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Impaired conditional reasoning in alcoholics: a negative impact on social interactions and risky behaviors?

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ABSTRACT

Aims To study the 'social brain' in alcoholics by investigating social contract reasoning, theory of mind and emotional intelligence. **Design** A behavioral study comparing recently detoxified alcoholics with normal, healthy controls. **Setting** Emotional intelligence and decoding of emotional non-verbal cues have been shown to be impaired in alcoholics. This study explores whether these deficits extend to conditional reasoning about social contracts. **Participants** Twenty-five recently detoxified alcoholics (17 men and eight women) were compared with 25 normal controls (17 men and eight women) matched for sex, age and education level. **Measurements** Wason selection task investigating conditional reasoning on three different rule types (social contract, precautionary and descriptive), revised Reading the Mind in the Eyes Test, Trait Emotional Intelligence Questionnaire (modified version) and additional control measures. **Findings** Conditional reasoning was impaired in alcoholics. Performance on descriptive rules was not above chance. Reasoning performance was markedly better on social contract and precautionary rules, but this performance was still significantly lower than in controls. Several emotional intelligence measures were lower in alcoholics compared to controls, but these were not correlated with reasoning performance. **Conclusions** Conditional reasoning, including reasoning about social contracts and emotional intelligence appear to be impaired in alcoholics. Impairment seems to be particularly severe on descriptive rules. Impairment in social contract reasoning might lead to misunderstandings and frustration in social interactions, and reasoning difficulties about precautionary rules might contribute to risky behaviors in this population.

Keywords Alcoholism, conditional reasoning, emotional intelligence, evolutionary, precautionary rules, social contract, theory of mind, Wason.

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INTRODUCTION

Evolutionary psychology has proposed that the brain has been shaped by natural selection to solve adaptive problems encountered repeatedly by humans throughout their evolutionary history. These specialized mechanisms have been referred to as 'Darwinian algorithms' [1]. Specialized neurocognitive reasoning mechanisms include the ability to detect cheats in cooperative transactions [2,3] and the ability to identify appropriate precautions in hazardous situations [4,5].

These reasoning abilities have been investigated frequently using the Wason selection task [6], which asks people to look for violations of conditional rules of the form 'If P, then Q'. From formal logic, conditional rules are violated whenever P and not-Q occur. Social contracts are rules of the form: 'If you take the benefit (P), then you must meet the requirement (Q)'. Precautions are rules of the form: 'If you engage in the hazardous activity (P), then you must take the precaution (Q)'. Thus, social contracts and precautions in these forms have the same logical structure as more general descriptive rules ('If P,

then Q'), and the correct answer to detect a violation is the same in all cases (P and not-Q). They differ only in content (i.e. what P and Q stand for).

Healthy individuals perform poorly on this task when the rules are descriptive or abstract (10–30%), but they perform well when the rules are social contracts or precautions (65–85%) [7], supporting the idea that specific reasoning algorithms have evolved by natural selection because they help to solve specific adaptive problems [8].

The presence of separate, specialized context-dependent mechanisms in conditional reasoning is supported further by dissociation observed in a brain-damaged patient: social contract reasoning was selectively impaired while precautionary reasoning was preserved [9].

Furthermore, Ermer *et al.* [10] have used neuroimaging to show that reasoning about social contract rules activates different brain regions in healthy individuals than do reasoning about precautionary or descriptive rules, supporting the hypothesis of separate, specialized neurocognitive reasoning mechanisms. More specifically, reasoning about social contracts activated some of the same brain regions that Theory of Mind (ToM) tasks perform [11]. ToM is an essential component of social life, consisting of a capacity to attribute mental states to others, in order to predict and explain their behaviors [12]. Successful social contract reasoning requires identifying the mental states of others (what they regard as a benefit), whereas successful precautionary reasoning does not [10]. As reasoning about social contracts and engaging in theory of mind may share some of the same neural networks, these abilities may be part of a larger social inference network that supports human social interaction.

More recently, Reis *et al.* [13], showed that higher emotional intelligence (EI) predicted greater brain activity in left frontal polar and anterior temporal regions during social contract reasoning. Higher emotional intelligence predicted faster social exchange reasoning, suggesting that emotional intelligence and social exchange reasoning could be part of a broader neural computational network aimed at solving social problems. Higher harm avoidance scores were, for their part, associated with faster reasoning on precautionary rules.

