ORIGINAL STUDY

# Study of attention and perceptual processes by digital plot analysis of Rey-A Complex Figure in Alzheimer patients

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## Abstract

**BACKGROUND:** To make meaningful comparisons of the results of different research studies on neurocognitive disorders, it is essential to select an appropriate screening test to examine these deficits in memory and executive functions. Our goal is to study the neurocognitive profiles of Alzheimer patients by the specific and unfamiliar test to the Moroccan population. We hypothesize that this disease, the duration of evolution, and the level of education have an impact on the perceptual structuring of the Rey Complex Figure-A (RCF-A).

**METHODS:** Forty people who were selected, including 20 patients with Alzheimer's disease and 20 control subjects, performed both copy and memory of the RCF-A in a digital version.

**RESULTS:** The Alzheimer patient groups had lower copy and memory RCF-A scores compared to control groups. However, both groups show a statistically significant link.

**CONCLUSIONS:** We found that the RCF-A copy test is effective for detecting executive function disorder in patients with Alzheimer's disease. Current neuropsychological evaluations demonstrate significant diagnostic and prognostic potential, but existing studies are limited by a small number of clinically defined subjects. Memory tests are the most promising, but further studies with larger samples are needed.

## Introduction

Alzheimer's disease is a pathology that gradually and irreversibly destroys all cognitive functions. Inaugural troubles usually affect memory and especially episodic memory. Typically, patients have difficulty recalling past episodes and learning new skills. All the same, during the evolution of the disease, all memory systems can be degraded (Traykov *et al.* 1999). As a result, semantic memory and working memory are also disturbed very early. Their disruption is often early and has a significant impact on activities of daily living (Bherer *et al.* 2004).

The diagnosis of Alzheimer's disease is developed according to well-established criteria (McKhann *et al.* 1984). Neurocognitive disorders are sometimes under-

diagnosed and are characterized by impaired executive functions such as visual-constrictive, perceptual, spatial, mnemic, attention and planning abilities. These disorders have the effect of altering the health and quality of life of Alzheimer patients. In Africa and particularly in Morocco, no studies have been published on the screening of neurocognitive disorders in Alzheimer patients by computerized recording of the digital plot of Rey Complex (RCF-A).

Developed by André Rey in 1941, the RCF-A is composed of 18 elements hierarchically organized into three levels (Figure 1): the global shape (large rectangle), the external units (square, cross, triangle, diamond) and the elements integrated into the overall shape (line with different orientation, diagonal, circle with 3 small dots, etc.). The RCF-A is a test used in clinical psychology, school of psychology and neuropsychology to evaluate in a subject, the abilities of visual-constrictive, spatial, mnemic, nonverbal memory, attention and working memory as well as hierarchical planning and organizational capabilities (Baddeley 1993, Pickering 2001).

The main objective of this research is to screen neurocognitive function disorders in patients with Alzheimer's disease and to explore the impact of Alzheimer's on executive functions, such as visual-constructive, spatial problems and mnemic. For that we compare the achievements of the RCF-A of two groups by the computerized recording of the digital plot, it allows to analyze in a very fine way the realization of the RCF-A and the type of perceptive organization.

## Materials and methods

*Study location and population*

The study was conducted between June 2016 and December 2017, done at the Neurology Department of Hassan II University Hospital in Fes (Morocco). It included 40 people from the Moroccan population among which 20 are Alzheimer subjects and 20 control subjects. All patients signed informed consent to participate in this study.

The patients were classified into 3 classes of education level (illiterate, primary, high school / university). For each patient, a questionnaire was filled in regarding to their socio-demographic and clinical data: age, sex, duration of disease progression and clinical signs.

*Data collection*

For the evaluation of the neurocognitive functions of the patients and control subjects included in the study, we used the Rey type complex (RCF) type A test.

The FCR-A test is done in 2 steps, a copy phase and a reproduction phase.

The first step corresponds to the copy phase, i.e the model is presented horizontally to the subject and must be clearly visible and we ask him to copy this drawing. The patient schematizes the figure while looking at the model. The second step corresponds to the reproduction phase of the figure. The patient is asked to try to reproduce the figure even if it seems difficult without any support model.

