GSC Biological and Pharmaceutical Sciences
eISSN: 2581-3250 CODEN (USA): GBPSC2
Cross Ref DOI: 10.30574/gscbps
Journal homepage: https://gsconlinepress.com/journals/gscbps/

(RESEARCH ARTICLE)

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Effects of Koutoukou (local artisanal liquor) on the short-term memory of young people in school (Côte d'Ivoire)

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GSC Biological and Pharmaceutical Sciences, 2025, 33(02), 474-483

Publication history: Received 18 October 2025; revised on 25 November 2025; accepted on 27 November 2025

Article DOI: https://doi.org/10.30574/gscbps.2025.33.2.0476

Abstract

Introduction: Alcoholism is one of the most significant health risks worldwide. Côte d'Ivoire, which has been in economic crisis since the 1980s, compounded by a political crisis, is no exception to this scourge. It is increasingly common to see students drinking alcohol in bars located dangerously close to schools, amid general indifference. They are increasingly turning to inexpensive alcoholic beverages such as Koutoukou (a traditional, artisanal brandy) which, in addition to the ethanol common to all alcoholic beverages, contains several other alcohols that are potentially harmful to health.

Objective: The aim of this study was to assess the effects of Koutoukou consumption on the immediate memory and working memory of young learners.

Methods: The memory skills of 111 adolescents and young adults (schoolchildren and students) who consume this beverage were assessed using the WAIS III test after a blood alcohol level of 0.8 g/l was induced.

Results and conclusion: The results show that immediate memory is impaired in occasional KTK (CO) consumers only after alcohol consumption. This is not the case for CR consumers. In the latter, this memory is significantly impaired regardless of the period of alcohol consumption (before/after alcohol consumption). The same observations were made regarding working memory, with the difference that these memory impairments are more pronounced in CR.

Keywords: Koutoukou Consumption; Young Learners; Immediate Memory; Working Memory

1. Introduction

Alcohol abuse is a real public health problem. Harmful alcohol use is a well-known risk factor for disability and premature mortality [1] . Alcohol is considered the third leading risk factor for mortality, after high blood pressure and tobacco use. Alcohol abuse kills 3 million people each year and accounts for more than 5% of the global burden of disease. Approximately 400 million people, or 7% of the global population aged 15 and older, suffer from alcohol-related disorders. Among them, 209 million people (3.7% of the global adult population) are alcohol dependent. In addition to deaths and health damage, alcohol consumption causes social problems [2]. The use of this substance by adolescents and young adults varies considerably between countries and cultures, and between different population groups within a country [3]. In Côte d'Ivoire, it is increasingly common to see young people drinking alcohol in bars located

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dangerously close to schools, amid general indifference [4]. Rural populations and those living in densely populated urban areas often use traditional (artisanal) methods to produce alcohol. This is how koutoukou, the subject of our study, occupies a prominent place in the drinking habits of Ivorians. It is produced by distilling the fermented sap of oil palms (*Elaeis guineensis* Jacq). In addition to the ethanol common to all alcoholic beverages, this drink contains methanol, propanol, butanol, and other higher alcohols [5]. These alcohols are unfit for consumption and dangerous to health [6] . Surveys conducted in Côte d'Ivoire by [7] Diboh reveal that, for economic reasons, these young people are consuming more and more koutoukou. As the central nervous system of adolescents and young adults is still developing, we set out to determine the possible consequences of consuming this artisanal liquor on certain cognitive abilities, particularly short-term memory (immediate memory and working memory).

2. Subject, Materials, and Methodology

2.1. Study setting and population

The study was conducted at the Neuroscience Laboratory of Félix Houphouët Boigny University in Abidjan (Ivory Coast), in a room isolated from any external influence, during the period from February 2024 to May 2024. Pupils and students (n=111, average age 20.8±3.4 and average weight 62.1±6.3) from eight schools in three districts of the city of Abidjan (Cocody, Abobo, and Yopougon) were selected after a preliminary survey to determine their level of alcohol consumption, mainly koutoukou. Three (3) groups of subjects were formed, including two (2) experimental groups (n=37 each) and one control group (n=37). Individuals who consumed less than or equal to (≤) four drinks per month and no more than four standard drinks on a single occasion were placed in the occasional consumers (OC) group. Those who reported consuming five or more drinks per week were classified as regular consumers (RC) of this beverage [8] [4].

