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Effects of Kindjouss (local brandy) on the visuo-spatial working memory of young learners (Côte d'Ivoire)

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Abstract

Alcoholism remains a major health risk worldwide, and Côte d'Ivoire is no exception. More and more young people, particularly students, are consuming inexpensive alcoholic beverages such as Kindjouss, a strong homemade spirit containing various potentially harmful alcohols. This study aimed to assess the effects of Kindjouss on the visuospatial memory of these young people. To this end, the memory performance of 150 subjects (aged 18 to 25), including 100 regular consumers of this beverage and 50 controls, was assessed using neuropsychological tests (Corsi test and nine-picture test) after inducing a blood alcohol level of 0.8 g/L. The results initially reveal that Kindjouss is mainly consumed by young men in school (aged 18 to 25). In addition, this traditional beverage caused significant disturbances in visuospatial working memory in regular users, regardless of the period of alcohol consumption (before and especially after ingesting the beverage). Furthermore, this dose (0.8 g/l) of kindjouss is sufficient to cause cognitive impairment.

Keywords: Kindjouss; Visuospatial Working Memory; Regular Consumption; Cognition

1 Introduction

Alcohol, although traditionally considered a depressant [1], actually has a wide range of contradictory effects. Globally, its consumption is deeply rooted in social, cultural, and economic practices [2]. However, despite its festive and symbolic roles, alcohol also causes multiple adverse effects on public health. According to the World Health Organization, alcohol consumption caused approximately 2.6 million deaths worldwide in 2019, representing 4.7% of overall mortality [3].

There are significant disparities in alcohol consumption between different regions of the world. In Asia, practices vary considerably from country to country. In China, despite a long-standing cultural ban for certain religious groups, consumption of baijiu, a local spirit, remains very high, contributing to continued growth in the alcohol market [1]. On the American continent, alcohol is also omnipresent, both in social and commercial spheres. In Brazil, traditional alcoholic beverages such as cachaça continue to be widely consumed. However, the socioeconomic effects of this consumption are worrying, generating an estimated cost of more than $3.2 billion in health care expenditures and productivity losses in 2019 [4].

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Alcohol consumption in Europe has historically been high. In 2016, the average annual consumption of pure alcohol per adult was 10.3 liters [1**]**. In France, although daily consumption has declined overall since the 1970s, new trends such as binge drinking (excessive consumption in a short period of time) are on the rise among young adults [5**]**. In several European countries, alcohol continues to play a prominent role in social interactions and traditional rituals.

In Africa, the situation is changing rapidly. While some countries maintain low consumption for religious or cultural reasons, others are seeing a significant increase in alcohol consumption. According to the WHO, the continental average has increased by nearly two-thirds in just seven years [6**].** In Ghana, local alcoholic beverages such as akpeteshie, a homemade spirit, are widely consumed despite their high alcohol content [7**]**.

In Liberia, palm wine and other traditional fermented products remain common, and new beverages, such as kindjouss, made from fermented sugarcane juice, are gaining popularity [8]. In Côte d'Ivoire, traditional alcohol plays a major role in social and cultural practices. Among the most iconic beverages are koutoukou (a brandy) with a high alcohol content obtained through artisanal distillation, and bandji, a fermented palm wine consumed in both rural and urban areas [9**]**.

The production of these beverages, often informal, takes place in precarious sanitary conditions and without control of alcohol levels, thus exposing consumers to various health risks [10**].** More recently, kindjouss, a drink originating in Liberia, has been introduced in Côte d'Ivoire. Produced by fermenting sugar cane juice, kindjouss is now consumed in several Ivorian localities, although it remains poorly documented scientifically.

Beyond cultural aspects, chronic consumption of traditional alcohol, particularly beverages such as kindjouss, raises serious questions about their potential effects on cognitive health, particularly visuospatial memory, an essential function for orientation, navigation, and spatial recognition in the environment.

Previous studies suggest that low doses of alcohol may have stimulating effects on certain cognitive functions [11**].** However, this relationship remains to be explored in the specific context of kindjouss.

