International Journal of Scientific Engineering and Research (IJSER)
ISSN (Online): 2347-3878
Index Copernicus Value (2015): 62.86 | Impact Factor (2015): 3.791

# The Impact of Anemia on Cognitive Performance of School Children in Kenitra City through a Computerized Line Analysis of the Rey Complex Figure A Copy (FCR-A)

**Imane Achouri[1], Youssef Aboussaleh[1], Ahmed Omar Touhami Ahami[1], Philippe Wallon[2]**

[1]Department of Biology, Neurosciences and Nutritional Health/ Ibn Tofail University, Morocco
[2]Paris 8 University, Saint Denis, France

**Abstract:** ***Many studies throughout the world have shown the high prevalence of iron deficiency anemia in children and its impact on their academic performance through the diagnosis of neuro-cognitive abilities. However, studies in this field in school-aged children in Morocco, remain rare. Therefore, the aimed to investigate the impact of anemia on the neurocognitive performances among schoolchildren in Kenitra city, located in North western Morocco. The sample represents 152 students randomly chosen, aged between 6 and 14 years in an urban environment. The measurements of hematological parameters were performed, and a numerical version of the Rey A test was used to assess the cognitive profile of these children. The results showed that 16.2% of children were anemic. The clinical rating analyses of Rey test showed a very significant difference (p <0.05) between the two groups in the two trials (copy and recall)in both scores and techniques of realization. Thus, the results confirmed that iron status is a significant factor in cognitive performance in schoolchildren.***

**Keywords:** Anemia, cognition, Complex figure of Rey A, schoolchildren, Morocco

## 1. Introduction

One of the most common causes of anemia is iron deficiency, particularly in developing countries. School-age children are among the most vulnerable because of their increased nutritional needs. Thus, the World Health Organization (WHO) recently reported that the global prevalence of anemia in the general population is 24.8%, with an estimated range of 1.62 billion people suffering from it especially in Africa with 67.6% [1].

In Morocco, the surveys carried out in recently on the micronutrient deficiencies by the Ministry of Health demonstrated that 37.2% of pregnant women, 31.5% of children aged 6 months to 5 years, 32.6% of childbearing age women and 18% of men are anemic [2]; Other studies have shown that children with iron deficiency anemia are at stake for short-term intellectual impairment and this risk indeed continues despite iron supplementation therapy [3]. It is also shown with strong evidence that children with iron deficiency do have poor intellectual and motor functioning (1.73 IQ points for every 10 g/L of decline in hemoglobin level) [4].

The objective of this study is to assess the cognitive performances of anemic children aged between 6 and 14 years in public schools in the region of Kenitra in north-west of Morocco.

## 2. Methodology

### 2.1 Place and the sample study

A cross-sectional descriptive survey was conducted from October 2013 to May 2014 in three public schools in the region of Kenitra, located in north-west of Morocco. The selected sample consists of 152 school age children aged 6 to14 years old.

### 2.2 Biological data collection

A 5 ml blood sample collected by antecubital venipuncture and drawn into a container with EDTA for red blood cell (RBC), haemoglobin (Hb), haematocrit (hct), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC) analyses. All the blood analysis were measured using an automated cell counter (MS9-5S, Osny, France) by trained and experienced laboratory technicians in private laboratory of medical analysis under suitable conditions. The haemoglobin level was determined by cyanmethemoglobin method using a Drabkin reagent (D5941) containing potassium ferricyanide $K_3Fe(CN_6)$ and potassium cyanide (KCN). The potassium ferricyanide oxidises iron to form methemoglobin, and then, the potassium cyanide combines with methemoglobin to form cyanmethemoglobin; a stable compound which was measured by spectrophotometrically at 540 nm.

Anemia was defined as haemoglobin level below 11.5 g/dl for children aged between 6 and 11 years and below 12 g/dl for children aged from 12 to 14 years [5].

### 2.3 The cognitive evaluation

The sample for the present study consists of 152 school pupils divided into two groups in terms of whether or not they have anemia.

The Rey Complex Figure (RCF) test was performed using a computerized line recording (ELIAN).

The RCF test A, is a simple test invented by André Rey in 1942, the abstract and asymmetrical figure is composed of 18 elements hierarchically organized in 3 levels: the overall shape (large rectangle), the external units (square, cross, triangle, diamond) and the integrated elements in the overall shape (Figure 1).

The test consists of presenting the model (FCR-A) (Figure 1) to the child who is asked to make a copy first (free time) and then after 3 minutes, the model is removed to ask him to reproduce it in memory. The duration of the test is free for both phases (copy and reproduction).