Specific impairments on conditional reasoning may be present in certain psychopathological conditions. On one hand, evolved abilities for reasoning about social contracts should show relative resilience given their crucial importance in social life: detecting cheats is essential for cooperation to thrive. On the other hand, impairments in establishing and maintaining social relationships are common features of psychopathology. These impairments may be linked to conditional reasoning difficulties on social contract rules, especially if this capacity produces inputs for a general social inference system that includes ToM and EI abilities. Difficulties detecting cheats could interfere with successful social relationships and cooperation.

Alcoholic patients have difficulties orienting themselves in the social world. They display impairments in decoding non-verbal signals, in faces [14] and in voices [15,16], which may lead to negative consequences in interpersonal relationships [17]. Humor processing is also difficult in this population [18], a finding attributed to deficits in ToM and problems in executive functioning.

Adolescents from families with a history of alcohol dependence show diminished brain activation in the right middle temporal gyrus and left inferior frontal gyrus, compared to normal adolescent controls, when processing emotional expressions in the eye region. This result suggests that individuals at risk for developing alcohol dependence may have reduced ability to empathize with others' emotional states [19].

Emotional intelligence (EI) is the ability to recognize and express emotions in oneself and the ability to understand emotions in others [20]. High emotional intelligence is associated with reduced reactivity to stress [21], better coping abilities [22], greater feelings of wellbeing [23], better quality of life [24] and improved interpersonal relationships [25]. Furthermore, lower emotional intelligence is predictive of alcohol-related problems [26]. Alexithymia is a related concept, defined as difficulties identifying emotions in oneself. Logically, high EI is correlated strongly with low levels of alexithymia [27]. Alexithymia has been studied more widely in alcoholism than has EI; research shows consistently that alexithymia is encountered frequently in alcoholic populations [28] and is independent of anxiety or depression factors [29].

Thus, alcoholics show a number of difficulties in non-verbal decoding, theory of mind, emotional EI and alexithymia—that may reflect general impairment of a social inference system. Based on the proposed links between ToM, EI and social contract reasoning [10], we hypothesize that alcoholics will show difficulty reasoning about social contracts, along with deficits in emotional intelligence and in theory of mind tests.

Prefrontal cortex abnormalities have been described repeatedly in alcoholic patients [30]: this region appears to be particularly vulnerable to the toxic effect of chronic alcohol consumption. The prefrontal cortex has been implicated as an important brain structure for social perception [31], for the perception of emotional facial expressions and for theory of mind [32] and for reasoning about social contracts [13]. One hypothesis is that prefrontal cortex dysfunction is responsible for the social cognition impairments seen in alcoholism [33].

Alcoholism has also been associated, at least at onset, with a propensity to take risks [34]. Several genetic

Table 1 Characteristics of recently detoxified alcoholic and normal control subjects.

	Normal controls (n = 25)	*Recently detoxified alcoholics (n = 25)*
Male/female	17/8	17/8
Age	Mean = 40.4 (SD: 2.39)	46.3 (SD: 2.38)
Education #(1/2/3)	1/10/14	1/10/14
Familial history of alcohol	3/25	15/25
Familial history of drugs	2/25	1/25
Number of drinks per day	Mean = 1.79 (SD: 1.98)	Mean = 22.92 (SD: 1.99)
Number of inpatient stays	–	Mean = 1.56 (SD: 0.44)
Alcoholism duration (in months)	–	Mean = 112.40 (SD: 21.83)
Tobacco use	11/25	20/25
Opiate prior use	0/25	5/25
Cannabis prior use	2/25	6/25
Cocaine prior use	0/25	6/25
Amphetamines prior use	0/25	3/25
Hallucinogens prior use	0/25	2/25
Inhalants prior use	0/25	1/25
Benzodiazepines prior use	0/25	1/25
Present use of antidepressants	1/25	15/25
Present use of neuroleptics	0/25	2/25
Present use of anxiolytics	1/25	9/25
Alcoholic overdose	0/25	2/25
Beck Depression Inventory Score (BDI)	Mean = 3.04 (SD = 2.73)	Mean = 10.32 **** (SD = 6.66)
State-Trait Anxiety Inventory (STAI-A = state part) score	Mean = 31.08 (SD = 9.94)	Mean = 45.04 **** (SD = 15.71)
State-Trait Anxiety Inventory (STAI-B = trait part) score	Mean = 35.76 (SD = 8.63)	Mean = 50.96 **** (SD = 10.11)
Harm avoidance subscale	Mean = 12.88 (SD = 6.72)	Mean = 19 ** (SD = 9.21)
Mill hill vocabulary test score	Mean = 27.72 (4.24)	Mean = 25.56 (SD = 4.02)