The main objective of this study is therefore to determine the effect of kindjouss consumption on performance in tasks assessing visuospatial memory in young men. Specifically, the aim was to:

- Conduct an epidemiological study on kindjouss consumption in the Abidjan region, mainly in the municipality of Yopougon, which is home to all social classes.
- Assess the effects of acute Kindjouss consumption on users' visuospatial working memory

2 Subject, material and methodology

2.1 Study area and populations

The study was conducted in Abidjan, the economic capital of Côte d'Ivoire, and more specifically in the municipality of Yopougon, located in the western part of the city. Yopougon is the largest and most populous municipality, with an estimated population of over 1,571,065 inhabitants according to the General Population and Housing Census [12**]**. It is characterized by great socio-cultural diversity, strong economic dynamism, and an intense nightlife marked by a high density of maquis, bars, and outlets selling traditional and modern alcoholic beverages. These specific characteristics motivated the choice of Yopougon as the study area to assess the potential effects of alcohol consumption, particularly kindjouss, on visuospatial memory.

This work, carried out between May and August 2025, combined two approaches: an epidemiological survey of 1,271 individuals who frequented bistros (Kindjouss points of sale). Then another behavioral study aimed at assessing cognitive performance, particularly visuospatial working memory. To this end, 150 subjects, including 100 regular Kindjouss users and 50 controls (abstinent subjects), were assessed using two neuropsychological tests (the Corsi test and the 9-picture test). Individuals who reported consuming five or more drinks per week constituted the group of regular consumers (RC) [13] [14]**.**

Our sample consisted of males aged 18 to 25, with an average weight of 63.5±6.8.

Socio-demographic characteristics (gender, age, occupation, consumption habits, etc.) were collected using a questionnaire.

The tests were conducted on site (at the meeting places).

2.2 Inclusion and exclusion criteria

The study included male subjects who were regular Kindjouss users, aged 18 and over, residing in the municipality of Yopougon, and who had given their written informed consent.

Subjects under the age of 18, or those with metabolic diseases or apparent neurological, psychiatric, or cognitive disorders, were not included.

2.3 Materials

2.3.1 Technical materials for the epidemiological study

The materials for the epidemiological study mainly consist of a questionnaire adapted from that of **Camara** [15**]**.

2.3.2 Technical equipment for behavioral study

The equipment used in this study consists mainly of:

- A bathroom scale;
- A gay-lussac centesimal alcoholometer used to measure alcohol content;
- A graduated cylinder used to measure the quantity of koutoukou;
- A drinking glass;
- Kindjouss;
- An electronic blood pressure monitor with cuff for measuring (monitoring) blood pressure and pulse;
- A test of nine images of familiar objects (see appendix);
- A corsi test (see appendix).

2.4 Methods

2.4.1 Preparation and consumption of alcohol

On the day of the test, participants arrived sober, having fasted for at least 24 hours and not eaten for at least 8 hours to allow for rapid absorption of the alcohol [16]. The alcohol content of the solution was determined using a Gay-Lussac alcoholometer. To do this, the alcoholometer was immersed in the solution and the alcohol content was read directly on the graduated rod.

The subjects' body weight was determined using a scale. This, together with the alcohol content, was used to determine the volume of kindjouss to be ingested by the subject in order to obtain an approximate blood alcohol level of 0.8 g/l, based on the WIDMARK formula [17]. This formula takes into account the weight and gender (male or female) of the subject.

Thus, let A be the approximate blood alcohol concentration (or target blood alcohol concentration) and k the alcohol diffusion coefficient (0.7 for men and 0.6 for women); the density of ethanol being approximately 0.8, the formula is as follows:

$$A = \frac{V \times p \times 0{,}8}{k \times m}$$

from where

$$V = \frac{A \times k \times m}{p \times 0{,}8}$$

A = being the Approximate Blood Alcohol Concentration (desired blood alcohol concentration)
V = corresponds to the volume (in ml) of alcohol to be ingested by the individual
m = mass of the individual in kg
k = diffusion coefficient (K = 0.7 for men and k = 0.6 for women)
p = degree (percentage) of alcohol in the drink to be ingested

0.8 = density of ethanol.
A margin of ±10% was accepted. The ingestion time was set at 5 minutes.