For the collection of plots, we used the method of Wallon and Mesmin (2002) which consists of the patient making his digital plot on a paper CREDAGE10 A4 format using an electronic pen system "Anoto" which records the dynamics of the lines as a sequence of x and y coordinates as well as instantaneous pressures. The data is then transferred to a computer and analyzed by the ELIAN software (Expert Line Information Analyzer) which displays the dynamics of the patient's layout on the screen. Thus, the software classifies patients according to their digital layout into normal subjects, to be monitored and pathological subjects, that is to say with executive disorders.

*Inclusion of subjects*

The patients included in this study are all patients with Alzheimer's disease of all ages, schooled or not, regardless of gender and origin. Table II details the socio-demographic and clinical characteristics. Patients (subjects) unable to write and express themselves were not included in the study as they were visually impaired. The choices of the control subjects and the patients are homogeneous, all the subjects signed a consent.

*Automatic scoring procedure*

The different variables measured in the analysis are summarized in the tables below.

**Tab. 1.** the different scores given.

| Criterion | Modalities | Type of variable | Interpretation |
|---|---|---|---|
| Digital evaluation | 0 to 72 | Quantitative | execution |
| The type rating | Type 1 to 7 | Qualitative | Perceptual organization method |
| The orientation of the drawing | Vertical or horizontal | Binary | Specificity |

*Two (2) rating methods*

***Digital rating***

The Digital rating adapted from Osterrieth's (1944) work by Taylor (1959) is the most common traditional method for assessing the accuracy of realization. The figure is then divided into 18 elements (details), each being noted from 0 to 4:

- Correctly drawn and well placed (4),
- Correctly drawn and misplaced (2),
- Correctly drawn, well placed but imperfect (3),
- Deformed or incomplete and well placed (2),
- Deformed or incomplete and misplaced (1),

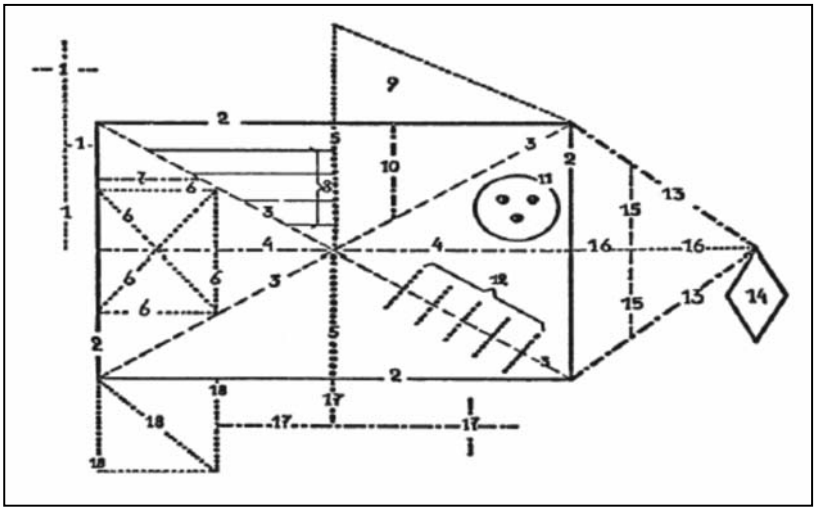

**Fig. 1.** Rey's Complex Figure in 18 Elements. (Mesmin &Walloon 2009)

- Unrecognizable or absent (0).

According to the accuracy of the copy, with a total score of 72 points.

***Rating in types***

The type rating established by Osterrieth (1944) and included in the new test manual (Wallon and Mesmin 2009). Each type is based on a different reproduction order. There are seven types, type1 being the best, type 7 being the worst:

**Type I:** The subject first draws the central rectangle and then the related elements. He identifies, by a visual analysis, the internal structure of the figure and reproduces it by organizing the positioning of the elements with respect to this basic structure. This type requires mental planning that precedes the execution. The execution requires the prospective aiming of the lines and the control of the angles (Benoît Virole 2011).

**Type II:** The subject first draws a peripheral element (often the cross) then draws the central frame and the adjacent elements. He clearly perceives the distinction between the central rectangle and the big upper triangle. The final shape is similar to the model and without the use of colors, nothing finally allows to distinguish a type I from a type II. There has been detection of the internal structure of the figure, and it is used as a control of the execution, but not as a model of execution.

