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# DIAGNOSIS OF DYSLEXIC DISORDERS AND IDENTIFICATION OF FACTORS ASSOCIATED WITH READING LEARNING DISABILITIES WITHIN THE MOROCCAN CONTEXT

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## SUMMARY

### Background:

Reading acquisition disorders constitute the main problem in children's learning. In Morocco, epidemiological data are very rare. Research, mainly in the English language, concerns either the sociological or the cognitive field. Few studies, among them not one in Arabic, have explored the link relating to social and cognitive factors. The purpose of our work is to study and analyze the cognitive and social variables related to different reading skills among Moroccan pupils in primary and secondary public schools.

### Material/ Methods:

From a sample of 754 learners (388 boys and 366 girls) ranging in age from 9 to 15 years with an average of 11.59 years, the diagnostic tests identified 145 students with deficient skills „Bad readers (BR),” 128 suspected of being in difficulty classified as « intermediate level (IL) » and a group of 481 children as good readers (GR). Statistical analyses have shown that the first two groups (BR and IL) represent 24% in the favoured areas compared to 43% in the disadvantaged.

### Results:

The analysis of scores and the nature of the errors made on various reading tests show that 41 students, or 5.43% of our sample, present a dyslexia profile. 13 (1.72%) of whom have very severe difficulties. The phonological aptitudes (Rapid automatized naming, phonological short-time memory and especially phonological awareness) mainly reflect the level of reading. These phonological abilities are highly influenced by early attendance of preschool and by the degree of exposure to written language at home. These data, which are unique in Morocco, are consistent to that of the published subject literature. They make it possible to plan preventive actions by generalizing pre-school teaching, particularly in precarious environments. These actions should be based on playful exercises aimed at improving phonological abilities at an early age, while exploiting the brain sensitivity to reading at that age.

### Conclusions:

Phonological awareness and rapid naming are the most implicated factors in the disparity of reading skills. These abilities are highly influenced by the integration of preschool at a very early age and by the degree of exposure to written language activities. Therefore, there is a need to plan preventive actions, based on playful exercises, aiming to improve phonological skills from the pre-school period

**Keywords:** learning, reading, diagnosis, dyslexic disorders, morocco

## INTRODUCTION

Reading is a complex mental operation, qualified as cognitive by specialists, it requires a long and difficult period of learning. Cerebral plasticity is the motor element in the neural processes involved in learning to read (Alain, 2009). Different areas of the brain are implicated in this mental activity, so that anomalies in one or more areas of these brain zones cause reading disorders. (Hale & Fiorello, 2004; Shaywitz, 2005). A study by Pugh and colleagues have showed that the main cause of reading disorders was related to a functional disconnection between the phonemic and graphemic systems in the lower parietal lobe (Fiorello, Hale, Snyder, 2006). According to scientific knowledge devoted to the mechanisms involved in the learning of reading, a theory of two ways seems to be imposed. After been recognized by the primary visual lobe and treated in its prelexical context by the left occipital-temporal junction, the information of the word to be read follows one of the two paths: the first so-called analytic (assembling or indirect, the word is read by grapho-phonological conversions). The second path is direct or addressing (the word is read in a global manner by accessing its meaning through the activation of the mental image of this word) (Billard & Delteil-Pinton, 2010)

The acquisition and automation of reading being a laborious cognitive process, can be affected by various factors that are both biological (uncorrected sensory deficits, attention disturbances, mental retardation and oral language disorders) and/or environmental (educational or pedagogical deficiency, the cultural deprivation, social and family problems).

However, apart from all these possible causes, a percentage of children still have significant alterations in reading skills: these are children with severe difficulties and whose profile evokes developmental dyslexia. Considerable advances in neuroscience within imaging have revealed that this specific reading acquisition disorder (proven, durable and unintended) is linked to cerebral dysfunction (Inserm, 2007; Shaywitz, Gruen, & Shaywitz, 2007; Vellutino, Fletcher, Snowling, et al, 2004). In Morocco, the prevalence and knowledge about this developmental disorder in the school environment is very limited. Moreover, the Department of School Education does not recognize the existence of this cognitive handicap (Badda, 2008).

