ORIGINAL ARTICLE

Neurocognitive profile study of Parkinsonian patients by automatic analysis of Rey's Complex Figure-A

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Abstract

OBJECTIVES: In order to know better the screening bias of neurocognitive disorders in the specific tests and unfamiliar to the population, we formulate the hypothesis that Parkinson's disease, the duration of evolution and the level of education have an impact on the perceptual structuring of the Rey-A Complex Figure (RCF-A).
MATERIALS AND METHODS: In the present study, two groups were compared: parkinsonian patients (n=60) and control subjects (n=60) with a numeric and order-of-work type using a computerized recording of the digital plot of the RCF-A, analyzed by the software ELIAN (Expert Line Information Analyzer) which renders on the screen the dynamics of the patient's path.
RESULTS: The results show a significant disparity between the two groups, concerning both the scores and the (technical) types of achievements of the figure (RCF-A). There is a statistically significant difference between the Parkinson's patient group and that of the control, indicating a clear loss of accuracy in the Figure.
CONCLUSION: Our study shows that Parkinson's disease affects neurocognitive functions in patients who suffer from perceptual and mnemic processes.

Introduction

Described for the first time by English scientist James Parkinson (Parkinson 1817), parkinson's disease (PD) is a chronic neurodegenerative disease affecting the dopaminergic, cholinergic, noradrenergic and serotoninergic system. PD is the second most common neurodegenerative disorder in the world after Alzheimer's disease (Bower JH *et al* 1999). The clinical manifestations of PD are not only motor. Non-motor manifestations are also found in Parkinson's disease (PD) such as pain, autonomic disorders, sensory disorders, sleep and alertness disorders, neurocognitive and neuropsychiatric disorders, and so on (Zesiewicz *et al* 2010). Neurocognitive disorders are sometimes under-diagnosed and are characterized by impaired executive functions such as visual-constrictive, perceptual, spatial, mnemonic, attention and planning abilities. These disorders have the effect of altering the health and quality of life of Parkinson's patients.

In Africa and particularly in Morocco, no studies have been published on the diagnosis of neurocognitive disorders in parkinsonian patients by computerized recording of the digital Rey's Complex figure (RCF-A).

Described for the first time in 1941 by André Rey, the RCF-A is composed of 18 elements hierarchically organized into three levels (Figure 1): the overall 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 of neuronal activity used in clinical neuropsychology to evaluate a patient's visu-constrictive, spatial, memory, nonverbal memory, attention, and working memory abilities as well as hierarchical planning and organizational capabilities (Baddeley 1993; Pickering 2001).

Our study objective is to detect neurocognitive and memory disorders in Moroccan Parkinson patients. Therefore we compare the achievements of the RCF-A of two groups by the computerized recording of the digital plot, it allows to analyze very finely the realization of the RCF-A and the type of perceptual organization.

Materials and methods

Location and population

The study was conducted between June 2016 and August 2017, conducted at the Neurology Department of Hassan II University Teaching Hospital in Fes (Morocco). It included 120 people from the Moroccan population among whom 60 are Parkinsonian subjects and 60 control subjects. All patients signed informed consent to participate in this study.

The patients were classified into 4 classes of education level (illiterate, primary, high school, university). For each patient, a questionnaire was completed on his socio-demographic and clinical data: age, sex, duration of disease progression and Hoehn and Yahr's stage of evolution (1967).

Data collection

For the evaluation of the neurocognitive functions of the patients included in the study, we used the Rey's Complex Figure (RCF) type A.

The RCF-A test is done in 2 steps. The first step corresponds to the copy phase, that is to say the patient sketches the figure by looking at a model and then asked to try to memorize the figure. 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 the patients according to their digital plot into normal subjects or to monitor and pathological subjects that is to say with executive disorders.

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),
- Unrecognizable or absent (0).

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

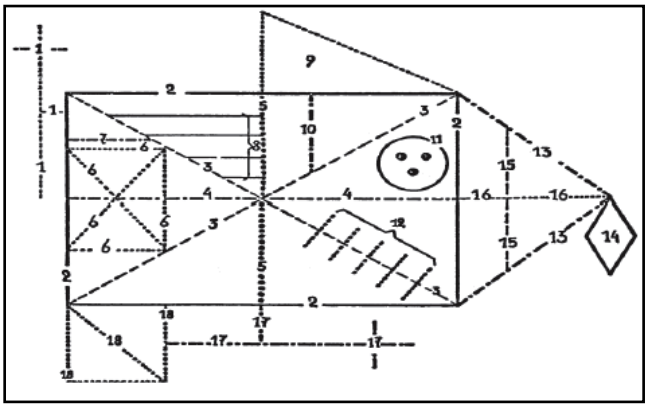

Fig. 1. Rey's Complex Figure in 18 Elements. Mesmin and Walloon (2009).