Level of education was coded as follows: level 1 = completion of the first 3 years of secondary school or equivalent; level 2 = completion of secondary school or equivalent; level 3 = post-secondary school training. $^{**}P = 0.01$; $^{****}P < 0.0001$. SD: standard deviation.

predispositions have been proposed, specifically for impulsivity [35] and novelty seeking [35]. Environmental factors could also lead to risk-taking. Risk-taking is argued to be a viable evolutionary strategy for young, unmarried, childless men to acquire resources for reproduction in unstable environments [24,36]. Because alcoholics frequently display risky behavior, we hypothesize that reasoning about precautionary rules may also be impaired in this population.

METHOD

Subjects

The alcoholic patient group consisted of 25 in-patients (17 men and eight women) diagnosed with alcohol dependence according to the DSM-IV-TR [37] (RA). All were in their third week of in-patient stay; that is, at the end of their detoxification process. Participants with a history of bipolar disorder, schizophrenia or dementia, assessed during the intake interview, were excluded.

The normal control group consisted of 25 volunteers (17 men and eight women) with no psychiatric record or personal history of alcoholism (NC). The NC group was recruited among the hospital staff employees and in the investigators' social environment. They were matched for sex, age and level of education with the patients of the alcoholic group. Historical variables were recorded. Presence of at least one first-degree relative (father and/or mother) with alcohol dependence drinking problems was considered as evidence for positive familial history. Antecedents for regular drug use were recorded (Table 1).

Written informed consent was obtained. The Université Libre de Bruxelles ethical board approved this research project.

Measures

Wason selection task

In the Wason selection task ([6]; Appendix S1—see Supporting information details at the end of the paper), participants read a story that describes a rule of the form 'If P, then Q'. Participants are then shown four cards containing information about P on one side of the card and information about Q on the other, representing the four possible logical categories (P, not-P, Q, and not-Q). Participants can only see one side of each card, and they are asked to indicate which card(s) they would definitely have

to turn over to see if the rule is being broken. The logically correct answer is always to pick the P and not-Q cards to turn over.

Eight social contract (SC; e.g. 'If you borrow the car, then you must fill up the tank with gas'), eight precaution (PRE; e.g. 'If you work with TB patients, then you must wear a surgical mask') and eight social descriptive (DES; e.g. 'If a person becomes a biologist, then that person enjoys camping') problems were selected from a larger set normed previously on undergraduates [$n = 64$, 14 males, age range 18–24 years, mean = 18.4, standard deviation (SD) = 0.99]. Scoring was performed as follows: one point was given for a completely correct response (P and not-Q cards selected, Q and not-P cards not selected); no points for all other responses. The maximum score was 8 for each condition (eight stories per condition). Results are reported as percentage correct. Reaction times for responses to each card were also recorded systematically.

Revised Reading the Mind in the Eyes Test [38]

The revised version of the 'Reading the Mind in the Eyes' Test was administered. Briefly, participants were presented with a series of 36 photographs of the eye region of the face, from different actors and actresses. Four complex mental state descriptors (e.g. dispirited, bored, etc.) were printed around the photograph. One of these words identified correctly the mental state of the person in the photograph. Participants were instructed to choose which of the four words best described what the person in the photograph was thinking or feeling. The test was scored by totaling the number of items (photographs) identified correctly. The maximum total score was 36. Reaction times were recorded systematically.

Trait Emotional Intelligence Questionnaire (modified version) [20]

This test has been translated in French and validated by Mikolajczak [21]. This version consists of 75 items, responded to on a seven-point scale (strongly disagree to strongly agree). It provides scores for four factors (wellbeing, sociability, self-control and emotionality) and two subscales (self-motivation and adaptability). A global score of EI is computed along with scores on the four factors and the two subscales.

Control measures

Beck Depression Inventory Scale (BDI short version in 13 items) [39] *and State Trait Anxiety Inventory for Adults (STAI-A, -B)* [40]. As alcoholism is frequently comorbid with depression and anxiety problems, the BDI and the STAI-A, -B were added as control measures.

Mill Hill vocabulary test (part B). This test was added to ensure sufficient vocabulary comprehension for reading the stories on the Wason selection task. This test consists of 36 items. Subjects selected the best synonym from among six options. The maximum score is 36 (French validation) [41].

