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Episodic Memory and Memory Training: An Example in Moroccan Subjects Who Recite the Koran

Mouna Abouhalim[1], Ali Afarfar[2], Mohammed Faouzi Belahsen[1,3]

[1]Department of Neurology, Hassan II University Hospital of Fez, Fez, Morocco
[2]Faculty of Letters and Human Sciences, Sidi Mohamed Ben Abdellah University, Fez, Morocco
[3]Laboratory of Epidemiology, Clinical Research, and Health Community, Faculty of Medicine and Pharmacy, Sidi Mohammed Ben Abdallah University, Fez, Morocco
Email: mounafes@gmail.com

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Abstract

Objective: This study aims to investigate the effects of memory training and recitation as cognitive activity on episodic memory performance. We chose memorization of the Koran as a model. **Methodology:** two groups of 50 participants, matched by age, school level, and gender were compared. The experimental group memorized the entire Koran and recited it regularly. Subjects with a history of psychiatric or neurological disorders, as well as those with hearing, visual, or language impairment were excluded from the study. To assess episodic memory in both groups, we administered the Reduced Memory Efficiency Battery 84. **Results:** Statistical data showed that participants who memorized and recited the Koran obtained better performance in episodic memory compared to the control group. **Conclusion:** This study demonstrates the beneficial effect of memorizing the Koran as a cognitive training activity characterized by repetition and retention on episodic memory performance. Further research is necessary to explore the impact of such memorization activities on various aspects of cognitive functioning and their underlying mechanisms.

Keywords

Memory, Episodic Memory, Memory Assessment, Cognitive Activity, Repetition, Cognitive Performance, Koran, Comparison, Memory Impairment

1. Introduction

Cognitive science places a significant emphasis on studying memory for two

primary reasons. Firstly, this cognitive function ranks among the most intricate abilities, susceptible to diverse psychological, physiological, and pathological changes of organic or functional origins. Secondly, there has been a recent surge in the prevalence of memory-related disorders, particularly in the context of neurodegenerative diseases such as Alzheimer's Disease.

The concept of episodic memory, introduced by Tulving (1972) in 1972, defines it as a system encompassing events and memories constituting an individual's personal history. Its principal function involves encoding, storing, and retrieving information while retaining its spatiotemporal context—a crucial component facilitating information retrieval. Issues in encoding or retrieving context inherently affect the quality of information encoding and retrieval. Consequently, difficulties in encoding or retrieving the context inevitably impact the information encoding and retrieval quality.

Encoding is the process of receiving sensory information and transforming it into a memory representation (Tulving, 1983), which is critical for efficient storage and retrieval. However, this memorization stage also depends on attentional resources that influence the selection of information based on predetermined goals (Newman & Lindsay, 2009). Following encoding, storage entails organizing and preserving information within long-term memory, dependent on specific changes in brain activity within hours of information acquisition Sleep plays a role in consolidating information by reactivating neural circuits related to daytime learning, occurring during deep sleep and rapid eye movement (REM) sleep. Sleep also helps reintegrate old representations with new information (Bermudez-Rattoni, 2010). Retrieval, the ability to access information stored in long-term memory (Rugg & Wilding, 2000), involves bringing stored representations to consciousness and includes re-composition, reactivation, and selection of grouped internal representations (Buchanan, 2007). Successful retrieval of information relies on accessing memory traces and choosing relevant information. Otherwise, various memory distortions can occur.

Episodic memory assessment uses various cognitive tests, including free recall, cued recall, and recognition tasks, to examine its different aspects. Numerous studies have focused on factors that may prevent or delay degenerative diseases affecting memory. Within this framework, several studies have identified protective factors against Alzheimer's disease, such as managing cardiovascular risk factors, regular physical exercise (Larson et al., 2006), and engaging in diverse physical and mental activities (Podewils et al., 2005).

This study aims to investigate the effects of memory training and recitation as cognitive activities on episodic memory performance, using Koran memorization as our model. Previous studies (Nosrati & Nouri, 2002; Al-Atlas, 2011) have explored memory performance by comparing participants who regularly memorize and recite the Quran with a control group. These studies found statistically significant differences favoring the participants who memorized the Koran.