2.4.2 Assessment of visuospatial working memory using the Corsi test

The **Corsi** block test consists of reproducing, in the same order or in reverse order, a sequence of pointing movements of different cubes shown by the examiner. The number of blocks increases gradually, allowing the visual-spatial span to be determined, which is the maximum number of blocks that the subject can recall without error. This test consists of a board on which nine cubes or blocks are fixed in a non-symmetrical arrangement and numbered on the side visible only to the examiner (see appendix). The examiner touches a number of blocks in a pre-established order and asks the subject to reproduce the sequence. The complete test consists of a first part with a recall of the sequence in the correct order, used to assess immediate visuospatial memory, and a second part in which the sequence is recalled in reverse order. The latter assesses visuospatial working memory.

Procedure:

The subject and the examiner sit facing each other on either side of a table with the Corsi block-tracing board placed in the center. The examiner points to different cubes in succession, increasing the number as the subject progresses, starting with examples involving a sequence of two cubes (see Appendix, Tables 1 and 2). After the two examples, two attempts are offered for each sequence of the same length. As soon as one of the two attempts is correctly reproduced, the first attempt at the next level is offered. When both attempts at the same level are unsuccessful, the test ends. The examiner uses their index finger to point to the cubes at a rate of one block per second. Once all the blocks have been shown, the examiner immediately asks the subject to reproduce the same sequence in the same order or in reverse order. In this study, only the forward condition was used. The score awarded corresponds to the level of the last sequence correctly reproduced. Self-corrections are allowed. Only sequences reproduced identically are considered successful.

2.4.3 Assessment of visuospatial working memory using the 9-picture test

The visuospatial memory test involves studying the arrangement, designation, and recall of images during spatial layout learning tasks [18]. The subject must memorize the arrangement of nine images of familiar objects (a boubou, a pig, a mango, a key, a bicycle, a canary, a mask, a machete, and a tam-tam) arranged in nine equal squares on a square frame placed in front of them. The time between the presentation of the images and recall is set at 30 seconds, during which the subject is given a simple interference task to perform (mental arithmetic or conversation). For each type of test, the criterion for learning the spatial arrangement is set at three successive attempts without errors. In case of failure, the test is stopped after ten attempts. During the various tests, correct answers are confirmed by the experimenter and errors are pointed out to the subject.

During the presentation preceding each designation or each evocation, the spatial arrangement of the images must not vary; each image always occupies the same place on the frame. However, the order in which the images are presented does not follow any obvious spatial organization and must vary from one trial to another.

These tests call upon working memory. This memory requires not only that the subject record different successive events, but also that they remember the order in which they occur and finally, use them selectively at a later stage. The layout of each image is shown successively for five seconds to the subject, who is instructed to remember the position of the image within the frame. During the presentation tests that precede the designations or evocations, the subject must not see the overall arrangement of the nine images on the nine squares of the frame, which means that each image is removed before the next one is presented. The subject must tell the experimenter the name of the image associated with the square presented to them. The recall of the nine boxes is a test that may or may not be successful. For each type of test, the criterion for learning the spatial arrangement is set at three successive attempts without errors. In case of failure, the test is stopped after ten attempts. During the various tests, correct answers are confirmed by the experimenter and errors are pointed out to the subject.

The sample is a series of trials, up to a maximum of ten when learning is delayed or has not been established. The characteristic studied is the number of errors per trial. Since spatial layout learning involves nine images of everyday objects, the maximum number of errors will be nine. For each type of test, the results are presented in a single-entry table with two columns, the first for recording the number of trials and the second for the percentage of errors. However, to make them easier to interpret, the numerical data in the results tables will be presented in graph form. For this study, the test was limited to the spatial designation test.

The error percentage is determined as follows:

$$\frac{\text{Nombre d'erreur pour l'essai considéré}}{\text{Nombre maximum d'erreurs}} \text{ X 100}$$

Soit

$$\frac{\text{Nombre d'erreurs pour l'essai considéré}}{9} \text{ X 100}$$

2.4.4 Data processing

Statistical analysis of the data was performed using R software (version 4.3.3) and the tidyverse, rstatix, and ggpubr packages. For all analyses, the significance threshold was set at $\alpha = 0.05$. The analyses were conducted on a subset of 150 participants who completed all three experimental conditions (pre-consumption, post-consumption, and control).