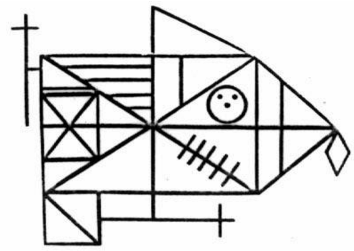

**Figure1**: Rey Complex figure A (RCF-A)

We used the digital version of the test consisting of a digital pen, "Anoto", equipped with a pencil ball and an infrared camera.
The used paper is finely rasterized. The frame is generated by a mathematical algorithm, which distributes a small and very light gray color dots in a very specific way. These points are read by the infrared camera which is equipped with the pen, which allows a very precise identification of the tracing point of the pen on the sheet (figure 2) [6].

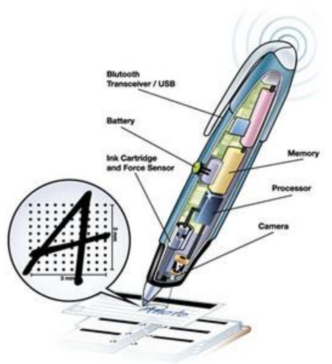


**Figure 2**: The digital pen and the digital testing paper [6].

Once the pen is connected to the computer, a specific "Elian" software "Expert Line Information Analyzer" automatically processes the data [8].

Two quotations are made: the numerical dimensioning and the dimensioning of the figures.

The numerical dimensioning which is carried out in this study by the same psychologist is based on the principle of noticing each of the 18 elements of the figure from 0 to 4 points according to the accuracy of each unit and relative position within the whole of the design. The total score is 72 points.

The obtained scores are organized into three classes of percentiles to interpret the results. The subjects whose central values between the 25th and 75th are considered to have a "normal" cognitive and neuropsychological profile, those between the 10th and 25th or 75th and 90th percentiles are considered "tangent" or "to be monitored", finally the subjects with extreme values either < 10th or 90th < are considered as "abnormal or pathological" cases.

The used type of organization is identified by using the ELIAN software, which records the succession of traits.
The breeding type rating is assessed according to the one established by [9] and then by Wallon [7]. There are seven types of organization:

- Type 1: The subject begins the drawing by the large central rectangle as a framework in which he will group the other elements. This type is seldom noticed among children.
- Type 2: The subject begins with one of the details and then completes his production by the central rectangle by using it as the framework of his drawing.
- Type 3: The subject begins by reproducing the full contour of the figure without explicitly differentiating the central rectangle. He obtains a contour in which the other interior details are placed.
- Type 4: The subject juxtaposes the details to each other and there are no directing elements in the drawing of the figure. The whole is globally recognizable and can be perfectly successful.
- Type 5: (detail on confused background): the subject provides a little structured graphic in which one cannot recognize the model, but certain details are clearly recognizable.
- Type 6: the subject returns the figure to a schema familiar to him and the figure is generally reduced.
- Type 7: The figure is very incomplete or has no connection with the figure. This is a "helter-skelter".

### 2.4 Statistical analysis

The statistical analyzes were performed using a statistical analysis software. We also presented in the tables the mean values, and the standard deviation for each variable.

We used analysis of variance and test khi-two to determine the association between anemia and cognitive performance of children. p <0,05 was taken as a minimum level of significance.

## 3. Results

### 3.1 Prevalence of anemia

The mean hemoglobin concentration was 12.51 g/dl. The Mean ± SD value of Hb, Hct, VGM, TCMH, CCMC and serum iron, according to sex are given in Table 1. There was no significant difference between girls and boys according to the variables.

The prevalence of anemia in the sample is 16.2%. This rate is higher for boys than girls but without any significant difference (p> 0.05).

**Table 1:** Hematological parameters

| Parameters | All children(N=152) | Boys (N=70) | Girls (N=82) | *P* |
|---|---|---|---|---|
| Hb (g/dl) | 12,51±0,79 | 12,46±0,9 | 12,56±0,63 | 0,29 |
| Hct (%) | 38,46±2,04 | 38,49±1,78 | 38,42±2,3 | 0,85 |
| MCV (fl) | 82,25±4,68 | 82,66±4,21 | 81,82±5,14 | 0,31 |
| MCH (pg) | 26,72±2,13 | 26,83±1,94 | 26,59±2,33 | 0,52 |
| MCHC (g/dl) | 32,38±1,06 | 32,38±1,02 | 32,39±1,11 | 0,96 |
| Seric iron (µg/dl) | 0,79±0,29 | 0,81±0,3 | 0,76±0,27 | 0,44 |

*Hb: Haemoglobin; Hct: haematocrit; MCV: mean corpuscular volume;*
***MCH: mean corpuscular haemoglobin; MCHC: mean corpuscular haemoglobin concentration analyses***

### 3.2Digital Rating

The descriptive analysis of the numerical dimensioning is illustrated in Table 2. The results are presented as position parameters (Mean, median, percentiles, minimum and maximum) and dispersion (standard deviation and coefficient of variation).