Temperament and Character Inventory [42] *(French version* [43]*) subscale 'harm avoidance'.* This test consists of 35 items. The subjects must answer true or false; a high score indicates a high harm avoidance tendency. This test was added because it has been reported [19] that this personality dimension was associated with reaction time on precautionary rules on the Wason selection task.

RESULTS

Reasoning performance (Table 2; Fig. S1; supporting information, see details given at the end)

Are alcoholic patients impaired on social contract reasoning compared to controls?

Yes. Alcoholics performed significantly worse on social contract problems (mean = 0.38, SD = 0.3) than did healthy controls (mean = 0.62; SD = 0.3; $F_{(1,48)} = 8.13$, $P = 0.006$; $\eta^2 = 0.145$).

Table 2 Significant results comparing groups on emotional intelligence (EI) dimensions.

	Detoxified alcoholics	*Normal controls*	*Statistic*	*Significance (effect size)*
Variables	*Mean (SD)*	*Mean (SD)*	*F (1,48)*	*P (η^2)*
Wason social contract	0.38 (0.3)	0.62 (0.3)	F (1,48) = 8.13	0.006 (0.145)
Wason precaution	0.52 (0.36)	0.71 (0.32)	F (1,48) = 4.17	0.047 (0.08)
Wason descriptive	0.07 (0.1)	0.46 (0.27)	F (1,48) = 45.63	<0.0001 (0.487)
EI self-control	78.3 (20.81)	96.2 (19.63)	F (1,48) = 9.78	0.003 (0.169)
EI well being	60.3 (12.64)	71.9 (10.97)	F (1,48) = 11.92	0.001 (0.199)
EI self-motivation	17.4 (4.45)	20.5 (4.04)	F (1,48) = 6.73	0.013 (0.123)
EI global score	327.4 (55.43)	373.1 (0.53)	F (1,48) = 9.27	0.004 (0.162)

SD: standard deviation.

Are alcoholic patients impaired on precautionary reasoning compared to controls?

Yes. Alcoholics performed significantly worse on precaution problems (mean = 0.52, SD = 0.36) than did healthy controls (mean = 0.71; SD = 0.32; $F_{(1,48)} = 4.17$, $P = 0.047$; $\eta^2 = 0.08$)

Are alcoholic patients impaired on descriptive reasoning compared to controls?

Yes. Alcoholics performed significantly worse on descriptive problems (mean = 0.07, SD = 0.1) than did healthy controls (mean = 0.46; SD = 0.27; $F_{(1,48)} = 45.63$; $P < 0.0001$; $\eta^2 = 0.487$)

Does alcoholic patients' reasoning performance benefit from social contract problem content?

Yes. Alcoholics performed significantly better on social contracts (mean = 0.38, SD = 0.3) than they did on descriptives (mean = 0.07, SD = 0.1): $t_{(24)} = 6.571$, $P < 0.0001$; $d = 1.55$.

In order to assess whether alcoholics' reasoning performance showed greater improvement with social contract rules (compared to descriptive rules) than did controls' performance, a multivariate analysis of variance for repeated measures with reasoning type (SC, DES) as the repeated-measures factor and group (RA, NC) as the between-subjects factors was computed. Alcoholics showed a greater relative performance benefit on social contracts (compared to descriptives) than did healthy controls $F_{(1,48)} = 4.327$, $P = 0.043$; $\eta^2 = 0.083$). In other words, the performance advantage of social contract content compared to descriptive content was greater for alcoholics than for controls.

Does alcoholic patients' reasoning performance benefit from precaution problem content?

Yes. Alcoholics performed significantly better on precautions (mean = 0.52, SD = 0.36) than they did on descriptives (mean = 0.07, SD = 0.1); $t_{(24)} = 7.562$, $P < 0.0001$; $d = 1.96$.

In order to assess whether alcoholics' reasoning performance showed greater improvement on precautionary rules (compared to descriptive rules) than did controls' performance, a multivariate analysis of variance for repeated measures, with reasoning type (PRE, DES) as the repeated-measure and group (RA, NC) as between-subjects factors was computed. Alcoholics showed a greater relative performance benefit on precautions (compared to descriptives) than did healthy controls: $F_{(1,48)} = 6.268$, $P = 0.016$ $\eta^2 = 0.115$. In other words, the performance advantage of precaution content compared to descriptive content was greater for alcoholics than for controls.

In sum, despite severe difficulties with logical reasoning (descriptive reasoning performance was at chance), alcoholics' reasoning about evolutionarily relevant rule classes, social contracts and precautions was relatively well-preserved.

