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Comparative Study of the Memory Skills (Working Memory) of Alcoholics, Cannabis Addicts, and Multiple Drug Addicts Admitted for Treatment at the Croix Bleue Reception Center (Ivory Coast)

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ABSTRACT

Drug use is a phenomenon common to various countries around the world, both developed and developing. According to the WHO, approximately 400 million people worldwide suffer from disorders related to alcohol and drug use. Côte d'Ivoire is no exception to this scourge**.** In recent years, research has been conducted on the impact of psychoactive substances on alertness and cognition. However, no comparative studies have been conducted on the effects of these different psychoactive substances. The objective of this study is to compare the memory performance, particularly the working memory, of alcoholics, cannabis users, and poly-drug users.

To this end, the working memory of 120 subjects, including 90 patients (30 alcoholics, 30 cannabis users, 30 poly-drug users) admitted for treatment at the Croix Bleue reception center and 30 controls, was assessed using the digit memory test from the Adult Intelligence Scale 1st part-3eedition (WAIS III).

The results show that all three groups of subjects had significantly impaired working memory prior to treatment. This impairment was even more pronounced in cannabis users. In addition, recovery of this memory function after treatment (withdrawal) was more difficult and slower in cannabis users than in poly-drug users and alcoholics. The latter group had the least impaired working memory and the best cognitive recovery after withdrawal, without however matching the memory performance of the control group.

Keywords: drugs, working memory, cannabis users, alcoholics, poly-drug users.

INTRODUCTION

Addiction is one of the most obvious consequences of drug use. It drives users to consume these substances again because of their initial pleasant effect on the nervous system. A drug is a psychotropic or psychoactive substance that alters the activity of the central nervous system (sensations, perceptions, moods, feelings, motor skills) or alters states of consciousness [1]. In fact, it is a product that can lead to physical and/or psychological dependence. Some of these drugs are illegal because they are classified as narcotics, which means that their use and trade are prohibited, except in medical and/or scientific contexts**.** The use of psychoactive substances exposes users to harmful consequences for their health and social life [2]. In recent years, we have seen an increase in drug use in countries around the world, both developed and developing. According to the World Health Organization [3], 2.6 million deaths worldwide each year are due to alcohol consumption, representing 4.7% of all deaths. Narcotics are responsible for 0.6 million deaths. It also reports that approximately 400 million people worldwide suffer from alcohol and drug use disorders. Of these, 209 million people are dependent on alcohol.

According to the United Nations Office on Drugs and Crime, Africa remains a key transit region for cocaine in the west, heroin in the east, and cannabis resin, mainly produced in the region, in the north. According to a report by the United Nations Office on Drugs and Crime [4], drug use in Nigeria is twice the global average. Cannabis remains the most commonly used illicit drug in this part of the world, followed by amphetamine-type stimulants. According to the National School for Territorial Executives [5], the

quantity of amphetamines, cocaine, opiates, and prescription opioids used for non-medical purposes, as demanded by West Africans, is expected to more than double by 2050, from approximately 185 tons in 2018 to 430 tons.

Drug use is currently a major problem in Africa for political and health authorities. While cannabis abuse appears to have stabilized globally (prevalence: 3.4%), it continues to increase in Africa, where the current prevalence among individuals aged 15 to 64 [6]. A wide variety of illicit substances are present in West Africa, causing physical and mental health problems and other social issues [7] [8].

In Côte d'Ivoire, studies have been conducted addressing the problem of psychoactive substances. Each study revealed different determinants and indicators as well as several factors related to the use of these substances [9]. In addition, research has been conducted on the impact of psychoactive substances on alertness (electroencephalogram) [10] [11] but also on cognition, mainly on attention and memory [12] [13] [14]. However, no comparative study has been conducted on the effects of these different psychoactive substances. The objective of this work is therefore to compare the memory performance, mainly the working memory, of alcoholics, cannabis users, and poly-drug users.