Tab. 1. The differents evaluations made.

Standard	Modalities	Type of variable	Interpretation
Digital evaluation	0 to 72	Quantitative	Execution
Rating in type	Type 1 to 7	Qualitative	Perceptual organization method
The orientation of the drawing	Vertical or horizontal	Binary	Specificity

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 less good:

- 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 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.
- 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.
- Type VI: Reduction to a familiar diagram. 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 diagram.
- 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. A p-value <0.05 is considered statistically significant. The data was analyzed with Excel and the Statistics for Windows Social Science software version 21 (SPSS Inc., Armonk, New York, USA).

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

Variables	Parkinsons group n=60	Control group n=60
Sex		
Men	34 (56.7%)	34 (56.7%)
Women	26 (43.3%)	26 (43.3%)
Sex-ratio	1.3	1.3
Age (ans)		
Mean	58.18±11.57	57.43±11.86
Median	58	57
Extremes	17 et 80	17 et 80
Laterality		
right handed	54 (90%)	60 (100%)
Left	6 (10%)	0
School level		
Illiterate	25 (41.7%)	25 (41.7%)
Primary	23 (38.3%)	23 (38.3%)
Middle School /High school	10 (16.7%)	10 (16.7%)
University	2 (3.3%)	2 (3.3%)
Duration of evolution (year)		NA
Mean	5.61±3.7	NA
Median	4	NA
Extremes	1 et 13	NA
[1-5]	35 (58.3%)	NA
[6-10]	15 (25%)	NA
Plus de 10	10 (16.7%)	NA
Hoehn et Yahr		
Stage 0	0	NA
Stage I	1 (1.7%)	NA
Stage II	28 (46.7%)	NA
Stage III	27 (45%)	NA
Stage IV	3 (5%)	NA
Stage V	1 (1.7%)	NA

NA = not applicable

Results

Digital rating

There is a statistically significant difference between the Parkinson's patient group and the control group, indicating a net loss in the accuracy of the RCF-A.

Tab. 3. Breakdown by group mean scores of the digital score.

	Parkinsons group	Control group	*p*-value
FCR-A copy score	23.9±18.22	43.02±18.11	0.000
FCR-A memory score	14.23±11.95	24.5±12.84	0.000

Tab. 4. The average group of Parkinsonian and control group, depending on level of education.

	Parkinsons group		Control Group	
	Copy	Memory	Copy	Memory
Illiterate	12.04±7.40	7.9±3.8	32.1±13.9	16.6±8.9
Primary	24.5±16.4	14.9±11.8	48.1±18.25	27.3±12.14
High school	46.8±15.35	23.6±14.6	58.4±11.7	35.9±10.7
University	51±1.41	38.5±3.5	44±14.1	34±18.4

Tab. 5. The mean according to Hoehn and Yahr stage of Parkinson's patients.

Hoehn et Yahr	n=60/%	Mean/copy	Mean/memory
stage 1	1.66%	62	45
Stage 2	46.66%	27±18.9	15.14±11.2
Stage 3	45%	21.2±16.34	13.4±12.01
Stage 4	5%	7.33±1.2	5.33±1.15
Stage 5	1.66%	16	5

Tab. 6. Average score according to the duration of Parkinson's disease progression.

Duration of evolution	n=60/ %	Average copy	Average memory
1 à 5	58.33%	25±18.8	14.11±10.5
6 à 10	25%	17.9±13.9	10.2±9.4
11 à 15	16.66%	29.1±20.66	20.7±16.68

Tab. 7. Orientation of figures for both groups.

	Orientation	Parkinson's group	Control group
Copy Phase	H	54 (90%)	55 (91.67%)
	V	6 (10%)	5 (8.33%)
Memory Phase	H	55 (91.67%)	52 (86.67%)
	V	5 (8.33%)	8 (13.33%)

Digital rating according to the level of education. The level of education has an impact on the quality of realization of the RCF-A, significantly in the 2 groups (Parkinsonians and Witnesses). The higher the level of education, the more the accuracy of the figure is respected.