Several and varied pieces of scientific research have been conducted to study reading difficulties Stanovitch, Nathan & Vala-Rossi, 1986; Alegria, Leybaert & Mousty, 1994). This concern is reasonable when we know that reading acquisition is the basis for all other school learning and that children with social integration difficulties have reading difficulties Delahaie, Billard, Gillet, Tichet & Vol, 1998). By exploring emotional and behavioral problems, some studies describe reading difficulties as a potential factor in adolescent psychiatric disorders. (Arnold, Goldston, Walsh et al, 2005). Other studies have shown a strong link between school dropout, suicide attempts and written language difficulties among adolescents (Daniel,

Stephanie, Adam, Walsh & David, 2006; Bender, Rosenkrans & Crane 1999). The impact of social factors has been widely described in international documentation (Billard, Fluss, Richard et al, 2007; OCDE, 2004; Shaywitz, Fletcher, Holahan et al, 1999; Noble & McCandliss, 2005). A high frequency of reading disorders has been found in unfavourable environments (Brooks-Gunn & Duncan, 1997). Similarly, some authors have highlighted the association between the socio-economic level and learning disabilities in general (Brooks-Gunn & Duncan, 1997). In the field of cognitive science, the predominance of the phonological in the disparity of reading competencies has been consensually recognized (Vellutino, Fletcher, Snowling et al, 2004; Ziegler & Goswami, 2005; Wagner, Torgesen, Rashotte et al, 1997). In Morocco, the Supreme Council for Education stated, in its report on the state of the educational system, that a considerable number of Moroccan primary school learners have significant reading difficulties (Badda, 2008). But no study has examined the factors underlying the reading skills of these students. In conclusion, our study has in part the objective of filling the knowledge gap on the factors involved in reading difficulties in the Arabic language among Moroccan Arabic-speaking students. Our approach consists in identifying and analyzing factors that account for the variability of reading skills according to two main axes: the cognitive and socio-cultural, while taking into account their interactions. We will also attempt to interpret the influence of these factors from a neurobiological point of view, based on scientific data from recent studies in the field of neuroscience.

## **MATERIAL AND METHOD**

### **Population**

Our prospective study was carried out on a population of 754 primary and secondary school students enrolled in public teaching in the Beni Mellal-Khenifra region located in the centre of Morocco. The selection of the sample was based on academic performance (good, average and low) so that the learners, with equal proportions, selected belong to the three levels of academic performance.

### **Data collection**

The collection of general data was carried out by completing a fact sheet with students that provided information on socio-cultural and economic characteristics (the language spoken at home, siblings, parents' occupation and educational level, preschool attendance ...), subsequently from the students' medical records and by questioning their teachers. This led us to exclude 27 students from the initial sample of 781 participants, those who did not meet the exclusion criteria defining dyslexia (Sensory perception disorders, severe difficulties in oral comprehension, attention deficit and psychological emotional disabilities).

### **Protocol and tools for evaluating reading**

The tests were administered individually, the duration varying from one hour 30 minutes to 2 hours depending on the particularity of each student. The protocol consists of 12 tests, the latter evaluate the reading of isolated words in Arabic (5 tests), phonological aptitudes (5 tests), and visual-attention skills (2 tests). This evaluation is sometimes conducted in two stages, taking into account the availability of some participants and sometimes to avoid the state of fatigue observed in others.

- Reading Test in One Minute (RTOM) of words in Arabic vocalized (Khoms, 1999); (reading aloud).
- Reading tests (reading aloud) of the various categories of Arabic words (simple and plural words without diacritics, pseudo-words with and without diacritics) inspired by the LABEL software (software for evaluating and re-educating oral and written language of Arabic-speaking people) (Jaquier-Roux et al, 2005).
- Phonemic counting in Arabic (Badda, 2008): test based on the work of Ammar (1997);
- Suppression of the initial phoneme in Arabic (Badda, 2008): test based on the work of Ammar (1997);
- Comparison of letter sequences in French: a test that is part of the ODEDYS (Jaquier-Roux et al 2005). It is important to note that in this task the comparison time is taken into account
- Bells Test (ODEDYS, version 2005) (Jaquier-Roux et al, 2005)
- Rapid naming of images (RNI) in Arabic inspired by ODEDYS (2005)
- The verbal fluency test, the student is asked to quote as many words from a phonological or semantic category as possible in one minute.