I/ Materials and methods

1.1. Study setting and population

This study was conducted from March to June 2024 at the Croix Bleue reception center in Côte d'Ivoire. This center treats both alcoholics and illicit drug users.

The behavioral study involved 120 subjects (n=120), including 30 controls (abstinent individuals) and 90 patients admitted for treatment. The latter, divided into alcoholics (n=30), cannabis users (exclusive users of cannabis; n=30) and poly-drug users (users of different types of narcotics; n=30), were selected at random from among the patients registered at the center during the study period (Table 1). These patients, of both sexes, were aged between 16 and 49, with an average age of 24.02.

Inclusion criteria: subjects had to be admitted to the center during the study period, conscious, free of neurodegenerative diseases, able to follow specific instructions, and have given their written informed consent.

Materials

The material consisted of the Wechsler Adult Intelligence Scale Digit Span Test, Part 1, 3rd edition (WAIS III).

1.2. Methods

1.2.1. Assessment of memory skills in drug users: working memory

The Wechsler Adult Intelligence Scale Digit Span Test, Part 1, 3rd edition (WAIS III) is a subtest consisting of two series of exercises. The first (forward order) consists of 16 items comprising numbers to be repeated in the order presented by the experimenter. The second (reverse order) consists of 14 series of numbers to be repeated in reverse order of presentation by the experimenter (see Appendix 2) . The subject is seated comfortably in a chair. They are asked to repeat series of numbers in forward order (in the same order as the examiner). The number of numbers presented for recall increases with each successful attempt. The series stops after two failed attempts at the same item. This test assesses the subjects' immediate memory [15]. The second part of this test assesses working memory. It is carried out under the same conditions. The numbers are recalled in reverse order to that given by the experimenter. Here, however, two attempts are made for each item, even if the first attempt was successful. The series ends after two failed attempts at the same item. The control subjects undergo the same test. The scoring principle remains the same in both tests:

- 0 points for a failure;
- 1 point for a correct answer. The tests are conducted in the morning (9 a.m.) to minimize the effects of fatigue (physical and mental).

For this study, only the 14-item reverse order recall subtest, which assesses working memory, was used.

Each subject underwent three (3) assessments: before treatment, during treatment (midway), and after treatment.

1.1.2. Data processing

The data collected in this thesis were processed using GRAPHPAD software. The analysis of the memory performance of each group as a whole was compared with the other groups. It is therefore necessary to verify the significance of the probable e differences observed between the performance of drug addicts and that of controls in the digit memory test of the Wechsler Adult Intelligence Scale, 3rd edition (WAIS III). In other words, the aim is to determine whether the difference in performance values between the groups is significant or not. Comparisons were made using analysis of variance (ANOVA). The significance value considered is the probability (p) of 0.05. Thus, if "p" is less than or equal to 0.05, then the difference between the variables compared is significant. On the other hand, if "p" is greater than 0.05, then the difference between the two variables compared is not significant.

II/ Results and Discussion

2.1. Results

2.1.1. Results of the observational study

During the three months of our study, 118 patients were admitted to the Blue Cross Center for treatment (detoxification) (Table I). Patients with multiple drug addictions (Figure 1) were the most numerous (42%), followed by cannabis users (31%). Our work reveals that it is increasingly difficult to find individuals who consume only alcohol (27%).

The overall distribution of these patients by gender shows that , 87.29% of patients are men and 12.71% are women. The details of this distribution, including the type of drug addiction, are shown in Figure 2. In addition, the distribution of patients by age indicates that 57.04% of the patients in this study are adolescents and 42.96% are adults. The details of this intergenerational distribution, including the type of drug addiction, are shown in Figure 3. Our observational study reveals another important fact. Namely, that all alcoholics (100%) are adults over the age of 34. However, 80% of cannabis users are adolescents and 20% are adults, while 62.5% of poly-drug users are adolescents and 37.5% are adults.

