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Effects of Moderate Alcohol Intake on Problem-Solving Ability among Young People in Abidjan (Côte d'Ivoire)

Emmanuel Diboh[1*], Koffi Serge Pacôme Kouadio[2], Paterson Valery Disseka[3], Mathias Koffi Yao[2], Antoine Némé Tako[2]

[1]UPR Neurosciences, Environment Training and Research Unit (UFR), Jean Lorougnon Guédé University, Daloa, Côte d'Ivoire
[2]Biology and Health Laboratory, Biosciences Training and Research Unit (UFR), Félix Houphouët Boigny University, Abidjan, Côte d'Ivoire
[3]Laboratory of Human Movement Sciences, Development and Well-Being, National Institute of Youth and Sports (INJS), Abidjan, Côte d'Ivoire
Email: *emmanueldiboh@gmail.com

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Abstract

Background: The effects of excessive alcohol intake are well documented and are harmful to cognitive performance and cause social problems. When it comes to moderate alcohol intake, the conclusions are different depending on authors and methods used. Studies aimed at understanding these effects are few in Africa and basically in Côte d'Ivoire, where a large proportion of the young population regularly drink alcohol. The purpose of this research work was to investigate the effect of a low-dose alcohol intake on the ability to solve a Hanoi Tower-type problem. To do this, 112 young people in school, with ages ranging from 18 to 24, were subjected to the Tower of Hanoi test, after either consuming alcohol (to reach blood alcohol content of 0.2, 0.5 and 0.8 g/l) or not (blood alcohol content of 0.0). **Material/Methods:** To do this, 56 young male students, with ages ranging from 18 to 33, were subjected to the Tower of Hanoi test, after either consuming alcohol (to reach blood alcohol content of 0.2, 0.5 and 0.8 g/l) or not (blood alcohol content of 0.0). **Results:** When group comparisons are made, it can be seen that individuals in group E1 (BAC 0.2 g/l) performed better than the others in all four tests. Individuals in group T and group E2 performed the worst in tests 2 and 3 respectively. Comparisons between categories show that, at BAC levels below 0.5 g/l, CO individuals outperformed CR individuals in all four tests. However, at BAC levels of 0.5 g/l and above, CR individuals outperformed CO individuals. **Conclusion:** The data showed that low alcohol intake (0.2 g/l) increased problem-solving ability, through improved planning, probably due to a reduction in the effects of stress. Data also showed that regular alcohol drinkers were more able to withstand the acute harmful effects of alcohol when their blood alcohol content was above 0.5 g/l.

Keywords

Moderate Alcohol Intake, Planning, Young Consumers, Tower of Hanoi Test

1. Introduction

The ability to solve a problem is vital to survive and move forward in this ever-changing world and is more important in problem-solving activities. This is the case, for instance, in computer programming, architecture or music design. We also have problem solving cases in the assessment of students' skills in educational institutions. These problem-solving cases used by schools and universities can help learners to develop knowledge (which will be useful in everyday life) as well as being assessment tools [1]. However, addressing an issue requires good cognitive skills, which are unfortunately affected by behaviours like excessive alcohol intake. In fact, data showed that excessive alcohol intake has a profound impact on pupils' academic performance and is associated with poor grades in class [2] [3]. It also causes profound structural damage, such as the depletion of frontal cortical areas and the cerebellum, which are important structures for learning [4] [5].

In the case of moderate alcohol intake, the effects on cognitive functioning are open to debate. These effects might be negative or positive, depending on authors and the study methods used [6]. Research showed that a blood alcohol content of 0.5 g/l (corresponding to the consumption of two standard glasses of wine) could be sufficient to impair cognitive performance [7].

In contrast, Baum-Baiker ([8] 1985) concluded that moderate alcohol intake had a benefit on performance in young people. Few studies were carried out on this subject in Africa, and particularly in Côte d'Ivoire. However, according to Diboh *et al.* (2013) [9], 32.06% of students in the city of Abidjan regularly consume alcohol. In Côte d'Ivoire, research in this area should therefore be encouraged. This study was designed in this framework and aimed to assess the effect of moderate alcohol intake (blood alcohol content ≤ 0.8 g/l) on the ability to solve a problem among young school students in the city of Abidjan, using the Tower of Hanoi Test.