At the base of the scores obtained in the different reading tests, students will be classified into 3 groups: good readers (GR), readers suspected of being in difficulty who have an intermediate level (IL) and bad readers (BR). This classification is realized by taking into account the dispersion of scores around the average for each age category. The low level is confirmed by a very poor score, compared to the average, on several reading tasks. Within the deficit group, the profile of dyslexia is identified by analyzing the nature and frequency of the errors made.

### **Statistics**

The statistical analysis will be presented in two parts: descriptive statistics, to describe the results obtained by the general characteristics of the population. Analytical statistics, intended to clarify the relationships and correlations between reading skills and those achieved on the various cognitive tests as well as other socio-economic and cultural data. The comparison of the „GR”, „IL” and „BR” groups was carried out by Chi<sup>2</sup> for the qualitative variables and the variance analyses for the quantitative variables.

## Results

### Population characteristics

The population studied is composed of 388 boys (52%) and 366 girls (48%). The students' ages range from 9 to 15 years with an average of 11.59 years (standard deviation being 1.82 years). The entire population is distributed over 7 school levels, ranging from grade 3 of elementary school to grade 3 of high school. According to the language spoken at home, 43% of the people in our sample speak „Amazigh” and 57% speak Arabic.

### Descriptive study

#### *Study of socio-cultural factors*

Due to a lack of this kind of knowledge at the national level, we present in this first part the descriptive statistics of the scores obtained in the reading tests according to different population characteristics. The present work will be a pioneering reference to consult in terms of scores, particularly for the age categories studied. The dominance of the descriptive analyses of the timed test in the reading of vocalized word is based on the spelling transparency generated by the vocalized writing system of the Arabic language. This system is characterized by strictly regular phonographic correspondences, making it possible to fully exploit the phoneme-grapheme conversion (PGC) rules. The RTOM is also a test that measures addressing speed, which is an important variable in terms of reading automation: Many children read slowly by assembling procedure, and are therefore penalized in terms of reading time.

#### *Results of RTOM by age category and the reading levels in the sample studied*

The table (1) gives descriptive statistics for each age category at RTOM of vocalized words. The minimum score of zero (0) indicates the existence, within our population, of students with very severe reading difficulties, these students are failing to correctly decipher any words per one-minute unit of time. On the other hand, the maximum value of 139 words per minute testifies to a fluid and automated reading (see: Table 1).

In order to classify students into groups of „Good Readers” (GR), „Intermediate level” (IL) and identify the group of „Bad Readers” (BR), within which the pro-

Table 1. Descriptive statistics of the reading test in one minute by age category

Age (year)	9	10	11	12	13	14	15	16	sample studied
<b>Minimum</b>	0	0	0	0	0	0	4	2	<b>0</b>
<b>Maximum</b>	92	106	93	137	113	108	139	132	<b>139</b>
<b>Mean</b>	40,54	41,65	44,95	48,02	52,37	55,83	59,19	51,72	<b>46,89</b>
<b>Standard Deviation</b>	19,12	16,68	19,47	22,86	26,53	24,64	27,18	19,7	<b>24,14</b>

file of dyslexia will be identified, an analysis of scores by age category is necessary (see: Fig. 1). The proportions of the three reading levels in our sample are illustrated in Figure (1), 35% of the population surveyed did not automate the reading acquisition process.

*RTOM and reading level according to socio-economic environment*

The distribution of timed reading test (RTOM) scores according to socio-economic environment is represented in Figure 2.

A quarter of pupils with low scores are in the range of 0 to 37 words per minute in favoured zones compared to 0 -25 words per minute in non-favoured zones.