Table 1: Patients admitted for treatment for substance abuse during the study period

DRUGS PATIENTS	ALCOHOL DEPENDENT	CANNABIS ADDICTS	MULTIPLE SUBSTANCE ABUSE	TOTAL
BOY	27	29	47	103
GIRL	3	5	7	15
TOTAL	**30**	**34**	**54**	**118**

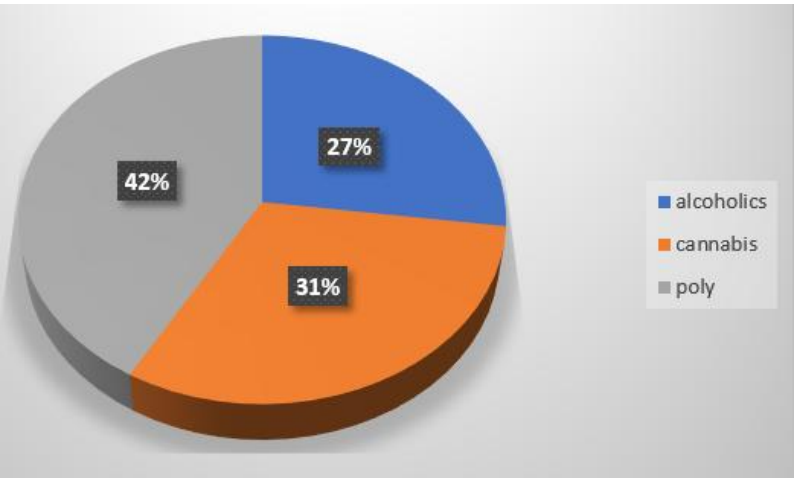

Figure 1: Distribution of subjects according to substance used

The majority of psychoactive substance users are poly-drug users

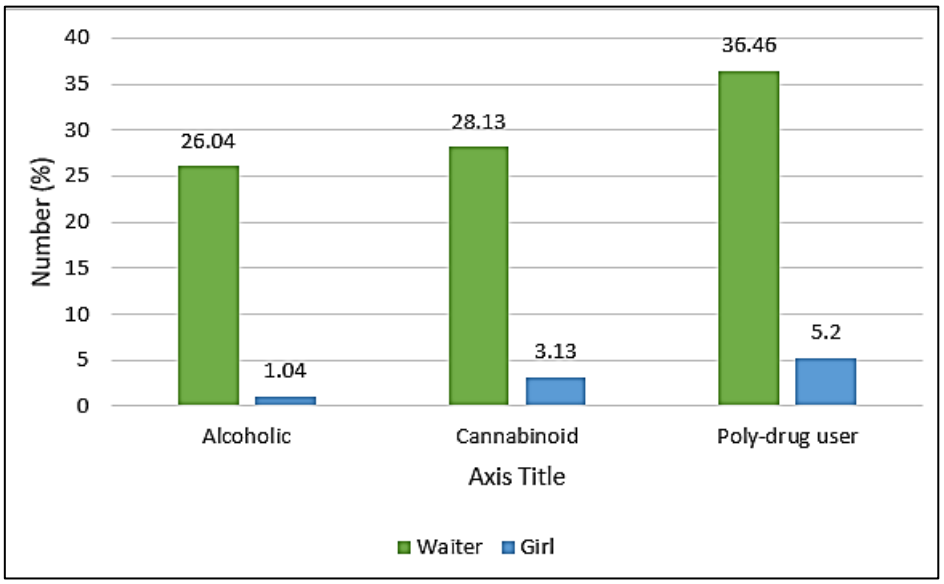

Figure 2: Distribution of subjects registered at the Blue Cross reception center during the study period according to gender

Drug addiction in Côte d'Ivoire is strongly influenced by gender, with boys being more affected.