2. Materials and Methods

This case-control study evaluates the impact of Koran memorization as a cognitive process on episodic memory performance. To assess this effect, we based our analysis on an assessment of two groups: an experimental group and a control group. All participants involved in the study were informed of the objectives and procedures, and they provided oral consent before undergoing the tests. Participants did not receive any financial compensation for their involvement.

2.1. Participants

Our sample included 100 participants. We selected 50 individuals who had memorized the entire Koran, regularly recited it, and agreed to participate in the study (experimental group). We then formed the control group matched as closely as possible in terms of gender, age range, and educational level. Participants have Moroccan nationality, are at least 18 years old, and have at least one year of schooling. However, we excluded persons suffering from disorders including hearing, visual, and language disorders, psychiatric, and neurological history. All participants were selected in Koranic schools, mosques, or universities. We divide these participants by age into four groups and three education levels. 44% of the participants are females, while 46% are males (Table 1).

To ensure that these participants had preserved overall cognitive functioning, we administered the Moroccan version of the Mini-Mental State Examination (Folstein et al., 1975; El Alaoui Faris et al., 2003) before each assessment. Participants scoring below 23 out of 30 were excluded from the study.

Data from the table shows that the number of participants in the control and experimental groups differs across the mentioned demographic categories. This is due to the difficulties we encountered during the recruitment of participants for the experimental group. However, the statistical analysis of these differences showed non-significant results, indicating that the two groups were overall homogeneous.

Table 1. Participants distributed by age, educational level, and gender.

		Experimental group	Control group	Total	Chi 2	*p*
Distribution of participants by age	Age group 1: 18 - 29 years	15	17	32	0.39	0.94
	Age group 2: 30 - 39 years	10	11	21		
	Age group 3: 40 - 49 years	12	10	22		
	Age group 4: 50 years and over	13	12	25		
Distribution of participants by education level	Level 1: Primary	19	13	32	2.49	0.25
	Level 2: Secondary	19	18	37		
	Level3: university	12	19	31		
Distribution of participants by gender	Women	22	16	38	1.52	0.30
	Men	28	24	62		

2.2. Procedure

To comprehensively evaluate episodic memory, we administered the Reduced Memory Efficiency Battery 84 (BEM-84) (Signoret, 1991a). This abbreviated version of the Memory Efficiency Battery 144 (Signoret, 1991b) assesses encoding, storage, and retrieval abilities for both visual and auditory information. It consists of eight tasks:

- Presentation of 24 figures for delayed recognition: Participants are presented with 24 figures that have no inherent meaning and are asked to memorize them for later identification among other figures.
- Immediate recall of a story: A story composed of 12 sentences is read aloud, and participants are asked to immediately repeat it with all its details.
- Immediate recall of a complex geometric figure: A geometric figure is presented to the participant for one minute, after which they are asked to reproduce it immediately without looking.
- Immediate recall of a list of twelve words: The examiner reads a list of 12 words, and the participant is asked to repeat them without regard to their order.
- Delayed recall of the story.
- Delayed recall of the complex geometric figure.
- Delayed recall of the list of twelve words.
- Delayed recognition of 24 figures: Participants are asked to recognize the 24 figures they saw at the beginning of the test among other figures that were not presented.

2.3. Test Adaptation

Since the original version of the Reduced Memory Efficiency Battery is in French, we translated the various items into Standard Arabic. However, the story was translated into dialectal Arabic as we considered that memorizing a story in Standard Arabic would be more challenging. After this step, we conducted a pilot trial of the test with a sample of 10 participants who provided feedback and highlighted difficulties they encountered in understanding the instructions. This step resulted in the adaptation of the Arabic version and led to the modification and clarification of certain instructions.

2.4. Statistical Data Analysis

Data collection was followed by a statistical analysis conducted in two stages: 1) calculation and comparison of mean scores and their standard deviations, and 2) statistical analysis of differences between the scores obtained by participants from the two groups using analysis of variance (ANOVA) and p-values. This procedure was performed using SPSS 20 software.

This study respected ethical rules, and all participants gave their oral consent, after an explanation of the objectives and progress of different stages of the study.

3. Results

3.1. Effect of Age, Education Level, and Gender on Participants' Performance in the Test

1) Effect of Age (See Table 2)

Comparing the scores obtained by participants in our study across different age groups, we observe a decrease in scores with increasing age (See Table 3).