The participants were non-alcohol dependent, male, and sober for at least 24 hours (h). They were selected after verification of their medical history and health status. To this end, the heart and liver status of the selected individuals was assessed by measuring blood transaminase levels. Individuals with hypersensitivity to alcohol, metabolic disorders, or apparent cognitive disorders were excluded.

2.2. Equipment

The equipment used mainly consisted of:

- A bathroom scale;
- A gay-lussac centesimal alcoholometer used to measure alcohol content;
- A graduated test tube used to measure the quantity of koutoukou;
- A drinking glass;
- Koutoukou;
- An electronic blood pressure monitor with cuff for measuring (monitoring) blood pressure and pulse;
- A memory test using the wechsler adult intelligence scale 3rd edition (wais iii) (see appendix.

2.3. Methods

2.3.1. Preparation and consumption of alcohol

On the day of the test, participants were required to have been sober for at least 24 hours and to have fasted for at least 8 hours to allow for rapid alcohol absorption [9][10]. 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 body weight of the subjects is determined using a weighing scale. This, together with the alcohol content, was used to determine the volume of koutoukou 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 [11]. This formula takes into account the weight and sex (male or female) of the subject.

Thus, let A be the approximate blood alcohol level 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:

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

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 consumed

0.8 = density of ethanol.

The desired blood alcohol level being 0.8 g/l, the volume of alcohol to be ingested is:

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

2.3.2. Assessment of the memory skills of subjects under the influence of Koutoukou: immediate memory and working memory

The WAIS III digit memory test is a subtest consisting of two series of exercises. The first (forward order) consists of 16 items composed of digits to be repeated in the same order as the experimenter. The second (reverse order) consists of 14 series of digits to be repeated in reverse order to that of the experimenter (see appendix).

Immediate memory assessment

The subject is then seated comfortably in a chair. An initial assessment is carried out before alcohol is ingested. The examiner asks the subject to repeat a series of numbers in forward order (in the same order as the examiner) at a rate of one number every 2 seconds. The number of numbers presented for recall increases as correct answers are given. The series stops after two failed attempts at the same item.

After this stage, the experimental subjects (CO and CR) have 3 minutes to consume a quantity of Koutoukou equivalent to a blood alcohol level of approximately 0.8 g/l. Memory capacity measurements are taken under the same conditions as before alcohol consumption, at the same intervals (every 15 minutes for 90 minutes after alcohol consumption). The control subjects (n=37) participate in the same tests, with the only difference being that they do not consume alcohol.

2.3.3. Working memory assessment

This was carried out under the same conditions as before (immediate memory). However, the numbers were recalled in reverse order to that given by the examiner. In this subtest, both trials of each item were carried out, even if the first trial was successful. The series ended after two failed attempts at the same item.

All tests were conducted in the morning (9 a.m.) to minimize the effects of fatigue (physical and mental).

2.3.4. Data collection

For each subtest, the element taken into account is the score obtained on each trial. To this end, the scoring rule is the same for both tests:

0 points for a failure;

1 point for a correct answer.

Variables

- There were two types of variables in this study:

- classification variables, which are consumer categories (CO; CR);
- dependent variables, which are the scores for each of the WAIS III subtests.
- Free consent: The informed consent of each participant was obtained in advance.

2.4. Statistical data processing

The data collected were processed using STATISTICA® 10.0 software. For each series of experiments, the three groups of subjects were compared: control subjects, occasional Koutoukou users (CO), and regular Koutoukou users (CR). The aim was to analyze the overall memory performance of each group and then compare it with the other groups. It was therefore necessary to verify the significance of the probable differences observed between the averages of the measurements obtained in each group and at different periods of alcohol consumption. In other words, the aim is to determine whether, at each stage of alcohol consumption, the difference in performance values between the groups is significant or not. To do this, an analysis of variance (ANOVA) was used to make these comparisons every 15 minutes. A probability (p) of 0.05 is considered the threshold for significance. Thus, if "p" is less than or equal to 0.05, then the difference between the compared variables is significant. On the other hand, if "p" is greater than 0.05, then the difference between the two compared variables is not significant.

3. Results

3.1. Evaluation of immediate memory

Figure 1 shows the evolution of the performance of the different groups of subjects under acute alcohol intoxication during the exploration of immediate memory.