- **Corsi test analysis**

Performance on the Corsi test was assessed by the visuospatial span score (higher = better performance). The data were analyzed by repeated measures ANOVA (factor: condition). In the case of a significant effect, post-hoc comparisons were performed with the Bonferroni-corrected Wilcoxon test.

- **Analysis of the 9-picture test**

Performance on the 9-picture test was assessed by the number of errors (lower score = better performance). Data were analyzed using a two-factor within-subjects ANOVA (condition × trial). In the event of a significant interaction, pairwise post-hoc comparisons were performed using the Bonferroni-corrected Wilcoxon test.

3 Results

3.1 Epidemiological study: Socio-demographic characteristics

The study sample consisted of 1,271 participants residing in the municipality of Yopougon, representing all social strata. Our work reveals that young adults (aged 18 to 25) are the most representative (78.4%), followed by those in the 26 to 35 age group (15.7%), then those over 35 (5.9%) (Figure 1). The vast majority (90.2%) of regulars at these bars are male. Women represent only 9.8% (Figure 2). Furthermore, 45.1% of those surveyed are young people in education, while the unemployed represent 27.5%, compared with 3.7% of civil servants. Individuals in other professions represent 11.8% of this workforce (Figure 3).

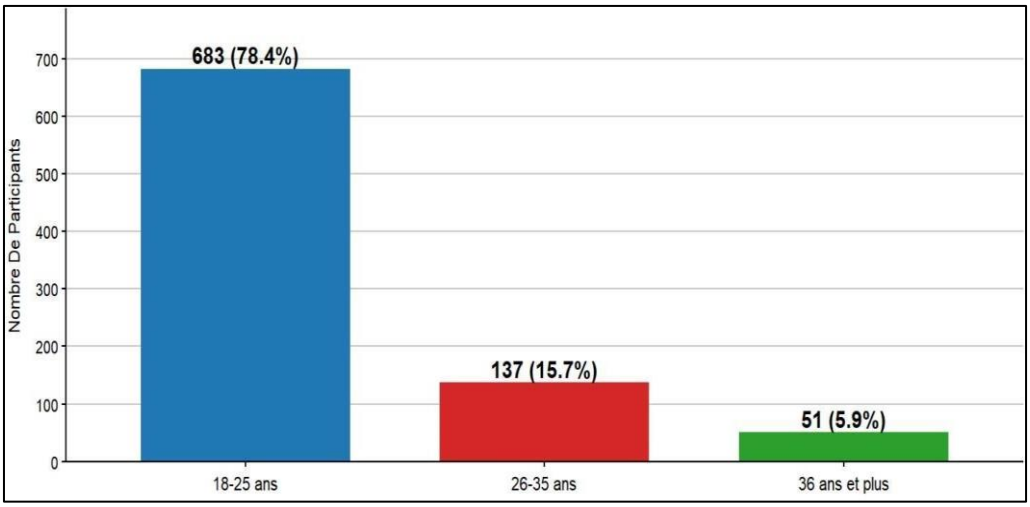


Figure 1 Distribution of regular kindjouss users by age group

This distribution shows a strong predominance of young adults (18 to 25 years old).

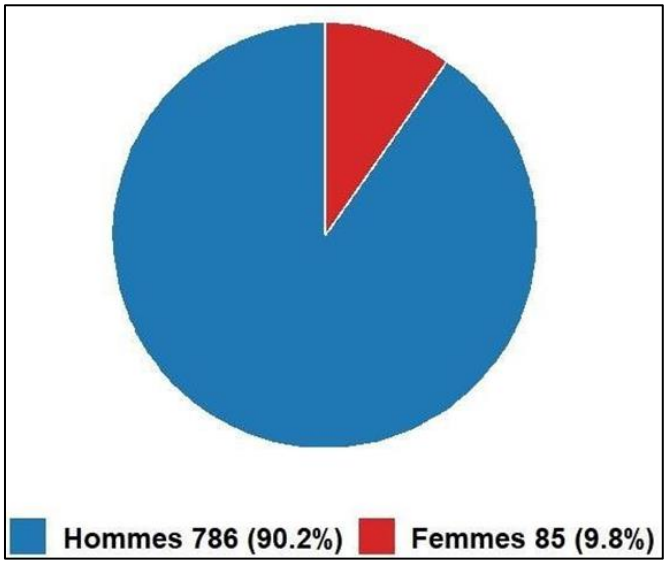


Figure 2 Distribution of participants by gender

The study population is overwhelmingly male (90.2%).