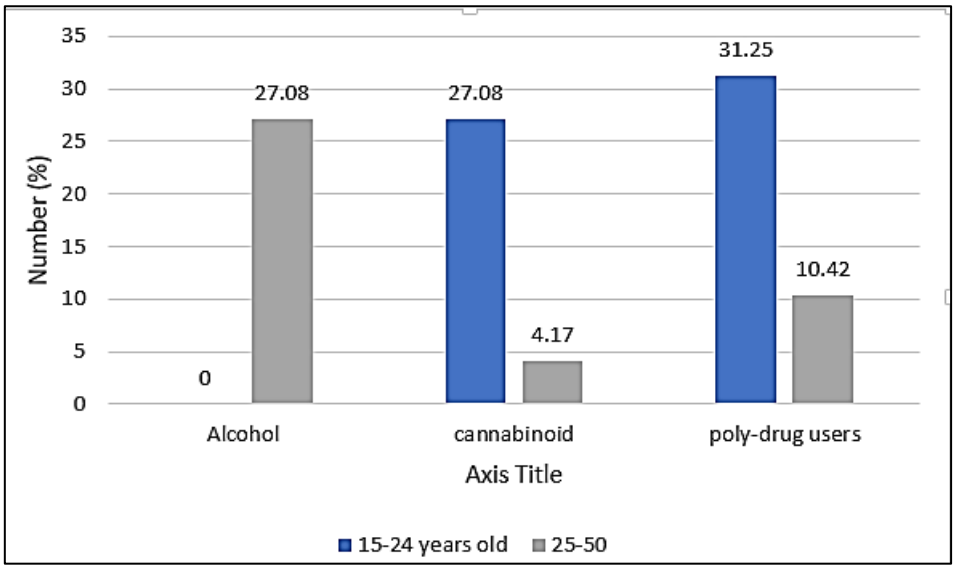

Figure 3: Distribution of subjects registered at the Blue Cross reception center during the study period according to age group

Adults are more attracted to alcohol than adolescents, who have a preference for narcotics when it comes to addiction.

2.1.2. Memory performance of different types of subjects before treatment ( ) (withdrawal)

Our work indicates that the memory performance of the control subjects is significantly superior to that of all the test subjects. Comparisons between the different groups give F (3,106) =142.8 for p=0.0001 (SA), F(4,05)=254.58 for p=0.000053 (SC), F(3,56)=155.02 for p=0.0006 (Figure 4). Comparisons between the different test groups also show that there is a significant difference only between the performance of alcoholics and cannabis users, as F(2,95)=150.3 for p = 0.0342 (SP # SC).

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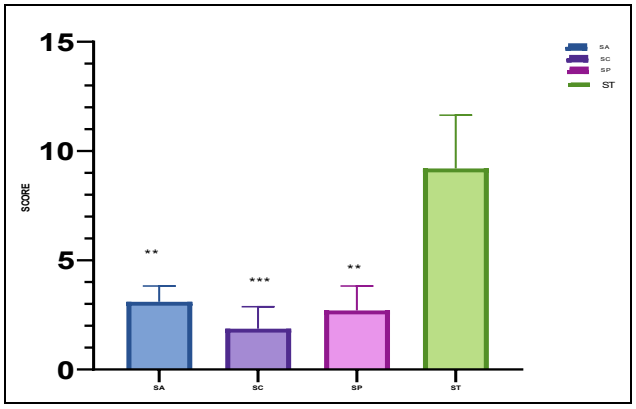

Figure 4: Evaluation using the WAIS III test (reverse order) of the working memory of the different groups of subjects before treatment (withdrawal)

SA: Alcohol-dependent subjects

SC: Cannabis-dependent subjects

SP: Poly-drug users

ST: Control subjects

*: significant; **: very significant; ***: highly significant

All three groups of subjects have significantly lower memory performance than the control subjects (abstinent subjects). However, the impairment is even more pronounced in cannabis-dependent patients.