3.1.1. Before alcohol consumption

Before ingesting Koutoukou, the memory performance of the CO subjects was almost identical to that of the controls (Figure 1). To this end, the comparison gives $F(1,39)=0.003$ for $P=0.95$. However, there is a significant difference between the performance of CR subjects and that of controls [$F(1,46)=4.27$; $p=0.04$]. The comparison between the performance of the two experimental groups (CO and CR) shows no significant difference, as $F(1,43)=3.06$ and $p=0.08$.

3.1.2. After alcohol consumption

Fifteen minutes after alcohol consumption, intergroup comparisons all yielded values of $p>0.05$. Consequently, there was no significant difference between the performances of the three groups in this study.

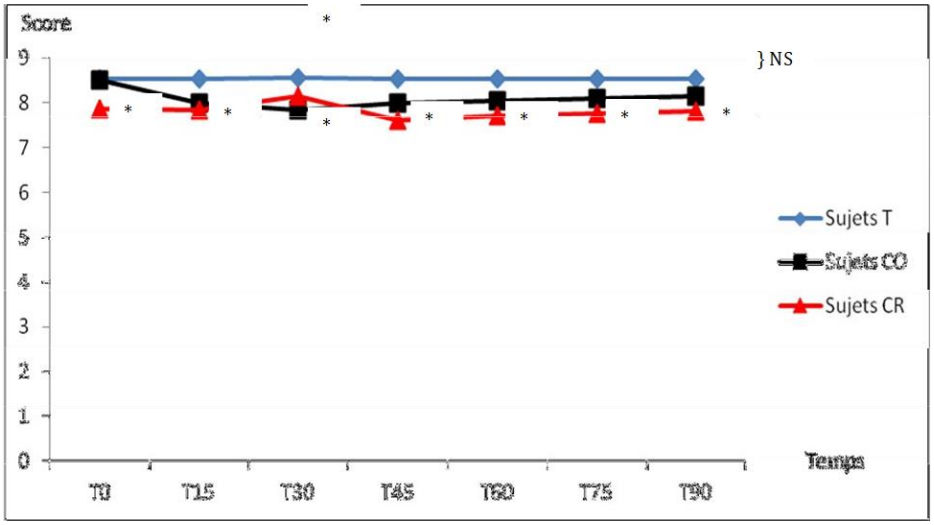
Thirty minutes after alcohol consumption, the CO subjects recorded their lowest scores, unlike the CR subjects, who obtained their highest scores in this test. In terms of intergroup comparison, the performance of the CO subjects differed significantly from that of the controls [$F(1,39)=3.90$; $p=0.05$]. In contrast, the performance of the CR subjects did not differ significantly from that of the controls [$F(1,46)=1.24$; $p=0.27$]. Similarly, the comparison of performance between the CO and CR subjects showed no significant difference ($F(1,43)=1.21$; $p=0.27$).

Forty-five minutes after alcohol consumption, the performance of the two test groups (CO and CR) differed significantly from that of the control group, with the comparison yielding $F(1,39)=5.56$ for $p=0.02$ and $F(1,46)=6.47$ for $p=0.014$, respectively. However, the comparison between the two experimental groups did not reveal any significant difference [$F(1,43)=0.94$; $p=0.33$].

Sixty minutes after ingesting Koutoukou, only the CR subjects performed significantly differently from the controls, with $F(1.46)=5.30$ and $p=0.025$. However, there was still no significant difference between the experimental groups [$F(1.43)=1.13$ and $P=0.29$].

Seventy-five minutes after taking the brandy, the findings were almost the same as previously (T60). The performance of the CO subjects was relatively close to that of the T subjects ($F(1,39)=2.83$; $p=0.10$) and the CR subjects ($F(1,43)=1.75$ for $p=0.19$). However, the performance of the CR group was significantly lower than that of the T group ($F(1.46)=7.85$; $p=0.017$).

Ninety minutes after consuming Koutoukou, CR subjects still had significantly lower memory performance than controls [$F(1,46)=8.40$; $p=0.036$]. The effects of alcohol appear to be attenuated in the CO group, as their performance is not significantly different from that of the controls, with $F(1,39)=1.99$ and $p=0.17$. Analysis of performance between the two experimental groups indicates that there are no significant differences ($F(1,43)=2.56$; $p=0.11$).



Comparisons of intergroup performance show no significant differences, except between CO subjects and controls at T 30. However, CR performance is significantly lower than that of controls (T) regardless of the period of alcohol consumption (before or after alcohol consumption; NS: not significant; *: Significant

Figure 1 Assessment of students' immediate memory in the WAIS III test (in direct order) according to the period of alcohol consumption

3.2. Working memory assessment

3.2.1. Before alcohol consumption

Figure 2 shows the evolution of performance in the different groups of subjects under acute alcohol intoxication during working memory testing.