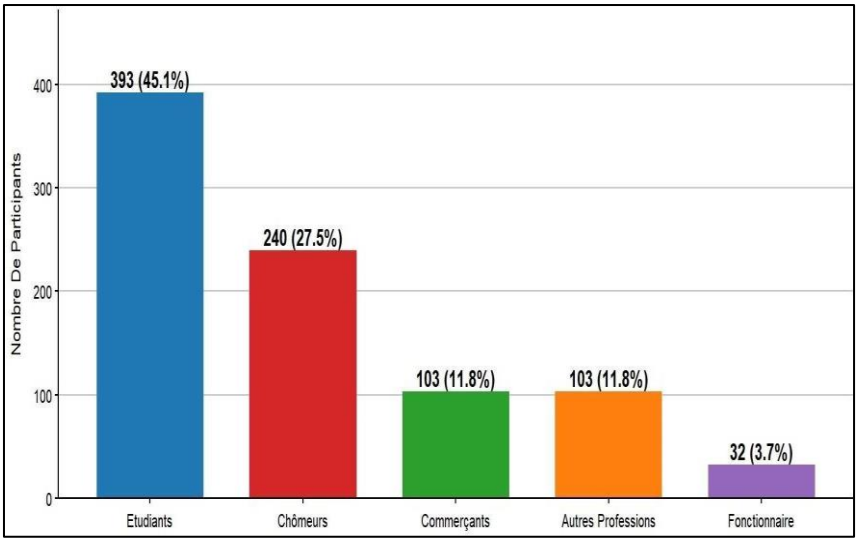


Figure 3 Breakdown of participants by occupation

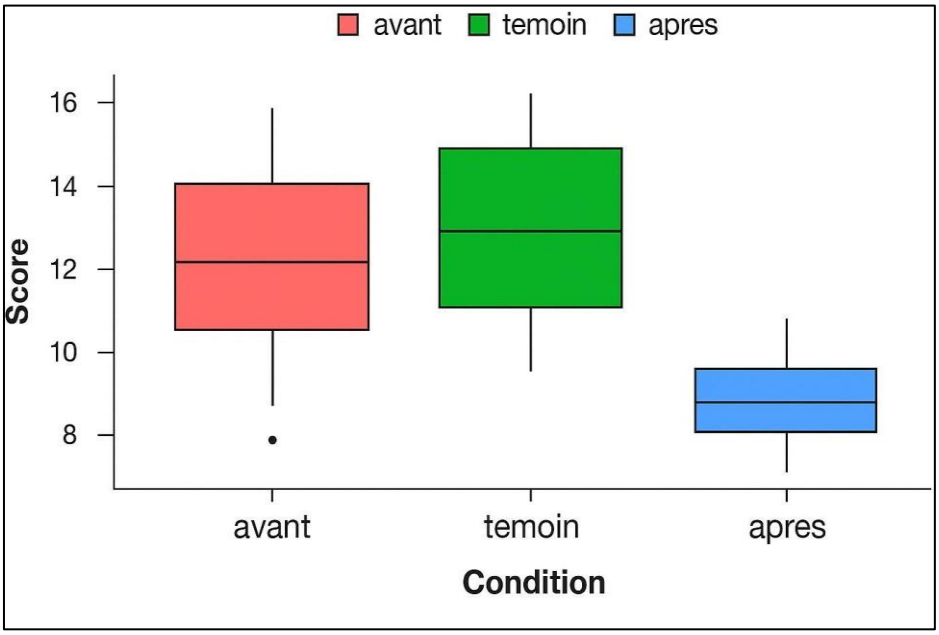
The breakdown of participants by occupation shows a strong predominance of students (45.1%), followed by unemployed individuals (27.5%).