**Type III:** This type is similar to Type II but of lower quality. The strategy of execution is by imitation of the overall contour of the figure by neglecting the analysis of the internal structure. Then, the subject positions the interior elements, sometimes badly positioned.

**Type IV:** The subject first draws a peripheral element then continues by a series of successive elements without referring to either the overall shape contour or the central rectangle. The final shape has element positioning errors. There is no use of an internal gnostic model but a copy by sectors without integration of the internal structure of the figure. It can be accompanied by neglect of sectors.

**Tab. 2.** Socio-demographic and clinical data of patients and normal subjects.

| Variables | Alzheimer Group | Controls Group | *p* |
|---|---|---|---|
| | ***n = 20*** | ***n = 20*** | |
| Sex | | | |
| Male | 10 (50 %) | 10 (50 %) | NS |
| Female | 10 (50 %) | 10 (50 %) | NS |
| Sex-ratio | 1,3 | 1,3 | |
| Age (years) | | | |
| Mean | 72,8 ± 8,84 | 69,20 ± 7,92 | NS |
| Median | 72 | 70 | |
| Extremes | 57 - 89 | 56 - 89 | |
| Laterality | | | |
| Right handed | 18 (90%) | 20 (100%) | NS |
| Left handed | 2 (10%) | 0 | |
| Academic level | | | |
| illiterate | 6 (30%) | 6 (30%) | |
| Primary | 12 (60%) | 12 (60%) | |
| High school or / university | 2 (10%) | 2 (10%) | |
| Duration of evolution (year) | | | |
| Mean | 2,7 ± 1,21 | NA | NA |
| Median | 2,5 | NA | NA |
| Extremes | 1 - 6 | NA | NA |
| [1-3] | 17 (85 %) | NA | NA |
| [4-6] | 3(15 %) | NA | NA |

**Type V:** Detail on confused background and are drawn in a disorganized way. We recognize elements of the figure but without any formal global structure.

**Tab. 3.** Illustrates the clinical signs of Alzheimer's patients collected using a clinical fact sheet

| Clinical signs | Alzheimer Case | Controls |
|---|---|---|
| Aphasie | 0 | NA |
| Agnosie (prosopagnosie) | 10 (50%) | NA |
| Hallucination | 7 (35 %) | NA |
| Depression (under antidepressant treatment) | 17 (85%) | NA |
| Apraxia | 3 (5%) | NA |
| Agressive | 8 (40 %) | NA |
| Strolling | 9 (45 %) | NA |
| Fall unconscious | 6 (30 %) | NA |
| Concentration disorder (agitation) | 16 (80 %) | NA |

NA = not applicable NS = not significant

**Tab. 4.** Breakdown by group of the mean scores of the digital evaluation

| | Alzheimer Group | Controls Group | *p* |
|---|---|---|---|
| RCF-A Score copy | 10,80 ± 8,09 | 40,30±19,50 | 0,000 |
| RCF-A Score memory | 6,85±4,74 | 20,9± 11,24 | 0,000 |

**Tab. 5.** Breakdown by group of the mean scores of the digital evaluation

| | Illiterate | Primary | High school or/university |
|---|---|---|---|
| Copy | 7,66 ± 4,59 | 11,08 ± 8,61 | 18,50 ±12,02 |
| Memory | 5,83 ± 2,92 | 6,83 ± 5,11 | 10,0 ± 8,48 |

**Tab. 6.** The mean of the numerical score according to age

| | Alzheimer Group | |
|---|---|---|
| Age class | Copy | Memory |
| [57- 66] | 11,5 ± 9,22 | 7,0 ± 5,17 |
| [67-76] | 11,00 ± 6,19 | 6,66 ± 3,55 |
| [77-90] | 10,12 ± 9,42 | 6,5 ± 5,9 |

**Tab. 7.** The mean of the numerical score according to the duration of evolution of the Alzheimer's disease

| Duration of evolution | n = 20/% | Mean copy | Mean memory | *p* |
|---|---|---|---|---|
| [1-3] | 85 % | 12,23 ± 7,94 | 7,35 ± 4,94 | 0,04 |
| [4-6] | 25 % | 2,67 ± 1,15 | 2,85 ± 1 | 0,72 |

**Type VI:** Reduction to a familiar scheme. The subject reproduces a church, or a fish, a man inside a house (etc.). He fails the abstract gnostic analysis and recovers on a familiar figurative scheme.
**Type VII:** incomplete. The subject draws a few scattered elements, often disjointed or executed in a form of scribbling.