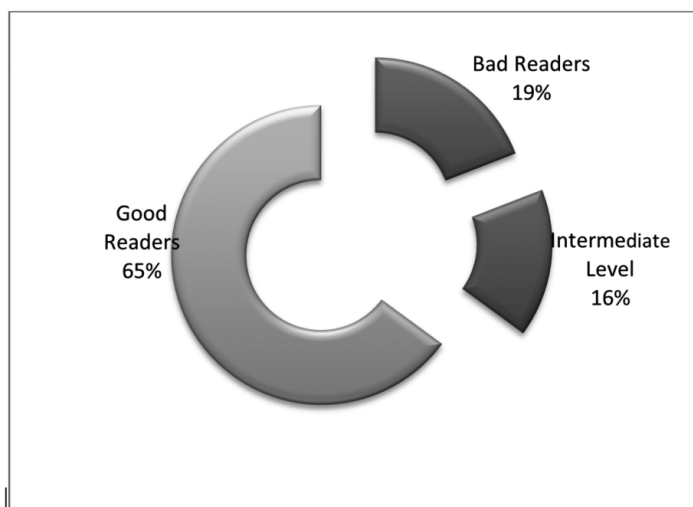


Fig. 1. Percentages of the three reading levels in the study population

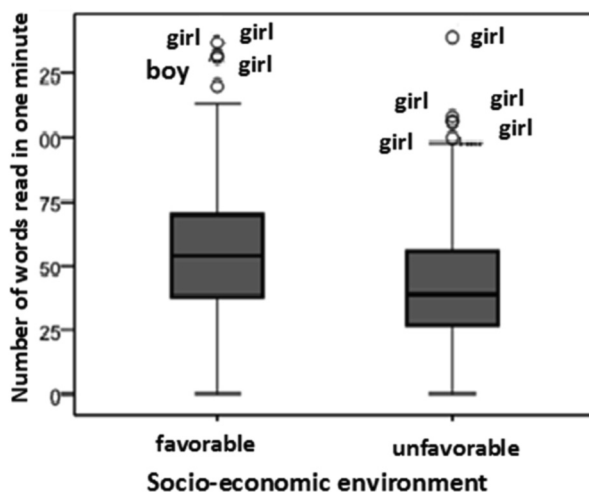


Fig. 2. Scores distribution at the RTOM according socio-economic background

The halves of learners with average scores are located respectively in both zones, between 37 and 71 and between 25 and 52 words per minute. Nine participants (eight girls and one boy) have atypical scores, compared to their peers, situated beyond the high borders. The score distribution is relatively symmetrical in privileged areas than it is in non-favoured areas. Learning reading difficulties are therefore not homogeneously distributed according to the socio-cultural environment, the proportions of the three reading levels in the two environments are illustrated in the figures below (Figures 3 and 4).

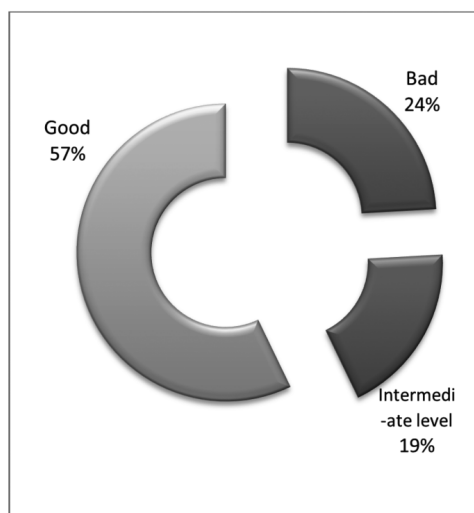


Fig. 3. Proportions of the three levels of reading in non-favored regions

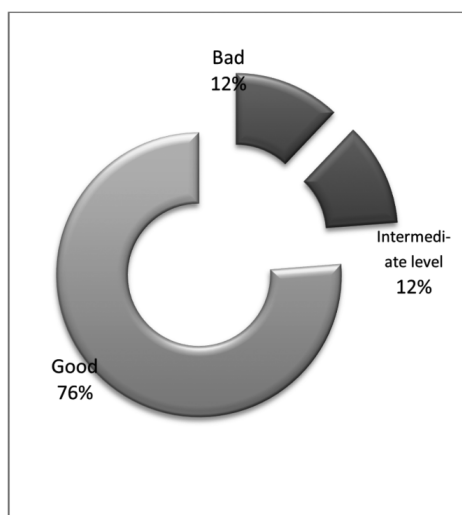


Fig. 4. Proportions of the three levels of reading in favored regions

*RTOM according to gender and preschool attendance.*

The results obtained at the RTOM are represented in the figure below, the girls average score is clearly higher: 52.04 words per minute than that of the boys: 42.09 words per minute (Figure 5). Similarly, there is an increase in the average score of words read correctly with the number of years passed in preschool (Figure 6).