2.1.3. Memory performance of the different groups of subjects dur -treatment (Figure 5)

The results reveal that SA subjects show a significant improvement in their working memory ($F(3,124)=73.51$; $p=0.012$). They also have the highest memory performance of the test subjects. However, this performance remains significantly lower than that of the control subjects, since $F(3,163)=75.51$ for $p=0.0051$. Our study also indicates no improvement in the performance of the SC subjects, unlike the SP subjects. However, this improvement is not statistically significant ($F(5,60)=97.21$; $p=0.82$).

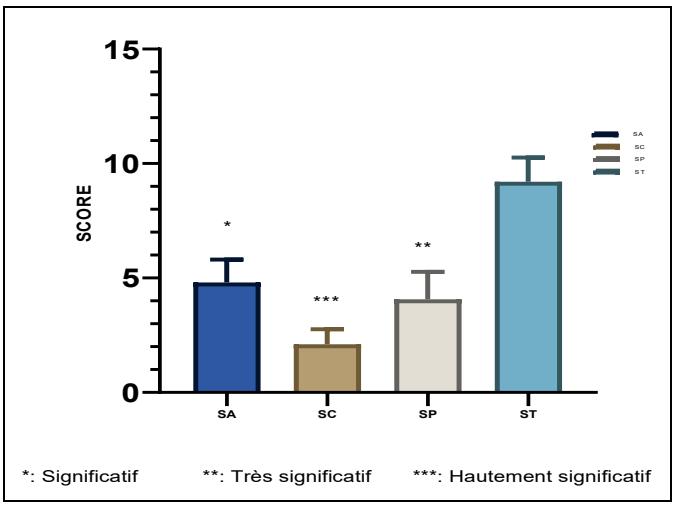

Figure 5: Evaluation using the WAIS III test (reverse order) of the working memory of the different groups of subjects during (mid-term) treatment

There was an improvement in the memory performance of alcohol-dependent and poly-drug-dependent subjects. However, this was not the case for cannabis-dependent patients. Nevertheless, the performance of all test subjects remained significantly lower than that of the control subjects.

2.1.4. Memory performance of the different groups of subjects after withdrawal (Figure 6)

Our work indicates a very significant improvement in SA subjects compared to their performance before treatment ($F(3,108) = 151.1$; $p = 0.006$). In addition, improvements were also recorded in PS and SC subjects, although these were not statistically significant [($F(5,101) = 65.12$; $p = 0.96$) for SC and ($F(4,65) = 79.3$; $p = 0.089$) for PS]. The performance of SC subjects remains the lowest.

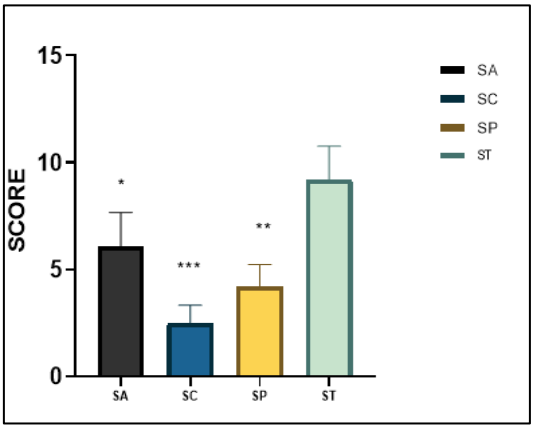

Figure 6: Assessment of working memory in different groups of subjects after treatment using the WAIS III test (reverse order).

There was virtually no improvement in memory performance among cannabis users, unlike poly-drug users and especially alcoholics, among whom a significant improvement was noted. Nevertheless, their working memory remained significantly lower than that of the control subjects.