3.2.2. Before alcohol consumption

Before alcohol consumption, the performance of occasional Koutoukou consumers (OC) and that of the control group (C) were identical. However, the comparison between regular consumers (RC) of this beverage and the control group yielded F(1.46)=6.95 and p=0.01: the difference is therefore very significant. Similarly, the comparison between the two test groups indicates a very significant difference in performance, as F(1,43)=5.92 for p=0.01.

3.2.3. After alcohol consumption

Fifteen minutes after alcohol consumption, a decline in performance was observed in the CO subjects compared to the controls. The difference was significant (F(1,39)=4.14; p=0.04). It was also noted that the CR subjects performed significantly worse than the T subjects (F(1,46)=15.13 for P=0.003), followed by the CO subjects (F(1,43)=4.64 for p=0.03).

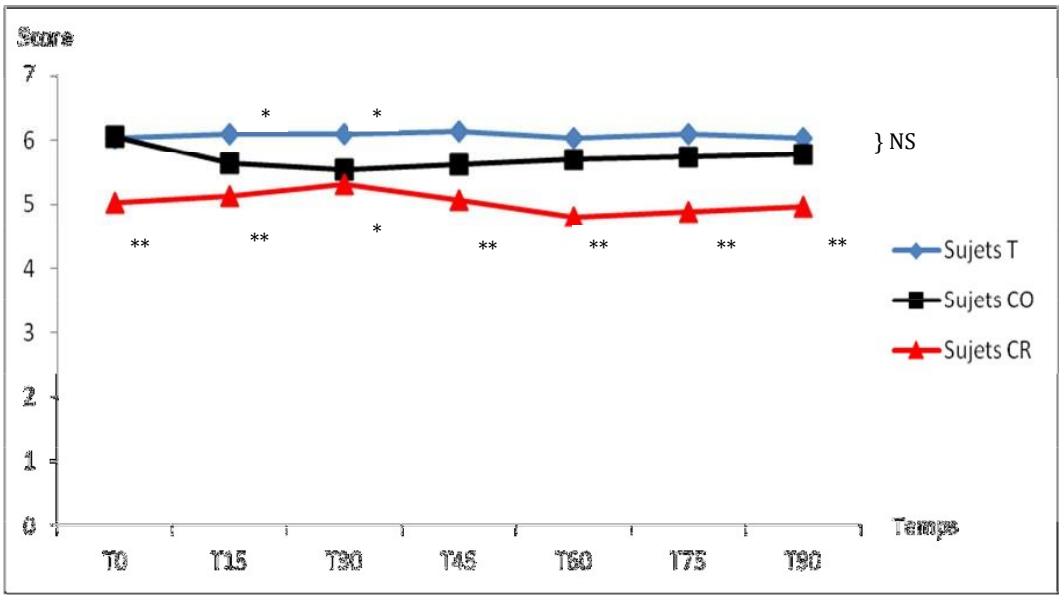
Thirty minutes after alcohol ingestion, the CO subjects recorded their lowest performance in this test. Comparison with the control subjects gives F(1,39)=5.62 and p=0.02: the difference is therefore significant. Conversely, at the same time (^{30}minutes), the CR subjects recorded their best scores. Nevertheless, the difference with the control subjects' performance remains very significant, as F(1,46)=11.45 and p=0.001. The CO and CR subjects' performance is similar. In this regard, the comparison gives F(1,43)=1.38 for p=0.24: the difference is therefore not significant.

Forty-five minutes after alcohol consumption, the CO subjects began to return to normal (T0 value). The comparison between the CO subjects and the control subjects gives F(1.39)=2.29 and p=0.14: this difference is not significant. However, the performance of the CR subjects differed significantly from that of the controls (F(1.46)=15.29 and p=0.003). With regard to the test subjects' (CO and CR) , the comparison revealed that the difference observed in Figure 2 was not significant (F(1.43)=3.14; p=0.08).

One hour after consuming Koutoukou, the results of this test indicate a return to normal among the CO subjects. However, their performance is still lower than that of the T subjects. However, the difference is not significant (F(1,39)=1.26 and p=0.26). The CRs recorded their lowest performance. The scores recorded in the two experimental groups reveal a very significant difference in favor of the COs (F(51,43)=6.95; p=0.01).