Before identifying all the factors that can influence the variability of scores on various reading tests, the first observation to be drawn from this early stage of

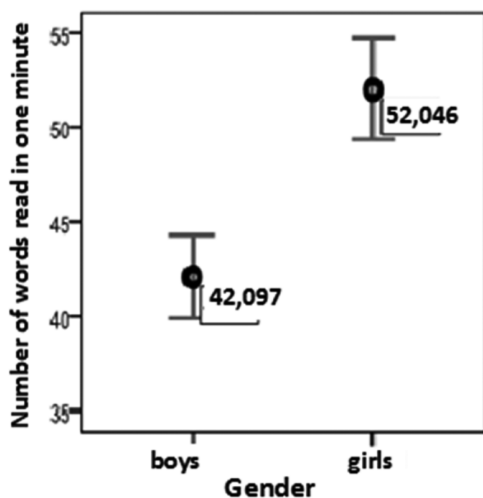


Fig. 5. Scores at the RTOM by gender

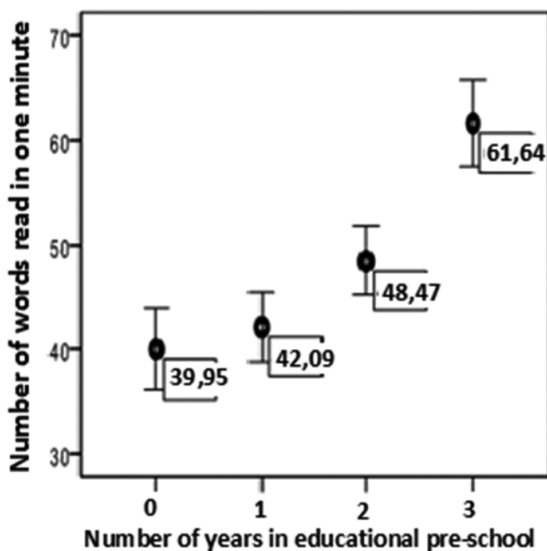


Fig. 6. Scores at the RTOM by learning preschool



the analysis is that gender-related cognitive skills as well as the age of exposure to written language activities are potential factors affecting reading learning.

*Scores at the RTOM according to parents' educational level*

The mean values of the RTOM scores according to the educational level of the parents are illustrated in the following figure (Figure7).

The mean scores of this test increase proportionally with the parents' level of education, the significance of the differences between the groups will be studied in the analytical analyses part.

*Reading simple and plural words without diacritics*

The distribution of scores in reading simple and plural words without diacritics according to the three levels of reading is represented in Figure 8.

In the category of simple words without diacritics (Figure 8a), the majority of good readers have a score above 7/10. While the scores of the „weak readers” group are distributed in the range of 0 and 7 out of 10. Within the latter, a few students scored above 8 out of 10, but they needed to set „pathological” times for decoding. The reading of plural words without diacritics is characterized by remarkable differences between the 3 groups. Thus, almost all the students in the „BR” group have scores below 5/10, while the majority of „good readers (GR) have scores above 8/10 (Figure 8b). Reading this category of words requires, in parallel with the assemblage process, a reinforced recourse to the lexico-semantic process, which seems very altered in those of the „BR” group.

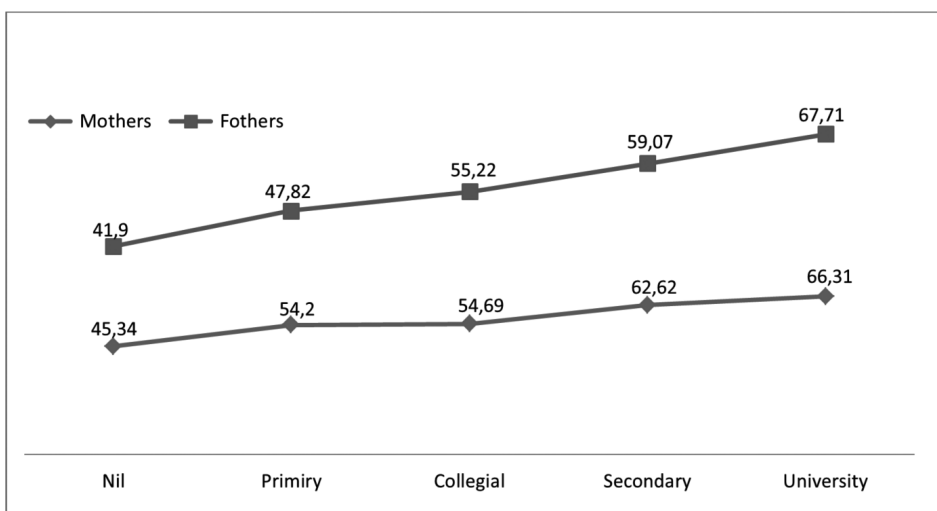


Fig. 7. Representation of the average scores at RTOM according to the educational level of parents