2. Material and Methods

2.1. Participants

In this study, 112 participants were recruited using a non-random sampling method (convenience sampling) and divided into four groups: a control group (T) and three experimental groups (E1, E2 and E3). Participants in groups E1, E2 and E3 were asked to drink quantities of alcohol to respectively approximate blood alcohol contents of 0.2 g/l, 0.5 g/l and 0.8 g/l.

Each group (control and experimental) was subdivided into two subgroups or categories: occasional consumers (OC) and regular consumers (RC). Each group comprised 28 individuals (14 occasional drinkers and 14 regular drinkers).

The Occasional Alcohol Consumer is a person whose consumption is ≤4 glasses/month and no more than 4 standard glasses on a single occasion and the Regular Consumer has a consumption ≥ 4 glasses/week) [10].

All the participants were male. They had a mean age of 21.9 ± 3.8 years (ranging from 18 to 24 years) and a mean mass of 61.8 ± 6.1 kilograms. The inclusion criteria were as follows: male, in good physical and mental health, had at least consumed alcohol once, able to read and at least 18 years of age. People with alcohol hypersensitivity, metabolic or cognitive disorders and colour-blind participants were excluded.

2.2. Technical Equipment

The technical equipment consisted of: pure ethanol (99.8%); distilled water; a flavouring to improve the palatability of the solution; a graduated cylinder; a weighing scale; a laptop computer; a drinking glass and a four-disc test of the Hanoi tower (see **Figure 1**).

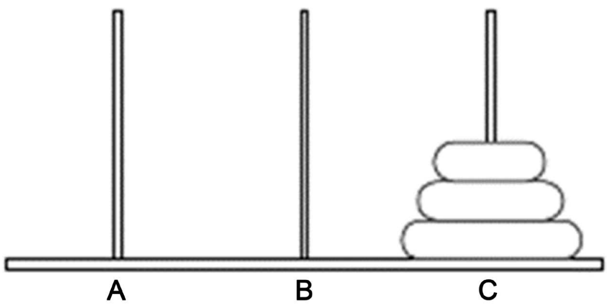

Figure 1. Diagram of a tower of hanoi test.

2.3. Preparation and Alcohol Intake

The alcohol taken up by participants had an ethanol concentration of 40% and was prepared by diluting 99.8% of ethyl alcohol with distilled water using the following formula:

$$C_i \times V_i = C_f \times V_f$$

C_i = initial concentration of alcohol

V_i = initial volume of alcohol

C_f = final concentration of alcohol

V_f = final volume of alcohol

On the day of the test, participants were sober for at least 24 hours and fasted for at least 8 hours to allow a rapid absorption of alcohol [11] [12].

The test was carried out in a room isolated from all external influences. An informed consent of each participant was obtained prior to experiment. According to an interview, participants who claimed to have consumed 5 or more standard glasses of alcohol at least once a week were considered as regular drinkers and those who consumed 3 to 4 standard glasses at least once a month were seen as occasional drinkers ([10] and [13]).

The participant's body mass was determined on arrival in the test room. The volume of drink to be taken by the participant was determined according to Widmark's formula ([14] Widmark, 1932):

$$V = \frac{T \times K \times M}{P \times 0.8} \text{ From which we have } V = \frac{T \times K \times M}{P \times 0.8}$$

T = Blood alcohol content

V = volume of alcohol consumed by the individual in ml

M = body mass of the individual in kg

K = the diffusion coefficient (K = 0.7 for men and K = 0.6 for women)

P = percentage of alcohol (40% = 0.4)

0.8 = density of ethanol.

Participants were given five minutes to drink the experimental alcohol solution. The test was carried out 15 minutes after drinking of the beverage.

2.4. Assessment of Problem-Solving Performance

In this study, the Tower of Hanoi test was used to assess the problem-solving performance of the different participants, according to Goldstein and Green (1995) [15], this test is used to assess planning, which is a process involved in problem-solving. The Tower of Hanoi test consists of three poles (marked A, B and C) placed vertically and with several discs (four in this study) of decreasing size. Each disc was pierced in its centre to be placed around one or other of the three poles. The discs were initially placed around stake A in decreasing order of size, forming a tower. The aim of the game is to move the discs until you reach the final point where all the discs are around stake C in decreasing order. The discs may come and go freely on the stakes according to two rules:

- move only one disc at a time and;
- never place one disc on top of a smaller one.

The rest interval between two trials was one minute (1 min). This interval was occupied by distractors (a series of general culture questions).