Digital rating according to stage of evolution Hoehn and Yahr (H-Y). The study of the digital rating in the Parkinson group according to the stage of the disease shows a greater loss of accuracy in the most advanced stages.
Digital rating according to the duration of evolution. The study of the digital rating in the Parkinson group according to the duration of evolution, shows a loss of greater accuracies beyond 10 years of evolution.

Rating in type

The distribution in type of realization, represented below, shows that types III and IV are the majority in the copy and memory phase in Parkinsonian patients, whereas types II and III are the majority in normal subjects in a statistically significant manner.

Orientation

The majority of Parkinsonian and control subjects achieved horizontal production. Vertical reproduction was noted in 11 cases in the copy phase and in 13 cases in the memory phase with no significant difference between the 2 groups. Parkinsonian patients and control subjects who reproduce the vertical figure are older and have a low level of education.

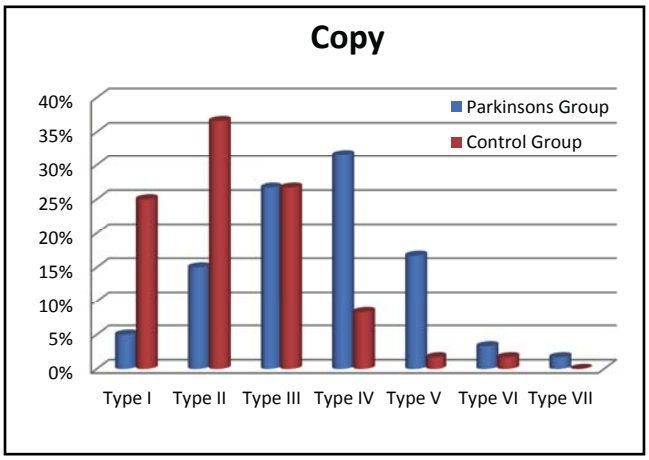

Fig. 2. Copy phase of Parkinson's patients and control subjects.

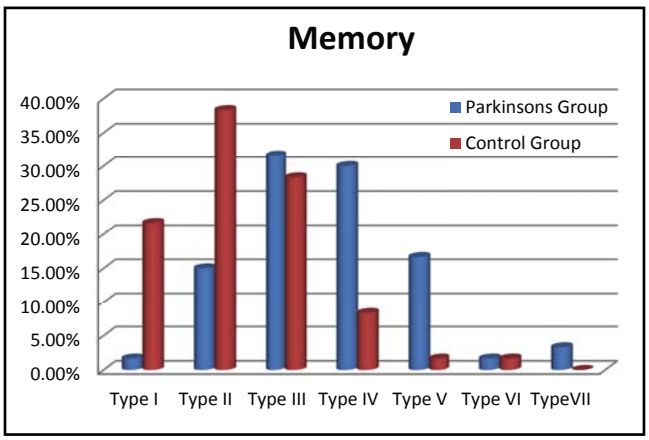

Fig. 3. Memory phase of Parkinson's patients and control subjects.

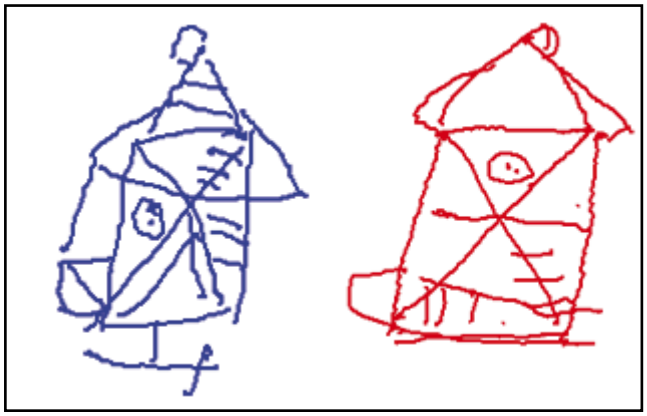

Fig. 4. Reproduction in copy and memory of a 50-year-old Parkinson's patient.