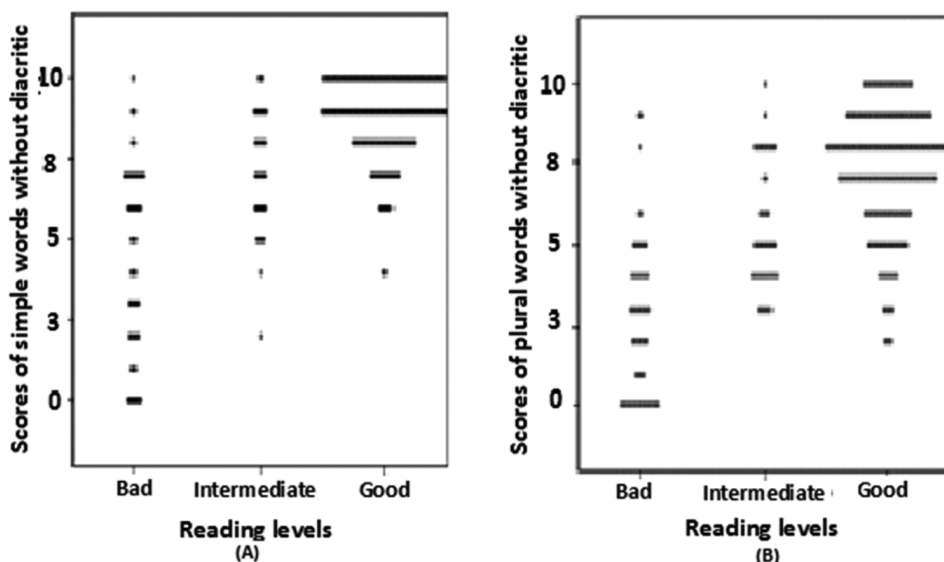


Fig. 8. Graphical representations of reading scores of simple words without diacritics (A); of reading scores of plural words without diacritics (B)

#### *The reading of pseudo-words with and without diacritics*

The reading of pseudo-words involves the phonological process (assemblage process), it requires the correspondence of graphemes-phonemes and the respect of their sequence.

We think that when decoding pseudo-words with diacritics, the students are required to perform important orthographical verifications, which makes decoding this category of words costly in terms of attentional capacities. These verifications seem to be carried out first at the level of the consonant skeleton and second at the level of the vocal signs. In this case, the cognitive overload limits the number of letters that can be mobilized in the short-term memory and prevents the correct decoding of the word. The student is unable to allocate enough attention to the vocalic signs (Figure 9).

#### *Incidence of the dyslexic profile in the sample studied*

Within the sub-population of Bad Readers (BR), the study of scores obtained and the qualitative analysis of errors produced during reading allowed us to identify a group of 41 children (5.43% of the initial sample studied) whose reading attitudes evoke a developmental dyslexia profile. These children with significant deficits, in several domains assessed, constitute the group of „dyslexics.” Within this last group, 13 students (1.72% of the initial population) had very severe difficulties during all the activities proposed, they obtained a score of 0 in some reading tests. These participants are classified as the most severely disabled and having the „symptoms” of „severe dyslexia.” The proportions of the four reading levels identified are shown in Figure 10.

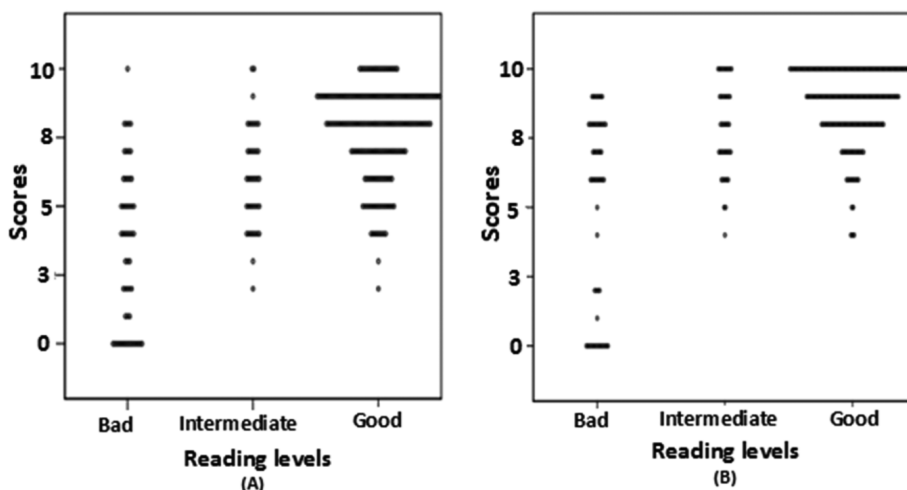


Fig. 9. Graphical representations of pseudo-words decoding scores with diacritics (A); and of pseudo-words decoding scores without diacritics (B)