Table 2. Scores obtained by participants across different age groups.

		Number	Mean scores	Standard Deviation
On the overall sample	Age group 1	32	57.87	11.35
	Age group 2	21	55.57	10.06
	Age group 3	22	50	15.87
	Age group 4	25	46.44	9.62
On the experimental sample	Age group 1	16	62.32	9.32
	Age group 2	10	55	11.31
	Age group 3	12	56.7	11.71
	Age group 4	12	47.80	9.72
On the control sample	Age group 1	17	55.44	11.31
	Age group 2	11	56.09	10.50
	Age group 3	10	41.70	16.54
	Age group 4	12	47.80	9.75

Table 3. Statistical analysis of differences between the mean scores of the four age groups.

	Overall sample		Experimental sample		Control sample	
	F	*p*	F	*p*	F	*p*
Comparison between the 1st and 2nd age groups.	0.03	0.86	0.21	0.07	0.17	0.53
Comparison between the 1st and 3rd age groups.	1.86	0.17	2.05	0.17	1.5	**0.03**
Comparison between the 1st and 4th age groups.	16.42	**0.000**	0.004	**0.000**	0.14	**0.04**
Comparison between the 2nd and 3rd age groups.	2.51	0.12	1.87	0.71	1.95	**0.02**
Comparison between the 2nd and 4th age groups.	1.94	0.17	0.12	0.08	0.007	**0.01**
Comparison between the 3rd and 4th age groups.	0.86	0.35	1.56	**0.04**	0.57	0.59

The statistical analysis of the differences between the age groups reveals the following results:

- For the overall sample: a significant difference between Group 1 and Group 4 ($p = 0.000$).
- For the experimental group: a significant difference between Group 1 and Group 4 ($p = 0.000$), and between Group 3 and Group 4.
- For the control group: a significant difference between Group 1 and Group 3 ($p = 0.03$), Group 1 and Group 4 ($p = 0.04$), Group 2 and Group 3 ($p = 0.02$), and between Group 2 and Group 4 ($p = 0.01$).

2) Effect of Education Level (See Table 4)

Analyzing and comparing the mean scores obtained for each educational level shows an improvement in scores with higher levels of education (See Table 5).

The statistical analysis of the observed differences between the three educational levels reveals the following:

- For the overall sample: a significant difference between primary and secondary levels ($p = 0.008$), primary and university levels ($p = 0.000$), and between secondary and university levels ($p = 0.012$).
- For the experimental group: a significant difference between primary and secondary levels ($p = 0.02$), and between primary and university levels ($p = 0.002$). However, the difference between secondary and university levels is not significant ($p = 0.42$).
- For the control group: a significant difference between primary and secondary levels ($p = 0.02$), primary and university levels ($p = 0.000$), and between secondary and university levels ($p = 0.001$).

3) Effect of Gender (See Table 6)

The gender-based analysis of the performance of the participants shows that women perform better on the test compared to men. These differences are significant for the overall sample ($p = 0.001$) as well as the experimental group ($p = 0.002$). However, we did not find significant differences between the scores obtained by women and men in the control group.

3.2. Comparison of Scores between the Experimental Group and the Control Group

1) Overall comparison (See Table 7)

We observe that participants in the experimental group achieved higher overall scores (M = 55.94) compared to those in the control group (M = 49.66). This difference is statistically significant ($p = 0.01$).

2) Comparison of scores based on age (See Table 8)

When comparing the scores of participants from both groups based on their age, we notice that for age groups 1 and 3, participants who recite the Koran have higher performances compared to the control group ($p = 0.02$). However, we did not find significant differences between the scores of the two groups regarding age groups 2 and 4.

Table 4. Mean scores with standard deviations of participants according to their educational levels.

	Education level	Number	Mean scores	Standard deviation
On the overall sample	level 1	32	45.25	11.24
	level 2	37	53.18	12.52
	level 3	31	60.12	9.38
On the experimental sample	level 1	19	49.94	10.07
	level 2	19	58.26	10.50
	level 3	12	61.62	9.77
On the control sample	level 1	13	38.38	10.34
	level 2	18	47.63	10.91
	level 3	19	59.21	9.12

Table 5. Statistical analysis of differences between the mean scores of the three educational levels.