**Table 2:** Descriptive analysis of the different items of the "copy" and "recall" trials in all children

| | Mean | Med | σ | Min | Max | Centiles | | | | CV % |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 10th | 25th | 75th | 90th | |
| Clinical rating (copy) | 60,98 | 65 | 11,06 | 5 | 75 | 46,1 | 56 | 69 | 71 | 18,13% |
| Clinical rating (recall) | 33,66 | 33 | 14,43 | 3 | 70 | 14,2 | 22 | 45 | 53 | 42,86% |

***Med: median; σ: standard deviation; Min: minimum; Max: maximum; CV % : coefficient of variation. < 10 et > 90: Pathological cases; between 10$^{th}$ and 25$^{th}$ & between 75$^{th}$et 90$^{th}$: to be monitored; between 25$^{th}$ and 75$^{th}$: Normal cases.***

The results of the descriptive analysis which is presented in the former table show that all the mean scores corresponding to the different elements are located between the 25th and the 75th percentile. This class of values is grouping the normal persons in our sample. The distribution of the total points of the clinical score obtained by each student during the copying phase shows a very large dispersion of 18.13%. However, this variation is much more pronounced during the recall trial (42.86%).

Table 3 shows the average scores and their distribution in anemic and non-anemic children.

In copy trial, which provides information on the visual perception, the average score which was obtained from the clinical score is 55.5 in anemic children and 61.97 in non-anemic children with an observed significant difference (p <0.05). In the reproductive phase, which provides information on the working memory, the average score of clinical score in anemic and non-anemic children is respectively 23.85 and 34.87. The observed difference is significant (p < 0,05).

**Table 3:** Distribution of the prevalence of cognitive deficits in anemic and non-anemic children

| | Children with anemia<br>N=25<br>Mean ± SD | Children without anemia<br>N= 127<br>Mean ± SD | *P* |
|---|---|---|---|
| Clinical rating scores (copy) | 55,5 ± 7,94 | 61,97 ± 10,89 | 0,03* |
| Clinical rating scores (memory) | 23,85 ± 13,25 | 34,87 ± 13,88 | 0,005** |

*SD: Standard-deviation; * Significant at 0.05; ** Significant at 0.01*

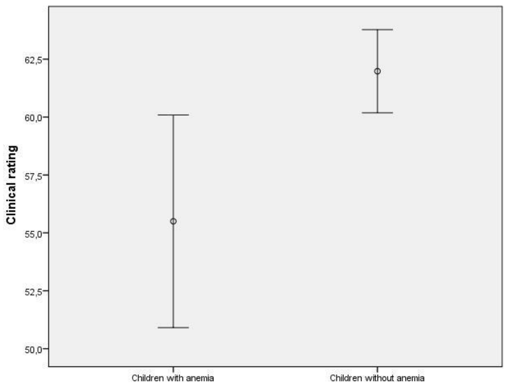


**Figure 3:** distribution of means of clinical rating, on copy trial, according to anemia

The variance analysis showed a significance difference between anemic and non anemic children in both copy (F=4, 69; 0,03) (Figure 3), and recall (F=8,09; p=0,005) (Figure 4) trials. This result demonstrated that children without anemia are more performant that anemic children.

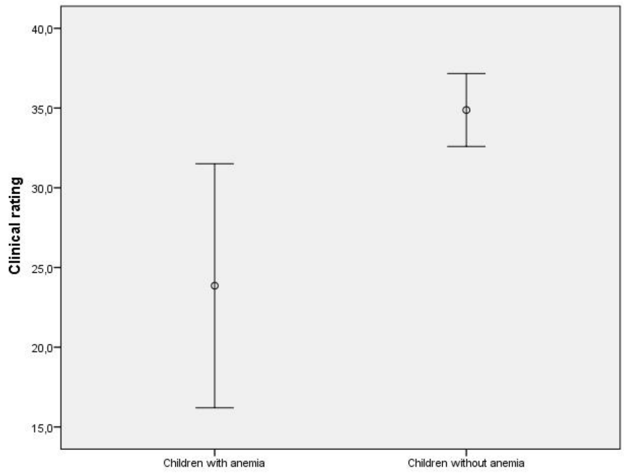


**Figure 4:** distribution of means of clinical rating, on recall trial, according to anemia.

According to the results presented in Table 4, it is shown that in the copy trial, type 3 and 4 are the most frequently used by anemic children, with the rates 50% and 37.5% respectively. However, the majority of non-anemic children chose types 1 and 4. Khi-square test showed a strong association between anemia and the reproduction type distribution (p <0.005).