Seventy-five minutes after alcohol consumption, the return to baseline values (T0) is even more pronounced in the CO group. In contrast, the working memory of the CR group still appears to be significantly impaired. Comparison of performance with that of the controls indicates a very significant difference ($F(1,46)=18.78$; $p=0.0008$). The same is true for the comparison between CO and CR ($F(1,43)=8.09$; $p=0.006$).

Ninety minutes after ingesting the brandy, the performance of the COs was closer to that of the controls ($F(1,39)=0.76$ for $p=0.38$). In contrast, the performance of the CR group remained significantly different from that of the control subjects [$F(1,46)=15.36$ and $p=0.0003$]. Furthermore, a significant disparity in performance between the two experimental groups was still observed ($F(1,43)=7.68$; $p=0.008$).



NS: not significant; *: Significant;**: highly significant

Figure 2 Assessment of subjects' working memory in the WAIS III test (in reverse order) according to the period of alcohol consumption

The scores of CR subjects are significantly lower than those of controls, regardless of the duration of alcohol consumption. The performance of CO subjects differs from that of controls only after ingesting Koutoukou.

4. Discussion

In this study, we set out to evaluate the effects of a blood alcohol level of 0.8 grams per liter of Koutoukou on students' short-term memory. This dose corresponds to the threshold for acute intoxication [12]. To this end, the memory performance of the control subjects was compared to that of occasional (OC) and regular (RC) Koutoukou consumers using the digit span test from the Wechsler Adult Intelligence Scale^{3rd}edition (WAIS III).

Before alcohol consumption (T0), the performance of RC subjects was significantly lower than that of OC subjects and controls. Indeed, it is accepted that regular or heavy alcohol consumption has deleterious effects on memory skills. The work of [13] Pitel show that chronic alcohol consumption causes varying degrees of impairment 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 recall events and project ourselves into the future). In addition, the work of Saltouse [14] highlights the vulnerability of young people's brains, as they continue to develop until adulthood, reaching peak capacity at the age of 22/25.

After alcohol consumption, CO subjects show a significant decline in performance from the fifteenth minute onwards, which is even more pronounced thirty minutes after alcohol consumption. This decline in memory performance would indicate a transient memory disorder, as confirmed by the work of [15] Apfelbaum. These authors show that alcohol reaches its maximum diffusion between 30 minutes and one hour after consumption. This rapid diffusion mainly affects the most irrigated areas, including the brain, which is the seat of memory [16].

Fifteen minutes is enough time for ethanol molecules to reach their target cells and produce their initial effects. Alcohol molecules are very small and dissolve easily in water and fat. As a result, they do not need to be broken down by digestive enzymes to enter the bloodstream, which explains how quickly they are absorbed [17]. Ninety minutes after consuming the traditional liquor, the performance of the two test groups, although still lower than that of the control group, was relatively similar in direct free recall, whereas the opposite was observed in reverse serial recall. Immediate memory appears to be less affected than working memory. Indeed, the latter, which is more complex than immediate memory, requires more attention and a certain mental flexibility [18]. This memory allows complex cognitive processing of stored information, following a conversation, performing mental calculations, dialing a phone number that has just been given, simultaneous translation by an interpreter, etc.

After reaching its peak during the first hour, it is clear that as alcohol is metabolized, the effects diminish during the following hour. Since the work of Widmark [11], the rate of ethanol degradation has been estimated at 0.15 g/liter/hour. The work of De Bruyn [19] shows that the rapid breakdown of ethanol leads to a return to normal alertness one hour after alcohol consumption. However, the persistent effects of Koutoukou could be due to its methanol and propanol content. Indeed, as the human body does not have a specific enzyme to metabolize other alcohols such as methanol and propanol, their degradation would occur through the same alcohol dehydrogenase, but at a slower rate than that of ethanol [20]. Our previous work [21] revealed disturbances in cortical activity (electroencephalographic abnormalities), with the appearance of abnormal EEG rhythms during wakefulness in regular consumers of this beverage, indicating brain damage.

