affective empathy                                    | 34.8 (5.3)                         | 35.3 (5.4)                     | .497| 35.6 (5.8)                         | 35.4 (5.8)                    | .800|
| Cognitive empathy                                   | 54.8 (6.2)                         | 56.5 (6.6)                     | .041| 59.9 (8.2)                         | 57.6 (8.5)                    | .023|

Values are presented as n (%) or mean (SD). ADHD, attention-deficit/hyperactivity disorder; NA, not available.

<sup>a</sup>IQ scores were assessed using the Wechsler Adult Intelligence Scale–Fourth Edition vocabulary and working memory/digit span subtests (25).

<sup>b</sup>Maximum 1 criterion for alcohol use disorder required for participation.

<sup>c</sup>Maximum 1 binge episode for healthy control subjects required for participation.

<sup>d</sup>The online study used the short form version of the Drug Use Disorders Identification Test.

attitudes of instrumental harm nor empathy had any effect on prosociality.
dictator game, ultimatum game, and reciprocal trust game. The findings demonstrated a medium effect size, which is comparable to previous findings on prosocial decision making in cocaine use disorder (13). Second, we found that individual performance varied on 3 important dimensions: attention, decision response time, and moral attitudes. Third, individual differences in prosociality could not be explained by drinking level history in the AUD group or recent psychiatric symptom load indicating trait-related prosocial deficits. To our knowledge, this is the first study to systematically identify reductions in components of interactive behaviors in young adults with AUD and describe the processes underlying these reductions.

Altruistic behavior is reduced in individuals with other substance use disorders when measured by self-report (42) or decision responses in a combined dictator/distribution game (13). Individuals with other psychiatric disorders such as ADHD also show reduced altruistic decisions in the dictator game (14), whereas individuals with autism or schizophrenia perform on par with HC subjects (15,16). Our results support the advantage of using the dictator game for understanding social norm transgressions, and previous studies show that individuals with AUD compared with HC subjects are more likely to inflict punishment following unfair behavior from others (10–12). We extended this finding by showing that individuals with AUD also behave more unfairly toward others despite displaying no differences in the tendency to regulate unfairness between third-party others (i.e., third-party punishment or compensation). One interpretation of this discrepancy might be that only direct interaction is emotionally salient enough to trigger response deficits in AUD (11).

Reciprocal trust behavior was reduced in individuals with AUD, which aligns with findings in other psychiatric disorders [e.g., social anxiety disorder (43)]. Moreover, our results support that whereas reciprocating trust from others is reduced in AUD, the initiation of trust in others is intact. Thus, it seems that individuals with AUD have deficits when a response to another individual’s trust behavior is required. Alternatively, the reductions might be related to more general emotional deficits in recognizing and responding to the perspective of others. As an example, self-reported interpersonal difficulties in AUD have been related to general emotional deficits in voice and face recognition (44). Future studies should examine how reciprocity deficits are related to the fact that individuals with AUD often break the trust of others, resulting in difficulties in maintaining relations, as well as the relative role of reciprocity deficits in the maintenance of drinking behaviors and relapse (45).

Collectively, our results showing reduced prosocial decisions in AUD may echo previous research on the comorbidity of antisocial personality and AUD, which share some genetic loading (46) and have been shown to interact in producing more severe clinical symptoms, as well as in reducing empathy and distress from interpersonal relationships (47). Hence, it is possible that reduced prosocial behavior in AUD, at least

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Table 2. Multilevel Linear Regression Models for the Social Decision-Making Tasks

| Task                          | Lab Study       | Online Study     |
|-------------------------------|-----------------|------------------|
|                              | $B$ (95% CI)    | $p$              | $B$ (95% CI)    | $p$              |
| Altruistic Decisions          |                 |                  |                 |                  |
| Intercept                     | 17.81 (16.19 to 19.44) | $<2 \times 10^{-16}$ | - | 15.00 (13.14 to 16.86) | $<2 \times 10^{-16}$ | - |
| HC subjects                   | 3.17 (0.88 to 5.47) | .007             | 0.35            | 4.53 (1.97 to 7.08) | .001             | 0.44 |
| Fairness Decisions            |                 |                  |                 |                  |
| Intercept                     | 22.54 (21.52 to 23.57) | $<2 \times 10^{-16}$ | - | 21.05 (19.85 to 22.25) | $<2 \times 10^{-16}$ | - |
| HC subjects                   | 1.61 (0.15 to 3.06) | .031             | 0.29            | 2.30 (0.65 to 3.94) | .007             | 0.35 |
| Trust Decisions               |                 |                  |                 |                  |
| Intercept                     | 24.49 (21.78 to 27.20) | $<2 \times 10^{-16}$ | - | 18.34 (15.69 to 21.00) | $<2 \times 10^{-16}$ | - |
| HC subjects                   | $-0.90 (-4.73 to 2.93)$ | .648             | -0.06           | 1.99 (-1.65 to 5.64) | .284             | 0.14 |
| Reciprocal Trust Decisions    |                 |                  |                 |                  |
| Intercept                     | 18.21 (17.05 to 19.37) | $<2 \times 10^{-16}$ | - | 23.21 (21.19 to 25.24) | $<2 \times 10^{-16}$ | - |
| HC subjects                   | 2.00 (0.55 to 3.45) | .007             | 0.35            | 2.50 (0.03 to 4.86) | .039             | 0.26 |
| Third-Party Punishment Decisions |                 |                  |                 |                  |
| Intercept                     | 7.75 (6.38 to 9.11) | $<2 \times 10^{-16}$ | - | 6.17 (4.50 to 7.84) | $5.37 \times 10^{-12}$ | - |
| HC subjects                   | $0.00 (-1.55 to 1.54)$ | .996             | <0.01           | 0.28 (-2.00 to 2.57) | .809             | 0.03 |
| Third-Party Compensation Decisions |                 |                  |                 |                  |
| Intercept                     | 17.62 (14.71 to 20.53) | $<2 \times 10^{-16}$ | - | 14.00 (11.59 to 16.40) | $<2 \times 10^{-16}$ | - |
| HC subjects                   | 3.77 (-2.23 to -0.84) | .069             | 0.24            | 1.67 (-1.58 to 4.92) | .316             | 0.13 |