3.2 Behavioral study

3.2.1 Assessment of subjects' visuospatial memory using the Corsi test (Figure 4)

Analysis of variance revealed a highly significant overall effect of the experimental condition on performance in the Corsi test ($F(2, 58) = 115.39$, $p < 0.001$, $\eta^2g = 0.702$). The effect size observed was very large, indicating a major influence of alcohol consumption on visuospatial working memory abilities. Our results also indicate that the memory performance of the control subjects is significantly (p.adj = 0.0004) superior to that of the test subjects before alcohol consumption. This suggests that the latter have cortical damage due to their alcohol consumption habits. Furthermore, intragroup comparison according to the period of alcohol consumption indicates that the test subjects' memory

performance after consuming Kindjouss is significantly lower than their performance before alcohol consumption (p.adj < 0.0001).



Before: performance of kindjouss users before alcohol consumption; After: performance of kindjouss users after alcohol consumption; Control: performance of control subjects; *: significant; **: highly significant

Figure 4 Memory performance of subjects in the Corsi test

The analysis reveals a highly significant decline in performance following consumption of the traditional beverage ($p < 0.0001$, comparison of Before vs. After). It should also be noted that the memory performance of the test subjects is significantly lower than that of the control subjects even before alcohol consumption.

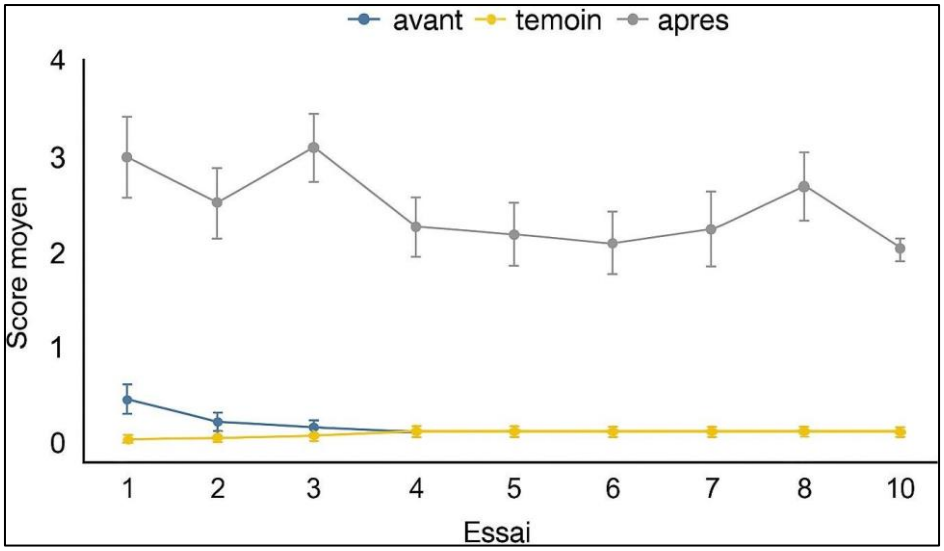
3.2.2 Assessment of subjects' visuospatial memory using the 9-picture test

The 9-picture test was used to assess spatial learning based on the number of errors made (Figure 5).

A main effect of condition was observed $F(1.02, 29.51) = 375.87$, $p < 0.001$, $\eta^2g = 0.671$). Errors were much more numerous in the post-consumption condition than in the pre-consumption and control conditions. In addition, a main effect of trial emerged ($F(4.42, 128.05) = 3.51$, $p = 0.007$, $\eta^2g = 0.030$), indicating a change in the number of errors over time.

A comparison of performance on the 9-image test between test subjects and controls before alcohol consumption showed no significant difference (p.adj = 1). This was not the case after alcohol consumption, where a very significant difference was observed (p.adj < 0.0001). Our results also indicate that the performance of Kindjouss consumers after alcohol consumption is significantly lower than their performance before consuming the traditional beverage (p.adj < 0.0001).

Overall, consumption of the substance led to a massive increase in errors and disrupted the learning process. Unlike the pre- and control conditions, where errors stabilized at a low level, the post-consumption condition remained high, reflecting a lasting impairment of spatial learning abilities.



Before: Performance of kindjouss users before alcohol consumption; After: Performance of kindjouss users after alcohol consumption; Control: Performance of control subjects; ns: not significant; **: highly significant

Figure 5 Memory performance of subjects in the 9-picture test

The controls had superior memory performance to that of regular kindjouss users, regardless of the period of alcohol consumption (before, but especially after alcohol consumption). However, after alcohol consumption, the gap widens significantly throughout the tests (test subjects make more errors in the designation tests), indicating that learning has not taken place.