**Table 4:** Distribution of anemic and non-anemic children according to types of realization

| | Type | Children with anemia (n=24) | Children without anemia (n=128) | $X^2$ | p |
|---|---|---|---|---|---|
| Copy | 1 | 1 (4,2%) | 29 (23%) | 18,32 | 0,003** |
| | 2 | 1 (4,2%) | 15 (14,5%) | | |
| | 3 | 13 (50%) | 18 (16,5%) | | |
| | 4 | 9 (37,5%) | 63 (44,2%) | | |
| | 5 | 0 (0%) | 1 (0,6%) | | |
| | 6 | 1 (4,2%) | 2 (1,2%) | | |
| Recall | 1 | 1 (4,2%) | 47 (33,9%) | 13,56 | 0,01* |
| | 2 | 3 (12,5%) | 13 (11,5%) | | |
| | 3 | 13 (50%) | 28 (22,4%) | | |
| | 4 | 6 (25%) | 24 (20,6%) | | |
| | 5 | 0 (0%) | 7 (4,2%) | | |
| | 6 | 2 (8,3%) | 10 (7,3%) | | |

**** Significant at 0.05; ** Significant at 0.01***

## 4. Discussion

Memory disorders are real problems which lead to disabilities in learning and hence to academic failure among children. Morocco is not immune to this problem as long as in a study of children in Kenitra aged 3 to 13 years, 27% of children suffer from perceptual problems and signs of memory deficits [10]. In another recent study among adolescents in Sidi Slimane region, 34% showed signs of perceptual deficit and more than 21% showed signs of memory deficit [11].

This study aims to show the relationship between anemia, constructional praxis and visual memory by the Rey complex figure test (FCR-A) in its computerized version. It has been widely validated as a psychometric tool which identifies various memory problems, visual perception of geometric shapes and spatial organization.

In the present study, we will focus on the main anemia effects on the neuro-cognitive abilities of school-aged children in Kenitra region.

Iron deficiency in children has been shown to impair cognitive functions and learning abilities [12]. These findings are consistent with some of the characteristics of learning disabilities studied [13]-[12]. Moreover, longitudinal studies consistently indicated that children anemic in infancy continue to have poorer cognition, school achievement, and more behavior problems into middle childhood [14]-[11].

According to the results of this study, 16.2% of children are anemic. Similarly, Aboussaleh found anemia in 12,2% of children in Kenitra region in Morocco [15].

Clinical rating of the RCF test showed a significant difference (p<0.05) between anemic and non-anemic children in both trials (copy and recall), which consequently shows that there is a relationship between anemia and cognitive performance of children. Other epidemiological studies have shown that iron deficiency anemia among young children is associated with delayed cognitive development [16]-[17]-[18].

The results demonstrated also that there is an adverse effect of anemia on perceptual organization (the type used). Non-anemic children perceived figures in several randomly assembled elements which form the whole unit (type 4) while the majority of anemic children seemed to perceive the figure in its totality, and hence bring it back to a familiar pattern (type 3). This strategy leads these children in the copy trial to produce little detailed figures and consequently achieve low scores once compared to non-anemic children. On the other hand, this type of reproduction seems to allow good memorization in children by using type 3 as long as they do not have much loss of information between the copy and recall trials. This observation was already confirmed by the work of the collaborators. Children who have used the strategy of juxtaposing details to each other (type 4) in the copy lost a lot of information during the recall trial and these two different levels of perception were also reported by many scientists. One of them is Bossuroy [19] who reported that French children preferred the technique of juxtaposition of details (type 4) and had more analytical work concentrating on singular objects which were located in the foreground, whereas, Burkinabe children tend to emphasize contextual information, with a holistic view which is more dependent on the context (type 3).

The results of the present study, confirm the existence of an important relationship between anemia and children's cognitive performance. This result is similar to one achieved by Sungtong [20] who demonstrated that hemoglobin level is correlated with school performance, particularly in school-age children with iron deficiency.