Results were extracted from separate multilevel regression models and show across the tasks of altruism, fairness, and reciprocal trust higher prosociality for the HC group compared with the alcohol use disorder group. In contrast, there were no group differences across the tasks measuring trust, third-party punishment, and third-party compensation (see Supplemental Results S1 for details).

HC, healthy control.
partly, shares variance with increased antisocial behavioral traits.

Individual differences are to be expected in AUD owing to the large symptom heterogeneity of the disorder in the population (i.e., any 4 out of 11 criteria required for a moderate AUD diagnosis according to the DSM-5). The wide response distribution in altruistic, fairness, and reciprocal trust decision making within the AUD group is therefore not surprising (Figure 2). The prosocial deficits were associated with several variables. First, attending the selfish response options was associated with subsequent choice even after controlling for early and late attentional deployment, which indicates the role of some valuation process and not merely tracking the mouse cursor prior to response. These findings preliminarily support a selfish attentional bias for individuals with AUD. In fact, previous research shows that attentional deployment toward selfish

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as compared with social stimuli might be an expression for not only individual preferences but also the causal role of attention on choices (7,19). Second, faster decision responses were associated with reduced prosociality across altruism, fairness, and reciprocal trust. This might indicate that individuals with AUD value prosociality less (19,22) and therefore require more time for deliberation compared with HC subjects in order to overcome selfish impulses. These findings also suggest a linkage to studies on other psychiatric disorders marked by impulsivity and reduced altruistic decision making, namely cocaine use disorder and ADHD (13,14). Thus, impulsivity and reduced prosociality might be overlapping phenotypes owing to the instant reward from selfish behavior (48) and should be further investigated in AUD and other psychiatric disorders. Third, moral attitudes disfavoring impartiality were associated with reduced prosociality. Although this effect was not equally clear in the online study, this provides a preliminary linkage between reduced prosocial decision making in AUD and explicit moral judgment, which aligns with research highlighting the role of moral reasoning in the change of behavior (49–51).

Variables not associated with reduced prosociality in AUD included individual differences in recent psychiatric symptom load and drinking history. This indicates that reduced prosociality in AUD has a trait-like stability, which neatly aligns with similar findings in individuals with cocaine use disorder (13).

Our study has limitations in need of discussion. Given the cross-sectional study design, the stated evidence for reduced prosociality as a trait-related factor in AUD should be interpreted with caution. In fact, a strong reduction in actual drug consumption can lead to some recovery of prosocial behavior in cocaine use disorder (52), providing support for a bidirectional effect, and highlights the importance of longitudinal study designs for more reliably assessing how prosocial behavior might change as a result of altered drug consumption over time. Also, we did not examine the relation to real-world behavior, such as social network size or social activities in daily life, which may explain parts of the group differences found in this study.

In conclusion, the current study is, to the best of our knowledge, the first to show that individuals with AUD exhibit reduced prosocial decision making related to altruism, fairness, and reciprocal trust. We found that these reductions could be explained by individual differences in attention, decision response time, and moral attitudes. Neither drinking level history in individuals with AUD nor current psychiatric symptoms explained these reductions, indicating stability over
time. Future directions include refinement of the prosocial task measures for better integration of the mechanisms underlying individual differences in AUD. For example, refinements could be made based on related task measures, e.g., a social gaze task administered in individuals with cocaine use disorder demonstrated differences in attention during social interaction that were related to reduced activation of the brain’s reward system (53). Taken together, our study shows that young adults with AUD have stable reductions in prosocial decision making during one-to-one interactions, suggesting a trait-related deficit in the early onset of the disorder.

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ARTICLE INFORMATION

From the Centre for Psychiatry Research (SJ, LK, NJ-L), Department of Clinical Neuroscience, Karolinska Institutet and Stockholm Health Care Services Stockholm County Council; Division of Psychology (SJ, PP, AO), Department of Clinical Neuroscience, Karolinska Institutet; and Department of Medical Epidemiology and Biostatistics (LK), Karolinska Institutet, Stockholm, Sweden; and the Department of Experimental and Applied Psychology (BL), Vrije Universiteit Amsterdam, Amsterdam, the Netherlands. NJ-L and AO contributed equally to this work as joint last authors.

Address correspondence to Simon Jangard, M.Sc., at simon.jangard@ki.se, Received Feb 9, 2022; revised May 3, 2022; accepted May 5, 2022. Supplemental material cited in this article is available online at https://doi.org/10.1016/j.bpsc.2022.05.002.

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