***Manual evaluation and orientation of the figure***
We rated the orientation of the figure Mesmin (2005), Bossuroy *et al.* (2013): Horizontal (H) and Vertical (V).

*Statistical analysis*
In the statistical analysis, patient characteristics are expressed as a percentage for the qualitative variables and as an average ± standard deviation for the quantitative variables. Chi-square (Pearson) and Student t tests were used to compare the variables. $p$ value <0.05 is considered statistically significant, with a number of degrees of freedom (d.f). The data was analyzed with Excel and the Statistics for Windows Social Science software version 21 (SPSS Inc., Armonk, New York, USA).

## Results

*Digital evaluation*
The results of this study demonstrate that there is a statistically significant difference with the degree of freedom (df) 25.35 between the Alzheimer's patient group and the control group, indicating a net loss of RCF-A accuracy.

The Pearson correlation between the Alzheimer's and control group was $r = 0.712$ with $p = 0.000$ in the copy phase. Similarly, the correlation in the memory phase gives $r = 0.640$ with a $p = 0.000$.

***Numeric quotation according to the level of education***
In Alzheimer patients the level of education does not have enough impact on the achievement of the RCF-A. We did not compare (verify) both groups and the sample size is small, and homogeneous (low participation rate).

***Numerical rating according to age***
The result analysis; of the numerical score in the age group of Alzheimer's patients shows a loss of greater accuracy of the RCF-A in older Alzheimer's patients, the older the patient, the RCF-A is less realized and the error will be more.

***Numerical rating according to the duration of evolution***
At the level of the numerical score according to the duration of evolution in the Alzheimer patient group, a greater loss of the realization (of accuracies) of RCF-A in copy and memory phases in the most advanced stages of the disease.

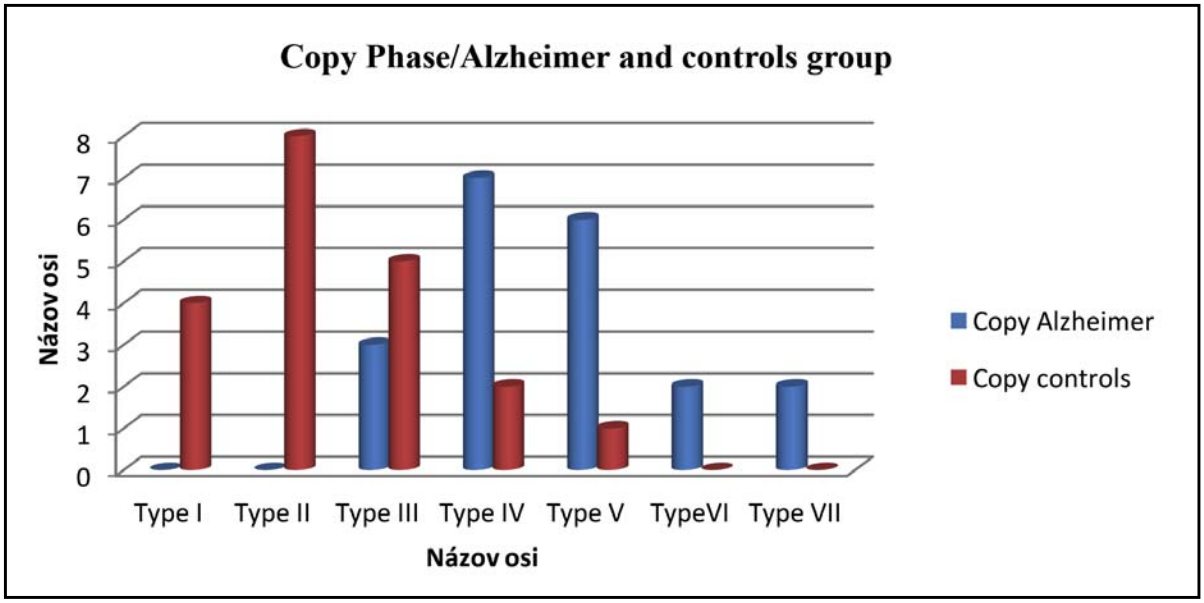


**Fig. 2.** Execution of the type in the copy phase of Alzheimer patients and control subjects

*Rating of type*

Distribution in type of realization.