	Overall sample		Experimental sample		Control sample	
	F	*p*	F	*p*	F	*p*
Comparison between level 1 and level 2	0.46	**0.008**	1.09	**0.02**	0.71	**0.02**
Comparison between level 1 and level 3	1.61	**0.000**	0.06	**0.002**	0.19	**0.000**
Comparison between level 2 and level 3	3.62	**0.012**	0.45	0.42	2.25	**0.001**

Table 6. Total scores between male and female participants.

	Gender	Number	Mean scores	Standard deviation	F	*p*
Overall sample	Femmes	38	57.92	13.30	11.17	**0.001**
	Hommes	62	49.66	11.12		
Experimental sample	Femmes	22	61.29	11.63	1.11	**0.002**
	Hommes	28	51.67	9.28		
Control sample	Femmes	16	53.09	14.05	0.27	0.19
	Hommes	34	48	12.33		

Table 7. Total scores obtained between the experimental group and the control group.

	Number of participants	Score averages	Standard deviation	**F**	***p***
Experimental group	50	55.94	11.40	6.62	**0.01**
Control group	50	49.66	13.05		

Table 8. Total scores obtained by participants based on age.

		Number of participants	Scores average	Standard deviation	F	p
Age group 1: 18 - 29 years	Experimental sample	15	62.32	9.32	0.27	**0.02**
	Control sample	17	53.44	11.31		
Age group 2: 30 - 39 years	Experimental sample	10	55	10.07	0.10	0.81
	Control sample	11	56.09	10.50		
Age group 3: 40 - 49 years	Experimental sample	12	56.7	11.71	0.64	**0.02**
	Control sample	10	41.7	16.54		
Age group 4: 50 years and over	Experimental sample	13	47.8	9.46	0.03	0.46
	Control sample	12	44.91	9.75		

3) Comparison of scores by education level (See Table 9)

It can be seen that the participants of the experimental group obtained higher scores than those obtained by the participants of the control group. These differences are significant for Level 1 (p = 0.002) and Level 2 (p = 0.008), and not significant for Level 3 (p = 0.49).

4) Comparison of scores based on gender (See Table 10)

When comparing the scores obtained by participants from both groups based on their gender, we noticed that women who recite the Koran have superior performances compared to the control group, with a significant difference (p = 0.05). However, the observed differences regarding men in both groups are not significant (p = 0.19).

5) Comparison of scores for different subtests

The reduced battery of memory efficiency 84 consists of four subtests: immediate and delayed recall of the story, immediate and delayed recall of the complex figure, immediate and delayed recall of a list of 12 words, and delayed recognition of 24 figures. The scores obtained by participants for these subtests are represented in Table 11, which shows higher scores among subjects in the experimental group compared to subjects in the control group. These differences are statistically significant for the recall of the complex figure (F = 5.49; p = 0.02) and the recall of a list of 12 words (F = 9.16; p = 0.003), and not significant for the recall of the story (F = 2.44; p = 0.12) and the delayed recognition of 24 figures (F = 1.52; p = 0.21).

6) Comparison of visual recall and auditory recall scores (See Table 12)

Visual recall indicates the total score for immediate and delayed recall of the complex figure and the delayed recognition of 24 figures, marked on a scale of 36 points. Auditory recall is the total score for immediate and delayed recall of the story and the list of 12 words, appraised out of 48 points. The comparison of performances between our two groups shows that participants in the experimental group have superior performances compared to participants in the control group in terms of visual recall (F = 5.11; p = 0.02) and auditory recall (F = 6.43; p = 0.01).

Table 9. Comparison of the total scores obtained by the participants according to the level of education.

		Number of participants	Scores average	Standard deviation	F	*p*
Primary level	Experimental sample	19	58.26	9.21	0.001	**0.002**
	Control sample	13	43.63	10.34		
Secondary level	Experimental sample	19	49.94	11.92	0.01	**0.008**
	Control sample	18	38.38	10.91		
University level	Experimental sample	12	61.62	11.5	0.52	0.49
	Control sample	19	59.21	10.22		

Table 10. Total scores obtained by participants based on gender.