2.2. Discussion

The first, observational part of our study revealed that girls are significantly less likely to be admitted for detoxification treatment. This result is consistent with those of **Beck** [16] and **Diboh** [8], who showed that drug use particularly affects men and that the differences observed between the sexes increase with age. There is a strong link between psychoactive substance use and age. According to **Choquet** [17], age is a discriminating factor in drug use. The significantly higher rate of use among 15- to 21-year-olds compared to 22- to 50-year-olds could be explained by the circulation of drugs in secondary schools, particularly those attended by children from wealthy families. Most of the alcoholics admitted to this center are adults. These results are consistent with those of **Yao** [18]. The latter also indicate that the most commonly consumed alcoholic beverage among this type of patient is koutoukou. This is a traditional local drink made from the distillation of fermented oil palm sap (*Elaeis guineensis Jacq.*). Cannabis remains the most commonly used illicit psychoactive substance. The majority of poly-drug users also use cannabis. This product appears to be the gateway to drug addiction. Our work is consistent with data from **Diboh** [8] **and the WHO** [3]. According to these sources, the most commonly used drugs in Côte d'Ivoire are, in order, cannabis (79.52%), opiates (11.81%), cocaine (7.08%) and crack (1.57%).

The behavioral study revealed that all three types of patients have significantly impaired working memory. This memory could be defined as a set of cognitive processes that keep information available for any task involving mental processing. This memory is mainly assessed using a reverse memory span test, which consists of recalling a series of words in reverse order [19]. It enables complex cognitive processing of temporarily stored elements (following a conversation, doing mental arithmetic, immediately dialing a phone number, simultaneous translation by an interpreter, etc.). It is therefore constantly in use [20]. Working memory is sensitive to distraction and interference (information is then irretrievably lost). This memory is responsible for maintaining and temporarily processing information.

The difference in performance observed between test subjects and controls is thought to result from the effects of these psychoactive substances on cognitive processes in general and, in particular, on the neural circuits involved in the memorization process. The brain optimally analyzes all the information it receives that is associated with the task at hand. Such analysis can only take place if the brain's overall activity is at its maximum. Anxiety and insomnia are among the psychological problems that drug users may face

[21]. These problems (anxiety and lack of sleep) have a significant impact on memory skills [22]. Numerous studies have shown that substance abuse can negatively affect several cognitive functions, such as executive functions [23], verbal fluency [24] [25], and impulsivity [26]. Furthermore, the work of **Diboh** [15] shows that disturbances in alertness with altered EEG rhythms, as well as a significant reduction in short-term memory performance (immediate memory and working memory) occur in regular consumers of koutoukou (a local artisanal liquor) [15], but also in regular consumers of narcotics [27] [8]. According to **Costentin** [28], narcotics reduce blood flow and therefore oxygen supply to the hippocampus, while stimulation of CB1 receptors in the mitochondria (which produce ATP, the fuel for cells) disrupts the energetics of the hippocampus, with amnesic effects. The lasting impairment of memory functions leads to a decline in intellectual performance. Morphological imaging studies, particularly MRI, show that regular and prolonged cocaine use can lead to a reduction in the volume of the prefrontal and temporal cortex, which can persist for several weeks after withdrawal [29]. Clinically, this abnormality may correspond to attention and executive function disorders, with loss of inhibitory control, impaired judgment, and difficulty making decisions. Amphetamines and new drugs, such as cathinones (mephedrone), may have effects comparable to those of cocaine. Neurological complications from opiates are rarer. They are linked to overdoses, particularly of heroin. These complications may also be linked to the use of tobacco, alcohol, cannabis, or cocaine, which is very common among heroin addicts and patients on methadone. Prolonged heroin use can also lead to a reduction in the volume of the prefrontal and temporal cortex, which is reversible after withdrawal [30]. Alcohol consumption (especially strong alcohol) exacerbates the cardiovascular toxicity of cocaine, increasing blood cocaine concentration by 30% and leading to the formation of cocaethylene, a metabolite that is more toxic to the central nervous system and cardiovascular system than cocaine alone, with a long elimination time [31]. Sedatives also cause memory impairment, especially when used with alcohol [32].