Alcoholics showed smaller decrements in reasoning performance, compared to controls, on social contracts and precautions than they did on descriptives.

Wason reaction times

Can reaction time differences between alcoholic patients and controls explain these results?

No. In order to assess whether alcoholics showed a difference in reaction times on the Wason selection task compared to controls, an analysis of variance (ANOVA) with Wason reaction times (RTDES, RTPRE, RTSC) as within-subjects factors and group (RA, NC) as between-subjects factor. Reaction time was computed by averaging reaction times to select (or not) each card for each problem type. Results failed to show any effect of group (Table 3).

Mind-in-the-Eyes test

Can differences in emotion recognition (a theory-of-mind component) between alcoholic patients and controls account for differences in social contract reasoning performance?

No. In order to assess whether alcoholics showed a difference in accuracy in emotion recognition (revised Mind-in-the-Eyes test), a one-way ANOVA was conducted comparing accuracy between RA and NC. There were no significant differences (Table 3).

Mind-in-the-Eyes test reaction time

Can reaction time differences in emotion recognition between alcoholic patients and controls explain these results?

Table 3 Non-significant results for reaction times (RT) for Wason problems and Eyes and for Eyes scores.

Variables	*Recently detoxified alcoholics*	*Normal controls*
Wason social contract RT	Mean = 7 364 (SD = 3512)	Mean = 7 245 (SD = 2601)
Wason precaution RT	Mean = 7 422 (SD = 3845)	Mean = 6 533 (SD = 3006
Wason descriptive RT	Mean = 9 273 (SD = 4355)	Mean = 9 669 (SD = 6407)
Mind-in-the-eyes score	Mean = 23 (SD = 4)	Mean = 23 (SD = 2)
Mind-in-the-eyes RT	Mean = 11 984 (SD = 4557)	Mean = 10 170 (SD = 3898)

No. In order to assess whether alcoholic patients showed a difference in reaction time when responding to the Mind-in-the-Eyes test, a one-way ANOVA was conducted comparing reaction times between RA and NC. There were no significant differences (Table 3).

There were also no significant correlations between emotion recognition scores or reaction times (Mind-in-the-Eyes test) with social contract problem accuracy or reaction time, nor with accuracy or reaction time on any of the other reasoning problems.

Emotional intelligence (Table 2, Fig. S2; supporting information, see details given at the end)

Can differences in emotional intelligence between alcoholics and controls explain differences in social contract reasoning performances?

No. In order to assess whether alcoholics showed differences in emotional intelligence, one-way ANOVAs were conducted on EI global scores and on all subscales (Table 2). There were significant differences between alcoholics and controls for global, self motivation, self-control and wellbeing scores.

An analysis of covariance (ANCOVA) was conducted with BDI, STAI-A and -B as covariates. All significant differences between RA and NC disappeared.

There were no significant correlations between emotional intelligence scores and social contract problem accuracy or reaction time, nor with accuracy or reaction time on any of the other reasoning problems.

Global EI was introduced as a covariate in the ANOVA comparing RA and NC social contract reasoning performance, but it did not affect the significance of the difference between the two groups.

Harm avoidance

Can differences in harm avoidance between alcoholic patients and controls account for differences in precautionary reasoning performance?

No. No significant correlations emerged between the harm avoidance subscale of the TCI and precautionary reasoning accuracy or reaction time.

Depression and anxiety scores

ANCOVAs were conducted to compare alcoholics' and controls' conditional reasoning performance using BDI, STAI-A and -B as covariates. Differences between groups remained significant for social contract and descriptive reasoning, but not for precautionary reasoning (Table 4).

Verbal ability

Can differences in verbal ability between alcoholics and controls explain these results?

Table 4 ANCOVAs comparing alcoholics and normal controls on reasoning conditions, controlling for BDI, STAI-A and B.

	$F(1,47)$	P	η^2
Social contract	5.20	0.027	0.104
Precaution	2.84	0.099	0.059
Descriptive	12.174	<0.0001	$\eta^2 = 0.52$

ANCOVA: analysis of covariance; BDI: Beck Depression Inventory; STAI: State-Trait Anxiety Inventory.

No. There were no significant differences in scores on the Mill Hill between the alcoholic and control groups (Table 1).