4 Discussion

In this study, we set out to evaluate the effects of a blood alcohol concentration of 0.8 grams per liter of Kindjouss on the visuospatial working memory of consumers of this beverage in the municipality of Yopougon. This dose corresponds to the threshold for acute intoxication [19].

Analysis of sociodemographic characteristics shows a predominance of young adults (18-25 years old), representing 78.4% of participants. These results contradict those of Yao [20], who found that the most represented age group in these traditional drinking establishments was those over 35 years old. Our work therefore suggests that young people are increasingly frequenting these types of places. This overrepresentation of young people in Kindjouss consumption could be explained by several factors. On the one hand, the 18-25 age group corresponds to “emerging adulthood,” a phase of neurodevelopmental vulnerability in which risky behaviors, including alcohol consumption, are common [21]. On the other hand, the socio-economic context of Yopougon, with a high proportion of students (45.1%) and unemployed people (27.5%), creates a fertile ground for regular alcohol consumption, often used as a coping strategy in the face of academic stress or precariousness [22]. Finally, the low cost of this beverage (100 CFA francs for a round of 25 to 20 ml) is an additional factor, especially in a difficult socioeconomic context for young people in this country. The overwhelming male predominance (90.2%) in our sample reflects Ivorian cultural norms, where alcohol consumption, particularly in public spaces such as bars, remains socially codified as a male activity. This observation corroborates data from the WHO (2018) [1], which identifies sub-Saharan Africa as the region with the most pronounced gender gap in alcohol consumption in the world. The majority of women who frequent these bars are the owners or managers of these establishments. However, these data are consistent with those of Yao [19] and Diboh [23], who found that women do not have a particular attraction to traditional liquors.

Alongside the epidemiological study, a behavioral study was conducted to assess the memory skills of users of this traditional beverage. Two neuropsychological tests were used for this purpose: the Corsi test and the 9-picture test.

Corsi blocks are used to assess nonverbal immediate memory or working memory in its visuospatial aspects, in children [24] as well as adults and older adults [25]. The working memory model developed by Baddeley and Hitch [26] posits the existence of three components: the central executive, which is an attentional control system that coordinates and regulates the processing operations performed by the other two subsystems and links them to long-term memory; the phonological loop, which specializes in verbal information; the visuospatial sketchpad, which processes nonverbal

spatial and visual information. McLean and Hitch [27] consider Corsi blocks to be a measure of this visuospatial sketchpad, with the span of attention reflecting the functioning of the central executive [28]. The Corsi block test requires remembering the different locations of the blocks that make up the sequence (spatial dimension) and the order in which they appear (temporal dimension) and therefore also draws on executive resources. Rudkin et al. (2007) [29] have shown that Corsi blocks place greater demands on attentional functions than a matrix test due to the need to construct a mental representation of the sequence of movements, which is even more pronounced in the reverse test [30].

Kindjouss would therefore significantly disrupt these various processes, namely attention, encoding, and above all the relationship between the central administrator and the visuospatial sketchpad. The results of the Corsi test demonstrate a particularly significant effect of Kindjouss consumption on visuospatial working memory. Statistical analysis reveals a highly significant main effect of the experimental condition with a very large effect size. Comparison of performance before and after consumption shows a marked deterioration in working memory capacity. The magnitude of this effect far exceeds the effect sizes usually reported in the literature on the acute effects of alcohol on cognition [31]. This particularity could be explained by two synergistic factors: the high ethanol concentration in Kindjouss (45% vol.) and the increased vulnerability of our young population, whose prefrontal cortex, a key structure for working memory, is still maturing [32]**.** From a neurobiological perspective, this massive impairment corroborates current models that attribute working memory deficits under alcohol to a disruptive action of ethanol on the dorsolateral prefrontal cortex and fronto-parietal networks [33] (Eriksson et al., 2015), these structures are crucial for the active maintenance of information and executive coordination, as recent neuroimaging studies have shown [34].