		Number of participants	Average	Standard deviation	F	*p*
Female	Experimental sample	22	61.29	11.63	0.97	**0.05**
	Control sample	16	53.09	14.05		
Male	Experimental sample	28	51.67	9.28	4.2	0.19
	Control sample	34	48	12.53		

Table 11. Different subtest scores between the experimental group and the control group.

		Number of participants	Average	Deviation standard	F	*p*
Recall of story	Experimental sample	50	12.89	4.6	2.44	0.12
	Control sample	50	11.43	4.74		
Recall the complex figure	Experimental sample	50	16.88	4.29	5.49	0.02
	Control sample	50	14.79	4.62		
Recall of list of 12 words	Experimental sample	50	17.97	3.22	9.16	0.003
	Control sample	50	15.63	4.41		
Delayed recognition	Experimental sample	50	8.28	2.07	1.52	0.21
	Control sample	50	7.68	1.99		

Table 12. Visual and auditory recall scores between the experimental group and the control group.

		Number of participants	Average	Standard deviation	F	*p*
Visual reminder	Experimental sample	50	25.05	5.48	5.11	**0.02**
	Control sample	50	22.45	5.99		
Auditory recall	Experimental sample	50	30.86	6.94	6.43	**0.01**
	Control sample	50	27.06	8		

7) Comparison of immediate recall and delayed recall scores

Immediate recall corresponds to the total scores obtained in immediate recall

of the story, immediate recall of the complex figure, and immediate recall of the list of 12 words, scored out of 36 points. Delayed recall corresponds to the sum of scores for delayed recall of the story, delayed recall of the complex figure, delayed recall of the list of 12 words, and delayed recognition of 24 figures. **Table 13** shows the comparison of scores for these two recalls between the control group and the experimental group. The observed differences between the two groups are significant for immediate recall (F = 7.67; $p = 0.007$) and delayed recall (F = 5.81; $p = 0.018$), favoring the participants in the experimental group.

4. Discussion

This study aimed to investigate the effect of regular Koran memorization and recitation on episodic memory performance. To do so, we used the reduced battery of memory efficiency to assess the performance of a group of participants who regularly recite the Koran with that of a control group. We hypothesize that repetition and regular recitation of a text would have a positive effect on memory. In a study published in 2023, Plater et al. showed that the repeated encoding of a set of visual stimuli in memory leads to greater activation of representations in long-term memory, and improves cognition, especially at the level of the interaction between long-term memory and perception (Plater et al., 2023). Similarly, Hazar et al. have shown that repeated recitation of 28 rhyming sentences (224 words) resulted in fluent recall and better mastery of verbal material in kindergarten children (Eghbaria-Ghanamah et al., 2021).

However, the question of the transfer of the effects of cognitive training to untrained cognitive modalities is very interesting. Wang et al. measured the effect of 20 training sessions in working memory and selective attention on ERP (event-related potentials) indices, during untrained working memory and cognitive control tasks. The results of this research revealed a transfer of changes in brain activity induced by cognitive training to untrained cognitive tasks (Wang & Covey, 2020). In the same way, our study assumes that memorizing the Koran can improve memory performance during untrained cognitive tests. The choice of the Koran as a text memorized, repeated, and recited regularly is explained by the fact that there are no other texts that are recited in their entirety and repeated regularly in our socio-cultural context. One of the advantages of this study is that the participants in our experimental sample learned and recited the same text.

Table 13. Immediate recalls and delayed recalls scores between the experimental sample and the control sample.

		Number of participants	Average	Standard deviation	F	p
Immediate recall	Experimental sample	50	24.26	4.84	7.67	0.007
	Control sample	50	21.29	5.83		
Delayed recall	Experimental sample	50	31.65	6.71	5.81	0.018
	Control sample	50	28.22	7.48		

The analysis of the test results was conducted in several steps. First, we examined the effects of age, educational level, and gender on performance. Next, we compared the total scores of the test between the experimental and control samples. Finally, we compared the scores obtained by the participants from both samples regarding the different subtests and types of recall.