During the realization of the RCF-A strategy in type, Alzheimer patients and control subjects are in the copy phase, we note the absence of types V and VII in control subjects. In addition, types II and III are predominant in the copy phase in control subjects. For types IV, V and VII are the majority in the copy phase in Alzheimer patients. The chi-square test gives a significant p. The Spearman correlation was $r$ = - 0.700 with a $p$ = 0.000 in the copy phase.

The strategy of carrying out the RCF-A in type, Alzheimer patients and control subjects in the memory phase, shows us the absence of types V and VII in control subjects. Otherwise, types II and III are predominant in the memory phase in control subjects. For types IV, V and VII are predominant in the memory phase in Alzheimer patients. The chi-square test gives a significant p. Correlation in the memory phase indicates that, $r$ = - 0.658 with a $p$ 0.000.

*Orientation*

The analysis of the orientation of the RCF-A, shows a low frequency of the vertical reproduction in the two groups, the majority of the Alzheimer patients and the control subjects having reproduced the vertical figure are older and have a low level of instruction.

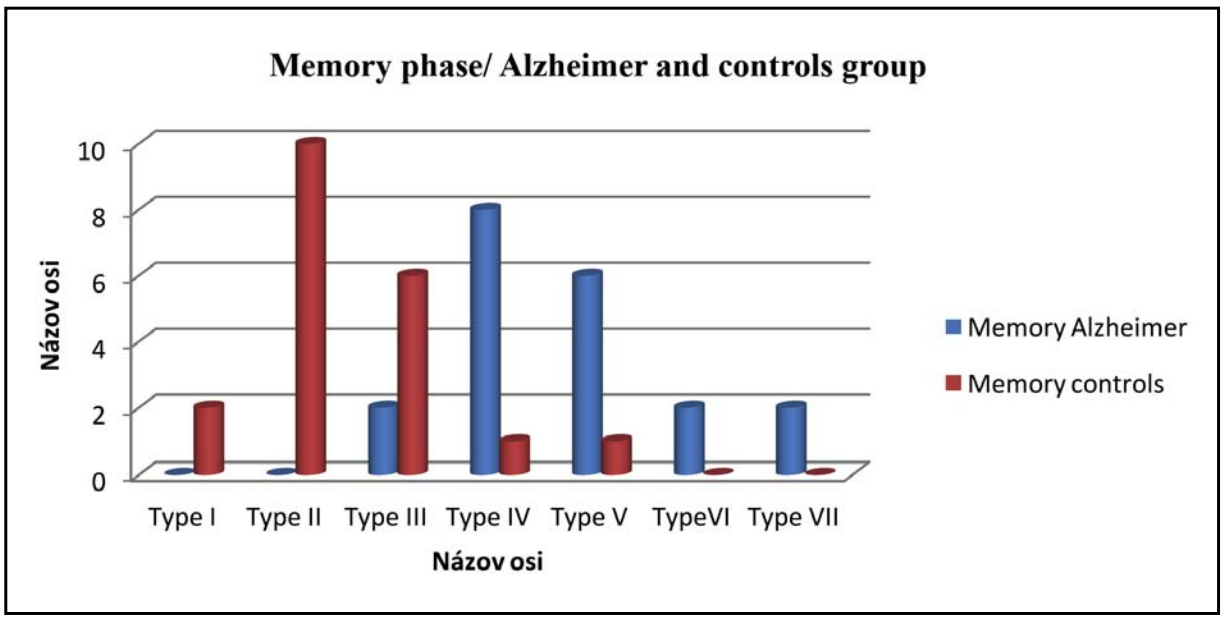


**Fig. 3.** Execution of the type in the memory phase of Alzheimer patients and control subjects

**Tab. 8.** Orientation of figures for both groups

| Orientation | | Alzheimer Group | Controls Group |
|---|---|---|---|
| Copy Phase | H | 18 (90%) | 18 (90%) |
| | V | 2 (10%) | 2 (10%) |
| Memory Phase | H | 19 (95%) | 17 (85%) |
| | V | 1 (5%) | 3 (15%) |