Data collection

For this study, 4 successive trials were carried out and the data collected were the number of actions (moves) performed to solve the problem, for each trial.

Variables

The study variables were of two types:

- the classification (or processing) variables, which were groups (T; E1; E2; E3) and the Consumer Categories (CO; CR) and;
- the dependent variable, which is the number of actions taken to solve the problem.

2.5. Statistical Processing

The data collected was first entered into a spreadsheet (created using Microsoft Excel 2016), then transferred and processed using STATISTICA® 7.1 software. This was used to generate graphs and compare the mean performance of different groups using the Kruskal-Wallis H-test (non-parametric test). To analyse performance between categories (CO and CR), the Mann-Whitney U Test (non-parametric test) was used.

The probability (p) of 0.05 was considered to be the limit of significance. Thus, if "p" is less than or equal to 0.05, the difference between compared means is significant. On the other hand, if "p" is greater than 0.05, then the difference between compared means is not significant.

The statistical meanings shown in the different figures were coded as follows: *: $p \le 0.05$; **: $p \le 0.01$; ***: $p \le 0.001$.

3. Results

3.1. Group Effect

Figure 2 showed the number of actions performed, by group and by trial, to solve the Tower of Hanoi problem.

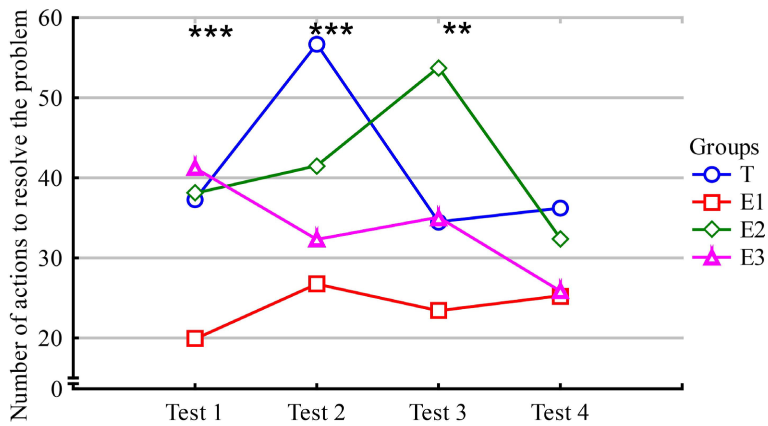

Figure 2. Evolution of the number of actions to solve the Tower of Hanoi problem during four successive trials for groups T, E1, E2 and E3. Individuals from group E1 (blood alcohol content of 0.2 g/l) performed better than the others in all four tests. Individuals from group T and group E2 had the most poor performances respectively for trial 2 and trial 3. The significances exhibited in this figure referred to Kruskal-Wallis H Test. The significance of multiple comparisons was not recorded.

For trial 1, the analysis indicated $H(3, 56) = 19.07$; $p < 0.001$. Multiple comparisons revealed that the performance of individuals from group E1 (19.87 ± 2.88) was significantly better (these individuals performed fewer actions than the others to solve the problem) than that of individuals from group T (37.29 ± 21.39) ($p = 0.008$). Likewise, the difference in performance between group E1 (19.87 ± 2.88) and group E2 (38.07 ± 21.77) was highly significant ($p = 0.007$). Finally, the difference in performance between groups E1 (19.87 ± 2.88) and E3 (41.23 ± 13.41) was also highly significant. ($p < 0.001$). The other comparisons did not show any significant differences ($p > 0.05$).

For trial 2, the analysis indicated H (3, 56) = 20.66; $p < 0.001$. Multiple comparisons revealed that the difference in performance between group T (56.71 ± 17.14) and group E1 (26.73 ± 10.90) was highly significant ($p < 0.001$). Similarly, there was a significant difference in performance between individuals from group T (56.71 ± 17.14) and those in group E3 (32.31 ± 8.32) ($p = 0.008$). The other comparisons showed no significant differences ($p > 0.05$).

For trial 3, the analysis revealed H (3, 56) = 11.85; $p = 0.007$. This indicated that at least two groups differ significantly. Multiple comparisons revealed a significant difference between the performance of individuals from groups E1 (23.40 ± 10.37) and E2 (53.79 ± 55.78) ($p = 0.006$). The other comparisons did not exhibit significant results ($p > 0.05$).