DISCUSSION

Overall, alcoholic patients' performance on the Wason selection task was significantly worse than controls' performance. Performance on descriptive rules was particularly impaired in alcoholics and was not above chance level. Alcoholic patients' performance was higher on social contract and precautionary rules, and the differences between the conditions were greater for alcoholic subjects than for control subjects.

Domain-general reasoning is deficient in alcoholics [44–46]. Cognitive difficulties are generally attributed to the chronic toxic effect of alcohol on the brain.

The longer an adaptation has been present, the more time natural selection has had to make that adaptation resilient to disruption by environmental stresses or disease processes, such as alcoholism, all else equal. One would expect brain circuits involved in crucial functions to be more resilient to cerebral insult.

Detecting cheats in social exchanges and taking precautions to mitigate hazards have been long-standing evolutionary problems for humans. Humans' domain-general logical and intellectual abilities, which may underlie descriptive reasoning, are presumably more recent. Thus, one would expect relative resilience in precautionary and social exchange reasoning, as we observed in the alcoholic patients.

Alternatively, we cannot exclude the possibility that conditional reasoning difficulties might precede and eventually promote the development of alcoholism. Future studies could investigate at-risk populations, such as children of alcoholics.

Significant differences remained between groups, when anxiety and depression scores were introduced as covariates, except for precautionary reasoning. Various comorbidities, including mood and anxiety disorders antecedents should be recorded in future studies.

As expected, emotional intelligence scores were significantly lower in alcoholics, specifically on the self-

motivation, self-control and wellbeing subscales. These differences disappeared when depression and anxiety scores were added as covariates. There was no relationship between EI scores and accuracy or reaction time on social contract problems. Reis *et al*. [13] reported a negative correlation between EI and reaction time on social contracts, but they used a different EI scale [47] than in our study. Surprisingly, alcoholics did not show deficits on the Mind-in-the-Eyes test, in contrast to previous research showing deficits in the recognition of emotional facial expressions in a task using whole-face stimuli [14]. Differences in task difficulty may account for this discrepancy. The whole-face task required subjects to rate the intensity of the emotional expressions. The Mind-in-the-Eyes test only shows the eye region of the face, and some patients may have emotion recognition difficulties due to failure to attend to relevant facial features (i.e. the eyes) [48]. Thus, limiting the stimuli to the relevant facial region (the eyes) may have facilitated alcoholic patients' performance.

We did not find a relationship between performance on the Mind-in-the-Eyes test and social contract reasoning on the Wason selection task. A relationship between theory of mind and social contract reasoning was expected because successful social contract reasoning requires understanding others' mental states (e.g. what they consider a benefit), and from the fact that brain regions activated by social contract reasoning were similar to some of the regions activated in theory of mind tasks [10]. To our knowledge, this hypothesized relationship has never been investigated on a behavioral level and therefore should be tested again in future studies. Furthermore, theory of mind has several components, both perceptive, tested here, and cognitive, i.e. the ability to reason about others' mental states [38]. Future studies could compare the cognitive component of theory of mind with social contract reasoning performance.

Harm avoidances scores were significantly higher in alcoholics than in controls. However, they were not correlated with reaction times on precautionary Wason problems, contra Reis *et al*. [13].

In our population, it is not possible to know whether high harm avoidance was present before alcoholism developed or is secondary to the negative consequences of alcoholism.

If alcoholics have difficulties reasoning about precautionary rules, they might fall into risky behaviors unintentionally. Alcoholics are known to exhibit impairments in executive functioning, which may explain the pursuit of risky behaviors despite negative consequences [49].

Difficulties reasoning about social contracts may have a negative impact for alcoholic patients in cooperative situations, and difficulties reasoning about precautionary rules may be an additional mechanism leading to alcoholics' destructive risky behavior. Future studies should explore whether difficulties in social contract or precautionary reasoning are associated with problems in real-life settings.

CONCLUSION

Conditional reasoning appears impaired in recently detoxified alcoholics compared to normal controls. This impairment is particularly severe in descriptive reasoning, whereas social contract and precautionary reasoning were relatively spared.

Conditional reasoning deficits may be part of a more general cognitive deficit in alcoholism and might contribute to difficulties in understanding cooperative transactions or precautionary actions in this population. Impairment in social contract reasoning might lead to misunderstandings and frustration in social interactions, and difficulty reasoning about precautionary rules may contribute to risky behaviors.

Declarations of interest

None.

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Supporting information

Additional Supporting Information may be found in the online version of this article:

Figure S1 Wason accuracy scores.
Figure S2 Emotional intelligence scores.
Appendix S1 Example of Wason's test

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