Yao [22] state that 3 hours after adult subjects ingested 125 ml of Koutoukou palm wine, memory impairments were recorded. These observations confirm the hypothesis that artisanal palm wine Koutoukou contains other molecules capable of potentiating the effects of ethanol [23] by competing with alcohol dehydrogenase during metabolism. Thus, methanol, propanol, and other chemical elements contained in palm wine Koutoukou are believed to be the cause of the significant decline in performance over time in subjects who have consumed it. As mentioned by Camara [24], such chemical compounds have very pronounced effects on alertness levels, which are related to central nervous system activation levels on the one hand and performance levels on the other. The present study also revealed during the recall phase that most errors occurred in the middle items. Those presented at the beginning and end were better recalled. According to [25, 26], these phenomena correspond to the primacy and recency effects.

5. Conclusion

In this study, we set out to evaluate the short-term memory of young learners who consume koutoukou in the city of Abidjan (Ivory Coast). To this end, our work reveals that immediate memory is significantly impaired in occasional consumers (OC) of this spirit, only after alcohol ingestion. However, in regular consumers (RC) of this liquor, immediate memory is significantly impaired regardless of the period of alcohol consumption (before and after alcohol consumption). The same observations were made regarding working memory, with the difference that these memory impairments are even more pronounced in RC.

The work of numerous authors over more than a decade, including our own, has consistently shown the harmful effects on health of traditionally produced koutoukou. Furthermore, its low production and retail cost constitutes an additional danger. It should be noted that these results were obtained with a blood alcohol level of 0.8 g/l, which is the threshold for acute intoxication. In reality, as consumption is generally well above this level, this research highlights the extent of the danger facing our country's youth.

Recommendations

Koutoukou alcohol consumption does not seem to be on the decline, with growing poverty resulting from the socio-political difficulties facing Côte d'Ivoire. The alarm must be sounded through the wide dissemination of this research on koutoukou in order to raise awareness among all segments of the population. It would also be wise to regulate the production of koutoukou, provide technical assistance and state subsidies in order to obtain a higher quality alcoholic beverage, the danger of which would lie solely in its abuse. We also recommend tightening the law against the sale and consumption of alcohol by minors. Given that the human brain continues to develop until adulthood and reaches its peak capacity at the age of 22/25, the recognized toxicity of this beverage could seriously hinder the development of this essential organ.

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: WAIS III Test

WAIS III: DIRECT ORDER

Subject type: …… Gender:…… Age:…… … Weight:…… Va (ml) =……

Direct Order: (Immediate memory)

ITEM	TEST	REFERENCE NUMBERS		ANSWERS Score (0 or 1)	
				ANSWER	SCORE
1	Test 1	1-7.			
	Attempt 2	6-3.			
2	Attempt 1	5-8-2.			
	Test 2	6-9-4.			
3	Test 1	6-4-3-9.			
	Test 2	7-2-8-6.			
4	Test 1	4-2-7-3-1.			
	Test 2	7-5-8-3-6.			
5	Test 1	6-1-9-4-7-3.			
	Test 2	3-9-2-4-8-7.			
6	Test 1	5-9-1-7-4-2-8.			
	Test 2	4-1-7-9-3-8-6.			
7	Test 1	5-8-1-9-2-6-4-7.			

	Test 2	3-8-2-9-5-1-7-4.		
8	Test 1	2-7-5-8-6-2-5-8-4.		
	Test 2	7-1-3-9-4-2-5-6-8.		

Direct Order Total Score (Max = 14)

WAIS III: REVERSE ORDER

ITEM	**TEST**	**REFERENCE NUMBERS**	**RESPONSES Score (0 or 1)**	
			RESPONSE	SCORE
1	Test 1	2-4 (4-2)		
	Try 2	5-7 (7-5)		
2	Try 1	6-2-9 (9-2-6)		
	Test 2	4-1-5 (5-1-4)		
3	Test 1	3-2-7-9 (9-7-2-3)		
	Test 2	4-9-6-8 (8-6-9-4)		
4	Test 1	1-5-2-8-6 (6-8-2-5-1)		
	Test 2	6-1-8-4-3 (3-4-8-1-6)		
5	Test 1	5-3-9-4-1-8 (8-1-4-9-3-5)		
	Test 2	7-2-4-8-5-6 (6-5-8-4-2-7)		
6	Test 1	8-1-2-9-3-6-5 (5-6-3-9-2-1-8)		
	Test 2	4-7-3-9-1-2-8 (8-2-1-9-3-7 4)		
7	Test 1	9-4-3-7-6-2-5-8 (8-5-2-6-73-4-9)		
	Test 2	7-2-8-1-9-6-5-3 (3-5-6-9-18-2-7)		

Total Score Reverse Order (Max = 14)