Our work also shows that poly-drug users (users of mixtures of cannabis, alcohol, tobacco, and drugs) have significantly better memory performance (during and after treatment) than cannabis users.

In fact, the state of unconsciousness (drowsiness or sleep) caused by the acute effects of drugs such as cocaine, heroin, opiates, crack, etc., tends to lead to a temporary cessation of consumption, unlike cannabis, which does not cause overdose. This means that cannabis users consume it all day, every day, as needed, since it is widely available and very affordable. In addition, the fact that it does not cause overdose is an argument in favor of presenting it as a "non-drug" in order to attract other users. One of the functions of sleep is to restore certain physiological parameters [33], memory, and even the entire cognitive system [34]. Hence the expression "sleep is restorative." Thus, sleep following the use of certain narcotics would limit the damage to the nervous system in poly-drug users.

In the present study, cannabis users have the most impaired working memory. Recovery of this memory function after treatment is also more difficult and slower compared to poly-drug users and alcoholics. Our work is consistent with numerous data in the literature. Indeed, chronic cannabis use is significantly associated with cognitive disorders, particularly attention disorders, working memory, prospective memory, and episodic memory, with alterations in the encoding, storage, and retrieval of information [35]. These disorders are related to the dose, frequency, duration of exposure, and age of first use (increased risk if use began before the age of 15) [36]. Twenty-five years of exposure to cannabis irreversibly reduces IQ by 8 points [28]. The impact of cannabis use on the brain has been assessed in more than 40 brain imaging studies. The effects of cannabis result in a dose-dependent decrease in gray matter density in the hippocampus, parahippocampal regions, and amygdala in regular users (daily use over several years) [36].

Most cannabis users are adolescents. This confirms the work of **Salthouse** [37], which highlights the vulnerability of young people's brains, as they continue to develop and mature until adulthood, reaching peak capacity at the age of 22/25. Therefore, any disruption before the end of this period could cause cognitive disorders of varying severity. Memory disorders in cannabis users are directly induced by THC and its binding to CB1 receptors. Researchers have therefore established a link between episodic memory disorders and the presence of numerous CB1 receptors in the hippocampus, a key structure in the brain network involved in the functioning of this type of memory [38]. When inhaled (in the form of smoke), cannabis, particularly its THC compound, is rapidly absorbed into the bloodstream, reaching peak concentration within 7 to 10 minutes after inhalation begins, with effects lasting 5 to 12 hours after consumption has ceased [39]. Maximum blood concentrations depend on the THC content of the product consumed and how it is inhaled: inexperienced and occasional smokers absorb about 10 to 14% of the available THC, while regular users, who probably have more effective inhalation techniques for retaining smoke in the lungs for longer, absorb twice as much [40]. Due to its high fat solubility, it accumulates in adipose tissue, where it reaches peak concentrations in 4 to 5 days. Its storage and slow solubility increase its half-life and distribution to other areas, including the central nervous system. Thus, repeated cannabis use leads to the accumulation of THC in the central nervous system. The retention of THC by the body therefore results in the persistence of its effects. This persistence can be long-lasting: biopsies of adipose tissue have shown that cannabinoid derivatives can be released up to four weeks after the last consumption of cannabis [39]. The fat-soluble nature of THC, the existence of an enterohepatic cycle, and renal reabsorption contribute to the persistence of its effects [39]. According to **Kloft** [41], even after 53 days of abstinence, adolescents' working memory remains impaired, whereas the effects of cannabis in adults disappear after one month of abstinence.