The 9-picture test reveals a more nuanced cognitive impairment profile. Indeed, the absence of significant differences between the "before" and "control" conditions, contrasting with the marked differences between "before" vs. "after" and 'control' vs. "after," could suggest that the mechanisms of immediate information consolidation remain functional, but that the quality of initial processing is compromised [35]. This distinct cognitive pattern, where initial encoding is preferentially impaired compared to consolidation, is increasingly documented in recent literature on the acute effects of alcohol. An fMRI study by Schweizer et al. (2018) [36] showed that acute alcohol intoxication specifically disrupted the activity of the default mode network and prefrontal cortex during encoding phases, reducing the efficiency of initial information processing. Furthermore, the work of Spinola et al. (2021) [37] corroborates the idea of a dissociation of effects: their meta-analysis concludes that alcohol mainly impairs the upstream controlled and attentional processes necessary for good encoding, while the more automated processes of memory consolidation remain relatively unaffected in the short term. This neurocognitive profile explains the relative preservation of the learning curve observed in our study, despite a marked decline in overall performance. Similar working memory deficits were observed by Diboh et al., 2025 [38] in consumers of koutoukou, a traditional drink very similar in production to kindjouss. In the specific context where kindjouss is socially accepted and culturally integrated, these results raise important public health issues. Indeed, the combination of high alcohol content, wide availability, and regular consumption among young adults represents a significant risk factor for individual and collective safety, particularly in situations requiring vigilance and precision (driving, operating machinery, etc.).

5 Conclusion

In this study, we set out to evaluate the visuospatial working memory of kindjouss users in the city of Abidjan. To this end, our work reveals that kindjouss is overwhelmingly consumed by young adult males in school. In addition, this traditional beverage caused significant disturbances in the visuospatial working memory of regular users, regardless of the period of alcohol consumption (before and especially after ingesting the beverage). Our work has thus revealed that, unlike many other so-called more "conventional" alcoholic beverages, a blood alcohol level of 0.8 g/l of kindjouss has a much more pronounced effect on cognition.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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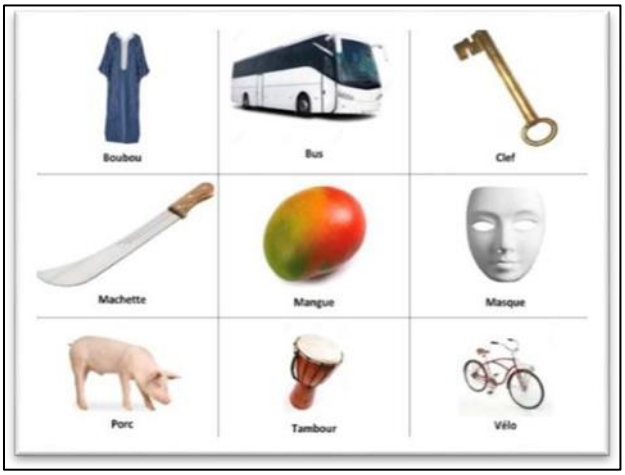
Appendix



Images of familiar objects used in the 9-image test

Test of the 9 images arranged in the frame

Wooden board with numbered cubes used in the Corsi test

CORSI TEST: presentation of items

Table 1 Sequences under place recall conditions

Example	**2-6**	**7-9**
level	trial 1	trial 2
2	8–5	6–4
3	4–7–2	8–1–5
4	3–4–1–7	6–1–5–8
5	5–2–1–8–6	4–2–7–3–1
6	3–9–2–4–8–7	3–7–8–2–9–4
7	5–9–1–7–4–2–8	5–7–9–2–8–4–6
8	5–8–1–9–2–6–4–7	5–9–3–6–7–2–4–3
9	5–3–8–7–1–2–4–6–	4–2–6–8–1–7–9–3–

Table 2 Sequences under reverse recall conditions

Example	**1-8**	**4-6**
level	trial 1	trial 2
2	9-4	7-5
3	6-8-5	4-6-3
4	2-5-1-8	9-3-5-2
5	5-3-2-9-7	3-1-9-4-7
6	1-6-8-4-7-5	2-6-9-3-8-5
7	5-3-8-6-2-7-4	2-3-8-5-1-9-7
8	4-9-1-6-3-8-7-5	4-8-5-9-7-2-1-6
9	3-7-8-1-2-6-4-9-5	1-5-6-3-8-4-9-2-7