## Discussion

We evaluated the neurocognitive disorders related to Alzheimer's disease in Moroccan patients by the use of the RCR-A test in its digital version by comparing them to a control group globally of the same age, sex and the same level of education. It is found that there is indeed a correlation between the two variables, in the copy and memory phase were determined for each group, the strength of the relations was compared. Correlation coefficients are used to quantitatively describe the strength and direction of the relationship between two variables, indicating that changes in one of the variables are proportional to changes in others.

Moreover, the analysis of the digital plots of the RCF-A test in copy and reproduction phase, in our patients, showed a clear loss of accuracy and errors of the RCF-A. This can be explained by concentration disorders, memory disorders, in particular working memory and impaired visuo-constructive and spatial capacities. We note that the working memory allows the maintenance and the active manipulation of the information necessary to carry out the immediate actions. It plays a leading role in the realization of a set of complex cognitive activities including problem solving and language comprehension. An attack of the latter is therefore likely to have major repercussions in different fields of cognitive functioning. The individual complaints commonly reported in the clinic by Alzheimer's patients could evoke such an attack. They report difficulties learning or performing new activities, or complex daily activities. This clinical action was confirmed by the study by Belleville (2009) who formally evaluated the current activities for which patients with Alzheimer's disease had a complaint.

For this purpose, we have used the RCF-A test for self-evaluation of memory, which evaluates many areas of activity, executive functions. In this RCF-A test, people with Alzheimer's disease reported difficulties in reproducing the RCF-A (in the copy and memory phase), but also in activities reflecting a weakening of their working memory or their attention.

According to the study by Kasai *et al.* (2007), who evaluated unilateral spatial neglect (USN) in patients with Alzheimer's disease, confirming the visuo-spatial deficit of these patients. The visual building capacity deficit in these patients was characterized by a reduced ability to draw the RCF-A, compared to healthy elderly subjects. In general, the right parietal lobe dominates the visual attention function, but the temporal sequence of the pathology of Alzheimer's disease has also been established. Thus the hippocampus is rapidly involved, followed by the temporal lobes, the parietal lobes being affected later.

We found that the higher the level of education, the better the accuracy of RCF-A and vice versa. This finding being verified in both groups

(We note that patients with low educational attainment, difficulty with CRF (the task requested) and commit more errors, and age plays an important role in the testing of Rey's complex figure. in our patients with Alzheimer's disease, age-related scoring score declines markedly in older subjects It has been observed that the ability to produce the figure decreases significantly with aging (age).

Ardila and Rosselli (2003), showed in their studies in normal elderly subjects that the Rey-osterrieth complex figure (FCRO) test scores dropped significantly after the age of 65, and especially after 70 years. Scores in the low-educated group are lower, especially among women, indicating that the FCRO may be highly dependent on education, as is often seen with drawing skills tests.

Other normative study by Deregowski (1989) pointed out that visuo-spatial and constructive capaci-