Analyzing the effect of age on the scores, we found that scores decrease in parallel with increasing in age. This result is consistent with other studies that have shown a negative effect of age on memory performance and a vulnerability of episodic memory that comes along with seniority (Poon, 1985; Poon, 1989; Mitchell, 1989; Desgranges et al., 1994). However, this effect is more pronounced in the control sample, where we found more significant differences between age groups compared to the experimental sample. This suggests that Koran memorization and regular recitation might mitigate the negative influence of age on episodic memory. A study by Belleville et al. (2018) implemented a two-month cognitive training program based on immediate and delayed episodic memory strategies and other cognitive tasks (dual-task, verbal organization techniques, and external memory aids) for older adults with mild cognitive impairment (MCI). The authors reported a significant effect on participants' memory and an aid in expanding the strategies individuals can use in everyday life for at least six months. Similarly, a literature review (Ruthirakuhan et al., 2012) highlighted that cognitive training can have a potentially durable positive protective effect in various cognitive domains. Additionally, it can contribute to the prevention of age-related cognitive decline and slow down the development of Alzheimer's disease. However, other research has shown that cognitive training sessions administered to older adults (memory, reasoning, and processing speed) did not have a positive influence on memory functioning during daily life, despite a modest effect on material recall and recognition for subjects with probable Alzheimer's disease (Cahn-Weiner et al., 2003) or a positive effect on processing speed and reasoning (Rebok et al., 2014).

Regarding the effect of the educational level on the participant's scores, we observed a positive influence on test performance. This finding aligns with several studies demonstrating the positive impact of education on memory performance (Poon, 1989; Signoret, 1991a; Lee et al., 2012; Guerrero-Sastoque et al., 2021). Some studies have specifically shown a positive effect of educational level on the verbal component of long-term memory (Pacaud, 1989) and particularly on episodic memory (Desgranges et al., 1994). In our study, the influence of educational level was more pronounced in the control sample than in the experimental sample, especially when comparing scores of participants with secondary education to those with university-level education. We can infer that Koran memorization may have a significant influence on memory performance that reduces the effect of educational level on scores obtained by the experimental group.

Regarding gender, we noticed that women obtained higher scores compared

to men. The question of gender's effect on cognition has been the subject of intense scientific debates. Some studies have shown significant differences favoring men in spatial rotation tasks (Linn & Petersen, 1985), while women outperform men in object location recall tasks (Voyer et al., 2007). A study by Halpern (2000) highlighted high performance in women compared to men in memory tasks involving several types of material (words, concrete images, faces, or narrative texts). In our study, the influence of gender is significant for the experimental sample, while it is not significant for the control sample. This could suggest that women improve their performance in episodic memory more than men during the process of memorizing the Koran. A study by Rahe et al. (2015) showed that a 6-week program of multidomain cognitive training had a significant effect on immediate and delayed memory and working memory in MCI patients in favor of women. Along the same lines, Raju et al. (2020) conducted a comparative study between women and men. The authors tested the effect of a brain training program on memory by the gender of participants using the Mini-Mental State Examination (MMSE). The results of this study highlighted a significant difference between the group of men and the group of women which shows that women improve their cognitive skills more after a brain training program.

The analysis of the total scores of the two samples of our study shows that the participants who memorized the Koran and who recited it regularly had better performance results compared to the control sample. As mentioned above, several studies have shown that cognitive training has a positive effect on cognitive and memory performance (Belleville et al. 2018); Ruthirakuhan et al., 2012; Kwok et al., 2013; Ngandu et al., 2015). Some studies have specifically concerned the memorization of the Koran. In a systematic review published in 2022, Che Wan Mohd Rozali et al. showed that listening and memorizing the koran improves physical and mental health and intellectual functioning (Che Wan Mohd Rozali et al., 2022). Nosrati & Nouri (2002), for instance, compared memory performance at the level of semantic memory and episodic memory between 3 groups of students: 60 students who were not Koran reciters, 60 who were in the process of memorizing the Koran, and another 60 who recite the Koran. The results showed significantly high memory performance in the group of students who memorized the Koran compared to the other two groups. A study by Al-Atlas (2011) also verified the effect of memorizing the Koran on memory. This study took into consideration that the memorization of the Koran involves two dimensions: spiritual and cognitive. The study was applied to 580 people of both sexes between the ages of 20 and 40, half of them were clerics who memorized the Koran. The comparison between the memory performances of the two groups was made using a questionnaire, a global cognitive assessment test, and a word recall test. Reem Al-Atlas highlighted significant differences in favor of subjects who recited the Koran at the level of all cognitive tests.