For trial 4, the analysis indicated that the differences in performance between groups were not significant (H (3, 56) = 6.99; $p = 0.072$).

3.2. Group Effect for Occasional Alcohol Consumers

Figure 3 showed the number of actions carried out, by group and by trial, to solve the Tower of Hanoi problem, for occasional alcohol consumers.

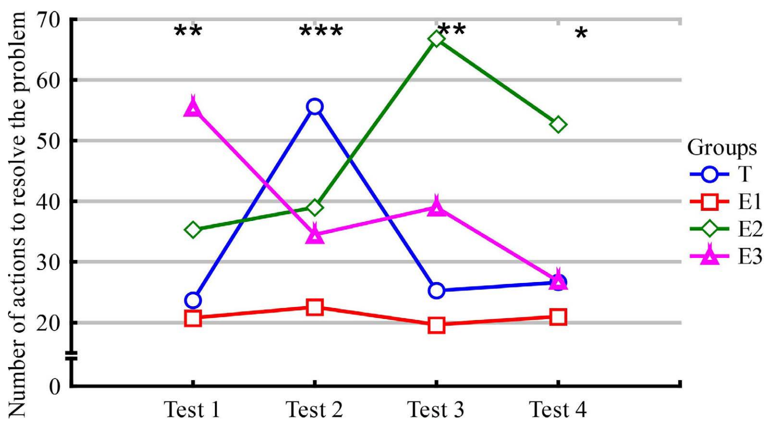

Figure 3. Evolution of the number of actions required to solve the Tower of Hanoi problem over four successive trials for groups T, E1, E2 and E3, for CO. Individuals from group E1 performed better than those in the other groups. Individuals from group T and group E2 performed the worst on trial 2 and trial 3 respectively. The significance values shown in the figure referred to the results of the Kruskal-Wallis H-test. Significance for multiple comparisons was not shown.

For trial 1, analysis of data indicated H (3, 30) = 12.82; $p = 0.005$. Multiple comparisons revealed that the mean performance of individuals from group E3 (55.33 ± 10.17) was significantly higher than that of individuals from group E1 (20.78 ± 3.07) ($p = 0.003$). The other comparisons did not show any significant differences ($p > 0.05$).

For trial 2, the non-parametric analysis of variance showed (H (3, 30) = 15.42; $p = 0.001$). Multiple comparisons concluded that there was a highly significant difference in performance between individuals from group T (55.75 ± 16.20) and those from group E1 (22.56 ± 8.82) ($p < 0.001$). The other comparisons did not show significant results ($p > 0.05$).

For trial 3, the non-parametric analysis of variance gave H (3, 30) = 12.88; p =0.004. Multiple comparisons revealed a significant difference in performance between individuals in group E1 (19.6 ± 6.22) and those from group E2 (66.71 ± 79.38) (p = 0.045). Similarly, groups E1 (19.6 ± 6.22) and E3 (39.00 ± 5.93) differed significantly (p = 0.007). As for the other comparisons, the differences observed were not significant ($p > 0.05$).

For trial 4, the analysis indicated H (3, 30) = 6.71; p = 0.021. The performance of group E1 (21.00 ± 11.49) differed significantly from that of group E2 (42.71 ± 35.39) (p = 0.027). The other differences were not significant ($p > 0.05$).

3.3. Group Effect for Regular Consumers

Figure 4 showed the number of actions carried out, by group and by trial, to solve the Tower of Hanoi problem, for regular consumers.