Our work has also shown that alcoholics have the least impaired working memory of the patients tested. These subjects also recover this cognitive ability better after withdrawal, without however matching the performance of the control group. When alcohol consumption is stopped, the effects on cognitive functions gradually diminish over time. In fact, the impairments observed at the beginning of withdrawal are partially reversible when consumption is stopped. These same observations were made by **Diboh** [13]. Most of the alcohol-dependent individuals encountered during this study were adults. Their nervous systems are already mature, which somewhat reduces the impact of their addiction on this essential organ. However, it is accepted that regular or heavy alcohol consumption has deleterious effects on memory skills. Many people have experienced memory lapses during the post-alcoholization period after a night of heavy drinking. Hence the famous questions "what happened" or "how did I get here." **Pitel's** work [42] shows that chronic alcohol consumption causes more or less severe disorders in different components of memory**.** These include disturbances in working memory (which allows us, for example, to remember a phone number immediately after looking at it) and episodic memory (which allows us to remember events and project ourselves into the future). The toxic effects of alcohol on the brain can be demonstrated by medical imaging: in particular, a decrease in gray matter has been observed in people who are alcohol dependent. The earlier alcohol consumption began, the greater the alteration in gray matter [43].

In Côte d'Ivoire, several studies have been conducted on alcohol consumption, particularly on koutoukou (a traditional homemade spirit) consumed by a large part of the Ivorian population, adults [18] and even schoolchildren and students [44] due to its accessibility and relatively low cost compared to other so-called "industrial" alcoholic beverages. The residents of the Blue Cross are heavy consumers of this drink. It is obtained by distilling fermented sap from the oil palm "*Elaeis guineensis Jacq.*". According to **Camara** [45], this liquor contains propanol, butanol, methanol, and many other unidentified chemical compounds, in addition to ethanol, which is common to all other alcoholic beverages. These other alcohols, which are unfit for consumption (toxic), are thought to potentiate the effects of ethanol. This artisanal liquor also impairs alertness and causes the appearance of abnormal electroencephalographic (EEG) rhythms (theta and delta waves) associated with wakefulness, with the disappearance of the visual stop reaction (VSR) [11].

Furthermore, alcohol abuse is a risk factor in more than 200 diseases and injuries [46]. In fact, a number of diseases are directly attributed to it [47], including cirrhosis of the liver, certain cancers (esophagus, liver, etc.), and heart disease [48]. Numerous data in the literature indicate that excessive alcohol consumption is considered one of the most common causes of high blood pressure [49] [50]. Those who regularly consume large amounts of alcohol are at greater risk, as this causes changes in the tissue of the heart's atrium , which increases the risk of fibrillation. The main danger of atrial fibrillation is that it can lead to the formation of a clot in the atria and cause a stroke [51].

Conclusion

In this study, we set out to compare the memory performance of alcohol-dependent, cannabis-dependent, and poly-drug-dependent patients admitted for treatment at the Croix Bleu reception center (Ivory Coast). The results show that all three groups of subjects have significantly impaired working memory. However, cannabis users have the most impaired working memory. Furthermore, recovery of this memory function after treatment (withdrawal) is more difficult and slower in cannabis users than in poly-drug users and alcoholics. The latter group had the least impaired working memory and showed better recovery of this cognitive function after withdrawal, although they did not match the memory performance of the control group (abstinent subjects).

In light of this work, we recommend incorporating cognitive performance assessment into withdrawal protocols for better patient care and to encourage participation in sports. These results should also be widely disseminated to raise awareness among young people of the dangers facing drug users, as it is very difficult to influence the production and distribution of these drugs. On the other hand, it is possible to influence the target population, which is our youth.

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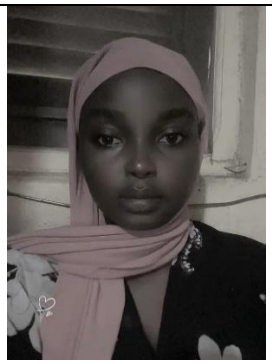	**Rahmata Aly** Neuroscience Research Unit, Biology and Health Laboratory, Biosciences Faculty, Félix HOUPHOUËT-BOIGNY University, Abidjan, Ivory Coast
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