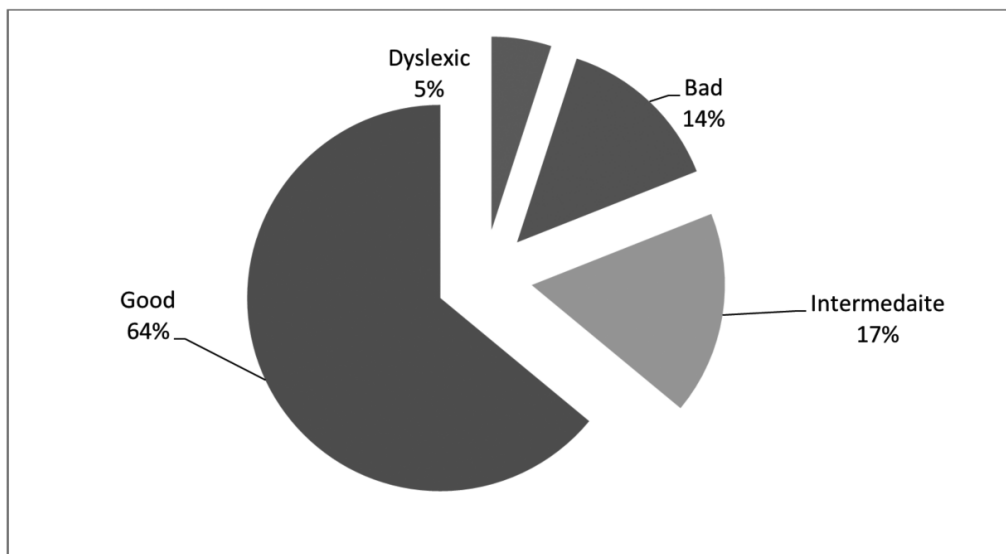


Fig. 10. Distribution of the four reading levels according to the population studied

*Distribution of „dyslexia” and „severe dyslexia” profile by gender*

Figures 11 and 12 illustrate the incidence of the dyslexic profile by gender. Among 41 „dyslexics,” the boys represent 63% compared to 37% of girls (26 boys and 15 girls, respectively 3.44% versus 1.98% of the initial sample). Among 13 students classified as having very severe difficulties, there are 9 boys and 4 girls (69% boys versus 31% girls).