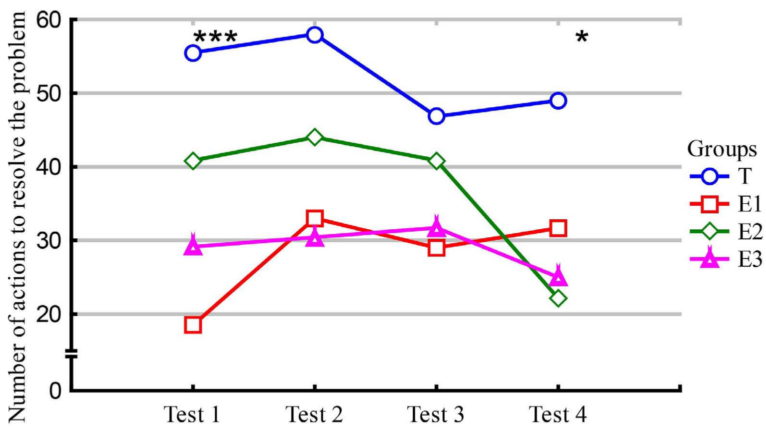

Figure 4. Evolution of the number of actions required to solve the Tower of Hanoi test problem over four successive trials for groups T, E1, E2 and E3, for the CRs. Individuals from groups E1 and E3 had the best performances on the four trials, even on trials 2 and 3 the differences in performance with the other groups were not significant. Individuals from group Thad the poorest performance on all four tests. The significances exhibited in referred to the Kruskal-Wallis H Test. The significance of multiple comparisons was not recorded.

For trial 1, the analysis revealed that at least two groups differed significantly (H (3, 26) = 17.53; $p < 0.001$). Multiple comparisons showed that the performance of group T (55.50 ± 21.36) differed very significantly from that of group E1 (18.50 ± 2.07) ($p < 0.001$). Similarly, the difference between groups E1 (18.50 ± 2.07) and E2 (40.86 ± 18.86) was significant (p = 0.012). The other comparisons showed non-significant results ($p > 0.05$).

For trial 2, H (3, 26) = 7.17; p = 0.066, so the groups were statistically identical in terms of performance.

For trial 3, differences in performance between groups were not significant (H

(3, 26) = 3.91; p = 0.271).

For trial 4, the analysis showed that the groups were significantly different in terms of performance (H (3, 26) = 8.77; p = 0.032). Multiple comparisons revealed that there was a significant difference between groups T (49.00 ± 23.80) and E2 (22.14 ± 8.19) (p = 0.028). The other comparisons showed no significant differences (p > 0.05).

3.4. Effect of Category for Groups T, E1, E2 and E3

Figure 5 showed the number of actions performed to solve the Hanoi Tower problem for the CO and CR categories, for groups T, E1, E2 and E3.

For group T, the differences between CO and CR were significant on trials 1 (p = 0.001) and 4 (p = 0.013). For the other trials, the result was p = 1.00 for trial 2 and p = 0.108 for trial 3. The latter was not significant.

For group E1, the analysis revealed a significant difference between CO and CR in trial 2 (p = 0.036). For the other trials, the differences were not significant (p > 0.05).

For group E2, the analyses did not reveal any significant differences (p > 0.05).

For group E3, the analyses revealed a significant difference between CO and CR for trial 1 (p = 0.001). However, the other trials did not show any significant differences (p > 0.05).

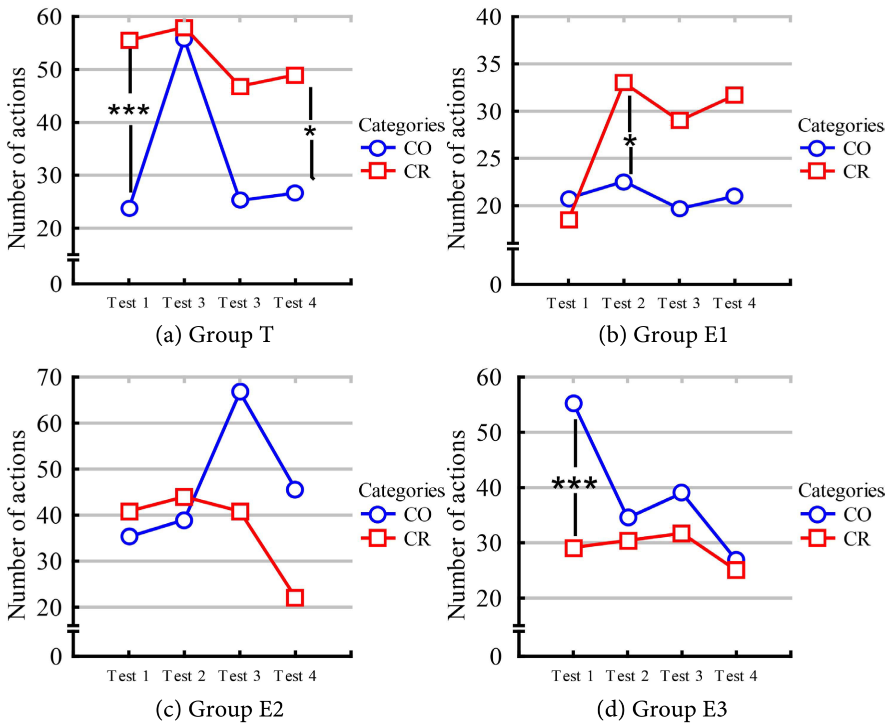

Figure 5. Evolution of the number of actions required to solve the Tower of Hanoi test problem over four successive trials for CO and CR categories, by group. For blood alcohol contents below 0.5 g/l, the COs performance was better than the CRs on all four trials. However, the CRs performance was better than the COs for blood alcohol contents equal or above 0.5 g/l. The significance values shown in this figure referred to the Mann-Whitney U test.