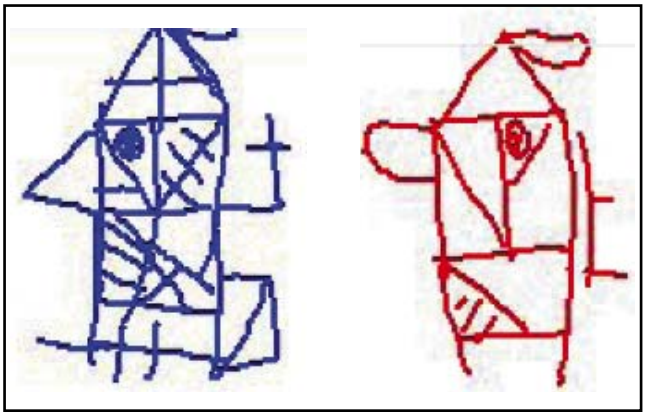

Fig. 5. Reproduction in copy and memory of a 49-year-old control subject.

Discussion

Parkinson's disease is a common (neurodegenerative) disease, whose well-known motor repercussions are often accompanied by cognitive impairment. The impact of the latter is significant and has a heavy impact on the quality of life of these patients. In addition, many researchers have been interested in screening tools and the usefulness of cognitive stimulation in these patients.

Cognitive disorders are similar to a sub-cortico-frontal syndrome because they result from the dysfunction of the prefrontal cortex whose afferent dopaminergic innervation is impaired. Fine studies in MRI that confirmed the anatomical reality of these cognitive disorders are not the only motor disorders often present.

Executive functions are often affected first. There are difficulties to be attentive, to plan the complex activities, to maintain and manipulate the information in memory. Learning abilities are also disrupted, the acquisition of new information in memory and the recovery of the latter are more difficult. Some individuals show significant impairment of visuospatial skills. As a result, the review of executive functions is crucial. Examination of cognitive disorders has been treated differently with other methods. We volunteered to use the RCF-A in its computerized version as a classic approach. This tool was used by Ahami et al. (2010), who emphasize the validity of RCF-A digital version analysis for the diagnosis of neurocognitive disorder in Moroccan populations.

We evaluated neurocognitive disorders related to Parkinson's disease in Moroccan patients by using the RCF-A test in its digital version compared to a control group.

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

On the other hand, the analysis of the digital plots of the RCF-A test in copy and reproduction phase in our patients, showed a net loss of the accuracy of the RCF-A. This can be explained by memory disorders, in particular working memory, and impaired visuo-constructive and spatial capacities. Grossman et al. (1993), after comparing the RCF-A and Parkinsonian versus the control groups, showed that Parkinson's patients disorganized the main structures of A-RCR in the copy phase. In addition to the layout problem, patients omitted more elements of the RCF-A compared to those of the control group in the copy phase.

Diamond and Deluca (1996), in their study of the Rey-Osterrieth Complex Figure Test in patients with aneurysm rupture, found a profound loss of information in the figure of Rey-Osterrieth and explains it by problems of encoding, consolidation and recovery.

In the group of Parkinsonian patients, it is noted that the advanced stage of the disease and / or a significant duration of evolution, aggravated the loss of accuracies. However, this is not verified for stages 1 and 5 because of low representativeness.

Difficulties in copying and reproducing in an organized way the RCF-A in Parkinson's disease patients suggest impaired visual memory and visuo-constructive abilities.

Karádi et al. (2015) assessed the RCF in Parkinson's patients and demonstrated that the duration of the evolution of the disease played an important role in the alteration of visuospatial capacities and all the more so that the motor signs of the disease predominated on the left.

The majority production strategy of type III and IV in the copy and memory phase led Parkinson's Disease patients to produce poorly detailed figures with low scores of the numerical rating in the copy and memory phase between group Parkinsons and controls.

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

The origin of executive disorders in Parkinson's patients is multifactorial. For some authors Brown et al. (1986), Delia Sala et al. (1986), motor disorders (rigidity and tremor) and their severity play an important

role in the alteration of working memory and visuo-constructive and spatial capacities. While others Levin et al. (1991), Sahakian et al. (1988) essentially criminalize the duration of evolution of the disease and the anti-parkinsonian treatment used.

Vertical reproduction is rare and does not show a difference between Parkinson's group and control group. The majority of subjects who reproduce the vertical figure are older and have a low level of education.

Conclusion

Our study confirms in Moroccan Parkinson's patients the existence of visual-constructive, perceptual, spatial and memory disorders regardless of the age and duration of the disease and not the level of education (on the other hand, these neurocognitives disorders are unevenly distributed according to educational level). Indeed (Table 4) these are more pronounced among illiterates and primary levels. These results are approved by comparison of two groups, patients and control subjects. However, a study including a larger number of subjects with control group is needed to more accurately assess the impact of Parkinson's disease on executive functions in Moroccan Parkinson's patients.

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

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