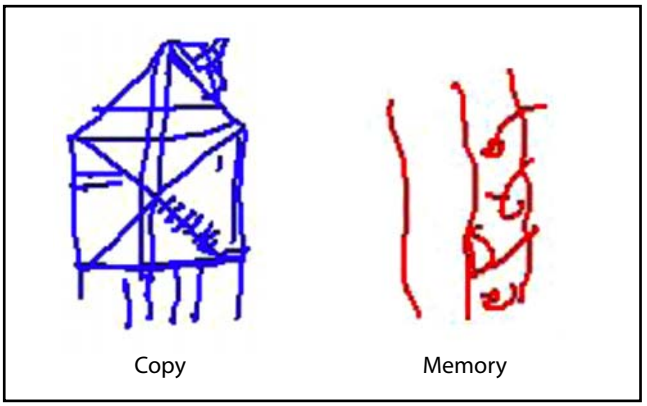


**Fig. 4.** Vertical Reproduction in Copy and Memory of a 78-year-old Alzheimer's Patient

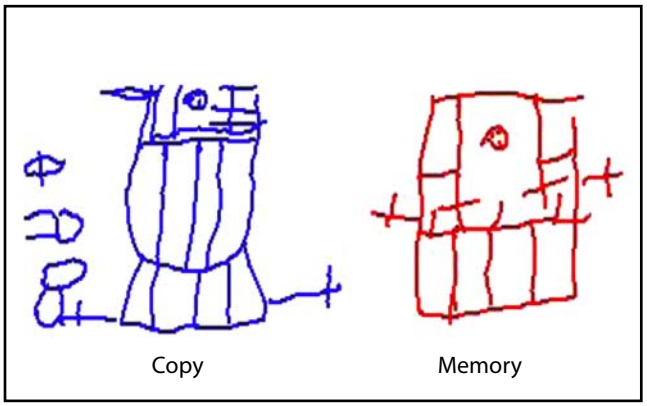


**Fig. 5.** Vertical reproduction in copy and memory of a 59-year-old control subject

ties depend on culture, and this cultural effect is the result of specific training in visuo-spatial skills.

The Ardila *et al.* (1989) study confirms the importance of educational level in interpreting the performance of visuo-spatial, visuo-construction and nonverbal memory tasks. It has been pointed out that cognitive changes during normal and abnormal aging are correlated with educational level (Rosselli & Ardila 1991). The pattern of cognitive decline during normal and abnormal aging is not completely similar in individuals of different levels of education. The level of education has been associated with the severity and even duration of Alzheimer's disease according to the Stern *et al.* (1994, 1995).

The analysis of numerical plots in the group of Alzheimer patients, shows that the advanced stage and / or a longer duration of evolution of the disease, aggravated the loss of accuracy of the realization of the FCR in the copy and memory phase. Elderly patients with a duration of disease progression of more than 3 years are impaired and are not able to perform the figure correctly.

Difficulties in copying and reproducing in an organized way the RCF-A in Alzheimer's patients suggest impaired visual memory and visuo-constructive abilities. The type IV and V majority production strategy in the copy and memory phase led Alzheimer patients to produce poorly detailed figures with low numerical score scores in the memory and copy phase between the Alzheimer's group and controls, subsequently production of type VI and VII minority strategies.

Moreover, the type of embodiment II and III prove better memorization of the figure and a small loss of information during the realization between the copy and memory phase.

Pelati *et al.* (2011), in a retrospective evaluation of patients with dementia, identified a form of confusion (memory distortions) of the FCRO. The cognitive profiles of confabulant and non-confabulant patients were similar, and only graphical confabulation could be predicted by poor semantic fluency performance.

We also note the reproduction of vertical RCF -A is rare and does not show any difference between Alzheimer group and control group. The majority of subjects who reproduce the vertical figure are older, more impaired and have a low level of education.

Indeed, Rey's complex figure reproduction is one of the most widely used clinical neuropsychological procedures for testing visual-spatial, constructive, nonverbal memory, working memory, attention, planning, perception and mnemic.

## Conclusion

Indeed, our study demonstrated that, when analyzing the Rey Complex Figure in patients with Alzheimer's disease that neurocognitive performance is impaired in particular executive functions, such as working memory, and an impaired visual-constructive, spatial, perceptive and memory-related abilities, highlighting the age and duration of disease progression on the realization of the RCF-A. Our results are approved by comparison of two groups, patients and control subjects. In a broader perspective, detailed and qualitative analyzes of the performance of Alzheimer patients in complex and multidimensional neuropsychological tasks, such as RCF-A, are able to provide cognitive information useful to clinicians and researchers. A better characteristic of the neurocognitive profile of each patient may lead the clinician to a diagnostic hypothesis of the early stage of patient evaluation and, from a research point of view, may play an important role in identifying deficits patterns of the cognitive populations. However a study including a larger (large) population of subjects with control group is more necessary to more accurately assess the impact of the disease on the executive functions in Alzheimer patients of the Moroccan population.

***Conflict of interest:*** The authors declare no conflict of interest

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