4. Discussion

In order to assess the effect of moderate alcohol intake (corresponding to the consumption of 1 to 3 standard glasses of alcohol) on problem-solving ability, a study was undertaken. Participants were divided into four groups of individuals who drank or did not drink alcohol to reach a blood alcohol contents of 0.0; 0.2; 0.5 and 0.8 g/l. They were then subjected to the Tower of Hanoi test four times in succession.

To comply with the recommendations of Ettorre (2004) [16], participants were all male. Perry's (2004) [17] study on women's vulnerability to alcohol intake showed that hormonal changes caused by the menstrual cycle do not allow effective conclusion to be made for inter-group comparisons.

Results showed that individuals with low-alcohol intake (Blood Alcohol Content of 0.2 g/l) performed better than others, that is to say control individuals (Blood Alcohol Content = 0.0 g/l) and individuals with high-alcohol intake (Blood Alcohol Content > 0.2 g/l). This tends to prove that alcohol intake (especially at low doses) leads to better planning and inhibits factors that can prevent problem solving. In fact, low-dose alcohol intake causes behavioural disinhibition [6] (Inserm, 2001) and reduces stress, which could improve performances such as planning.

These results are similar to those obtained on early experiments carried out on young people, showing that light and moderate alcohol intake improved some cognitive performances such as problem solving [8] [18]. Recent results also tend to confirm this hypothesis, with authors such as Mukamal *et al.* (2008) [19], Fernandez-Sola (2015) [20] and Lundgaard *et al.* (2018) [21] concluding from their research that alcohol has beneficial effects.

However, different results were obtained by Weisseborn and Duka (2003) [22]. These authors subjected 95 young people, divided into two groups (a group drinking alcohol to reach a blood alcohol content of 0.8 g/l and a group drinking a placebo), to a problem-solving test. They concluded that the alcohol consumers did not perform well than the placebo consumers. Similarly, recent results showed that alcohol affects most mental functions [23] [24]. This difference could be explained by the blood alcohol contents of individuals in the alcohol consumption group. Indeed, a blood alcohol contents of 0.8 g/l represents the threshold for acute ethyl intoxication, which causes disturbances in the cognitive functions of drinkers [6] [25] [26].

As for comparisons between categories of different groups, the data showed that regular consumers of alcohol outperform occasional consumers, in terms of performance, when the blood alcohol content were above 0.5 g/l. This could be explained by an adaptation effect in the brain. In fact, chronic and prolonged alcohol consumption, which may be similar to regular consumption, leads to the development of tolerance to the sedative or motor effects of alcohol [27].

Finally, the poor performance observed in the 2nd and 3rd trials, in control individuals and in individuals with a blood alcohol content of 0.5 g/l, in the category of occasional alcohol consumers, showed that these individuals did not yet master how to solve the problem. In the control individuals, this result could be explained by the stress induced by the test, which reduced their ability to solve the problem by causing confusion. Individuals from group E2 (blood alcohol content of 0.5 g/l), the failure to master the problem-solving procedure could be linked to the negative effect of alcohol on the memorisation and learning process, since alcohol disrupts the passage of information from short-term to long-term memory [28].

5. Conclusion

The aim of this study was to assess the effects of moderate alcohol intake on the problem-solving abilities of school-age children. The results showed that moderate alcohol intake (0.2 g/l), corresponding to the consumption of a standard glass of alcohol, leads to better planning of actions and therefore increases the ability to solve a problem. This positive effect may be due to the stress-reducing effect of low alcohol consumption. However, further studies should be carried out to provide more information on the topic. It was said that regular alcohol consumers are able to tolerate the acute effects of alcohol when their blood alcohol content was above 0.5 g/l. For the time being, schoolchildren should avoid drinking alcohol even moderate amounts of alcohol at school.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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