## 5. Conclusion

On the Basis of our results, memory scores are higher in non-anemic children. This confirms that iron in fact contributes to the improvement of the intellectual learning and memory performance in early childhood. Moreover, the order of carrying out the work (whether global or juxtaposing) in copy trial, impacts accuracy of recall. The results also confirmed that iron status is a significant factor in spatial organization and visual perception in schoolchildren**.** Therefore, nutritional education is associated with a cognitive remediation of impaired abilities which is necessary in managing this category of patients.

## References

[1] WHO, Worldwide prevalence of anaemia 1993-2005: WHO global database on anaemia, 2008.
[2] Ministère de la Santé, Lutte contre les troubles dus aux carences en micro-nutriment. Manuel à l'usage des professionnels de santé, 2008.
[3] Walker, S. P., Wachs, T. D., Gardner, J. M., Lozoff, B, Wasserman, G. A., Pollitt, E, Julie, A., International Child Development Steering Group. Child development: risk factors for adverse outcomes in developing countries. The lancet, 369 (9556): 145–157, 2007.
[4] Stoltzfus, R. J., Mullany, L., & Black, R. E, Iron deficiency anaemia. Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors 1: 163–209, 2004.
[5] WHO, Iron deficiency anaemia: assessment, prevention and control. A guide for program managers. World Health Organization, Geneva, Switzerland, 2001.
[6] Wallon, P., et Charles Mottier. Une méthode de recrutement rigoureuse pour l'admission en écoles professionnelles. Psychologie du Travail et des Organisations, 15 (2): 199–218, 2009.
[7] Mesmin, C, & P. Wallon. 2002. La figure de Rey, une approche de la complexité. Paris: Érès.
[8] P. Wallon, et C. Mesmin. 2009. Nouveau Manuel de la figure complexe de Rey, Paris: ECPA.
[9] Osterrieth, P. A., 1944. Le test de copie d'une figure complexe; contribution à l'étude de la perception et de la mémoire. Archives de Psychologie.
[10] Ahami, A.O.T., A. Lachheb, K. Dik, F. Azzaoui, Y. Aboussaleh, P. Wallon, et C. Mesmin, Etude des déficits perceptifs et mnésiques chez les enfants d'âge scolaire. Front. Neurosc. Conférence abstract: 2nd NEUROMED Workshop. doi:10.3389/conf.fnins.2010.12.00045, 2010.
[11] Eloirdi, A., A. Arfaoui, et A. O. T. Ahami, Evaluation des déficits mnésiques et perceptifs par la version numérique du test de la figure complexe de Rey A chez des adolescents scolarisés, 2016. Available: https://www.researchgate.net/publication/311666090.
[12] Bruner, A.B., Joffe, A, Duggan, A.K, Casella, J.F, Brandt, J. Randomised study of cognitive effects of iron supplementation in non-anaemic iron deficient adolescent girls. Lancet, 348:992– 6, 1996.
[13] Taras, H., Nutrition and student performance at school. Journal of school health 75 (6): 199–213. 2005.
[14] Grantham-McGregor, S., & Ani, C. A review of studies on the effect of iron deficiency on cognitive development in children. *The Journal of nutrition*, *131*(2), 649S-668S, 2001.
[15] Aboussaleh, Y., A.O.T. Ahami, F. Bonthoux, C. Marendaz, S. Valdois, et S. Rusinek, Performances cognitives des enfants anémiques âgés de 6 à 11 ans en milieu urbain du nord-ouest Marocain. Journal de thérapie comportementale et cognitive 16 (2), 49–54, 2006.
[16] Walker, AR., The remedying of iron deficiency: what priority should it have. British Journal of nutrition 79 (3), 227–235, 1998.
[17] Hurtado, E.K., A.H. Claussen, et KG. Scott. 1999. Early childhood anemia and mild or moderate retardation. Am J Clin Nutr; 69, 115-9.
[18] Murray-Kolb, L.E., & Beard, J.L. Iron treatment normalizes cognitive functioning in young women. The American journal of clinical nutrition, 85(3), 778-787, 2007.
[19] Bossuroy, M., et et al. 2014. The impact of cultural background on structural figure perception: Cultural biase in the reproduction of the Rey-Osterrieth Complex Figure, Journal of cognition and culture.
[20] Sungthong, R., Mo-Suwan, L., et Chongsuvitatwong, V. Effect of haemoglobin and serrum ferritin on cognitive function in school children, 11 (2): 117-122, 2002.

## Author Profile

**Imane Achouri** received the B.S. and M.S. degrees in Biological studies from Ibn Tofail University, Faculty of sciences in 2009 and 2011, respectively. She is now a PhD student in Department of Biology, Neurosciences and Nutritional Health/ Ibn Tofail University, Morocco.