The comparison between the scores obtained by the participants of our two

samples for each age group revealed overall higher averages in the experimental sample. These differences are only significant for subjects aged 18 - 29 and 40 - 49. For the age groups where we did not find significant differences (30 to 39 years and 50 years and over), this is explained by the level of education which was higher in the control subjects. These age groups are not very matched according to school level (See Table 14).

Regarding the level of education, we found significant differences in favor of subjects who recite the Koran for primary and secondary education levels. These differences fade at the university level. It was found that as the level of education increases, the influence of Koran memorization on the performance of our sample on the test decreases. This finding conforms with the results of the Chinese study performed by Kwok TC and collaborators in 2013 (Kwok et al., 2013) which found that subjects with a lower level of education had a better response to cognitive training compared to subjects with a lower level of education.

The results of the women who recited the Koran were superior compared to those of the women in the control sample. This difference was not observed in men. We can explain this on the one hand by the fact that studies have shown that women improve their cognitive abilities more after cognitive training (Rahe et al., 2015; Raju et al., 2020).

This difference between men and women could also be linked to the strategies used in memorizing the Koran. In fact, for the majority of men in our experimental sample, the memorization of the Koran was based on the traditional, essentially visual technique of writing the verses several times on a slate. On the other hand, the women mainly used auditory strategies which consisted of reading aloud with vocal repetition. The hypothesis that the memorization strategy of the Koran influences memory performance could be the subject of other future studies.

Table 14. Distribution of participants in the experimental and control samples by age group and level of education.

		Primary level	Secondary level	University level	Total
18 - 29 years	Experimental sample	4	6	5	15
	Control sample	4	7	6	17
30 - 39 years	Experimental sample	**5**	3	**2**	10
	Control sample	**1**	3	**7**	11
40 - 49 years	Experimental sample	3	7	2	12
	Control sample	4	4	2	10
50 years and over	Experimental sample	**7**	3	3	13
	Control sample	**4**	4	4	12
	Total	32	31	37	100

The analysis of the different subtests showed that for the recall of the complex figure and the recall of a list of 12 words, the differences were significant in favor of the subjects who memorized the Koran, which was not the case for the recall of history and delayed recognition of 24 figures. These last two subtests are more complicated compared to the others. For the recall of the story, the subject is invited to evoke the different elements of the story taking into account their order, which is not the case for the recall of the list of 12 words. Similarly, the recognition of the 24 figures is the only subtest that does not contain an immediate recall phase which increases the depth of information encoding.

For the analysis of the different types of recall, the memorization of the Koran had in our study a positive influence on all types of recall (visual, auditory, immediate, and deferred).

Our study highlights the importance of cognitive activity especially memorization, repetition, and recitation to improve episodic long-term memory performance. However, there were limitations of our study. Firstly, there were difficulties in the field regarding the recruitment of participants for the experimental sample. Indeed, the majority of men who memorize the Koran in our research come from Koranic schools which recruit subjects with a primary education level. These difficulties negatively influenced the matching of the two study groups based on educational level. Secondly, our study had a time constraint that prevented us from studying the neurophysiological mechanisms involved during a cognitive activity such as memorizing the Koran, or from verifying brain activity during such an activity. Some authors have demonstrated changes in activation in the temporal lobe and an improvement in cognitive reserve during cognitive training (Belleville et al., 2023). Future studies should focus their research on the cognitive, neurophysiological, and cerebral effects of memorizing and reciting the Koran or other texts of whatever nature. It would also be interesting to compare the effect of memorizing several types of texts (poems, songs, religious texts, etc.) on cognitive functioning.

5. Conclusion

This study allowed us to compare the memory performance of two groups using the reduced memory efficiency battery 84. The group of participants who memorized and regularly recited the Quran obtained better results compared to the control group. We concluded that memorizing the Quran as a cognitive training activity characterized by repetition and retention improves episodic long-term memory. Finally, it would be useful to demonstrate whether a similar cognitive activity prevents or delays the decline of memory or slows down its progression.

Conflicts of Interest

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

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