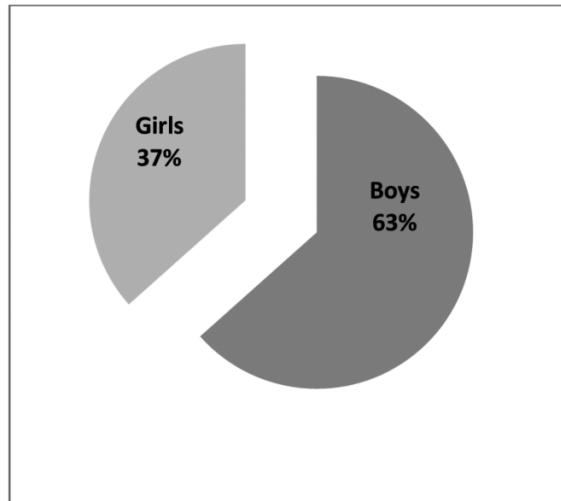


Fig. 11. Distribution of dyslexic profile by gender

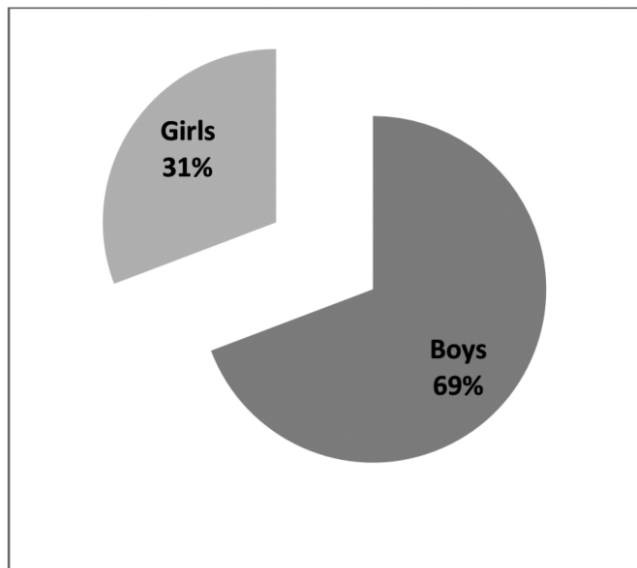


Fig. 12. Distribution of severe dyslexic profile by gender

### **Cognitive factors**

#### *Principal Component Analysis (PCA) of cognitive and social variables*

In this second part of the descriptive study, we will present the correlations between the different variables evaluating verbal cognitive functions (phonology, fluency) and non-verbal (visual attention) as well as the competencies underlying reading (rapid naming, short-term phonological memory, phonological awareness). The groupings of the variables, reflecting their inter-correlation-ships and

similarities/dissimilarity, given by the principal component analysis (PCA) are represented in Figure 13.

The PCA graph shows the presence of two slightly separated packages of variables which are positively correlated. The first translates strongly positive correlations between the RTOM, PSTM, PVF, SPVF, BT and the reading level, this signifies that the scores obtained in these tests are moving in the same direction. We also note the presence of negative correlations between these variables and the rapid naming of images (RNI) evaluated by time in seconds, which indicates that students who perform well in these tasks take less time to name the images and vice versa. The second group of variables shows a positive correlation between DTIPA, TPCA, and CLS. The distribution of all the points representing the variables with the reading level in only one side of the first component suggests that the phonological aptitudes (phonological awareness, short-term phonological memory, rapid naming) and visuo-attentional skills can be determining factors in the reading level.

The projection of different variables and factors on the factorial map of the PCA suggest that verbal and non-verbal cognitive functions (TBD, PVF, SPVF) and the underlying skills of reading (PSTM, DIPA, PCA) are correlated strongly and positively with parents' educational level, the number of years in preschool and, to a lesser extent, with siblings' schooling and educational level. Whereas, all these variables have a strong negative correlation with the number of school repetitions, this seems very logical since repetitions are noted among students

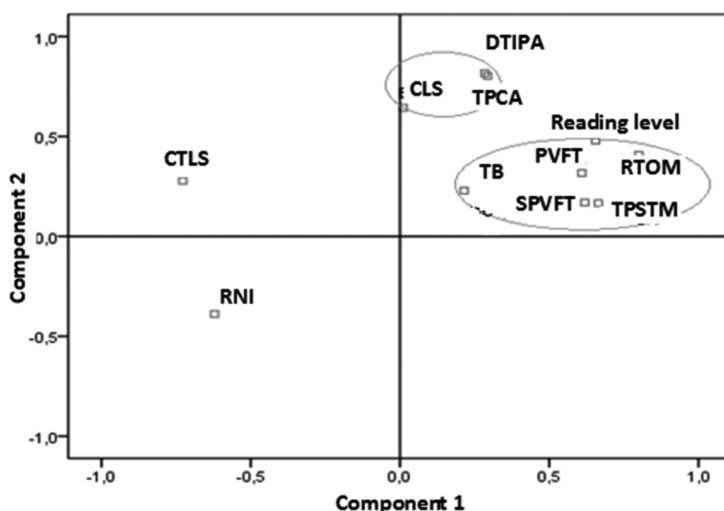


Fig. 13. Representation of correlations between the different variables evaluation cognitive functions by PCA

DTIPA: Deletion Test of the Initial Phoneme in Arabic; TPCA: Test of Phoneme Counting Arabic; RNI: Rapid Naming of Images; RTOM : Reading Test on One-minute; TB : Bells' Test; CLS: Comparison of Letters Sequences; CTLS : Comparison Time of Letters Sequences; TPSTM : Test of phonological short-term memory; PVFT: Phonemic verbal fluency Test; SPVFT: Semantic and phonemic verbal fluency Test

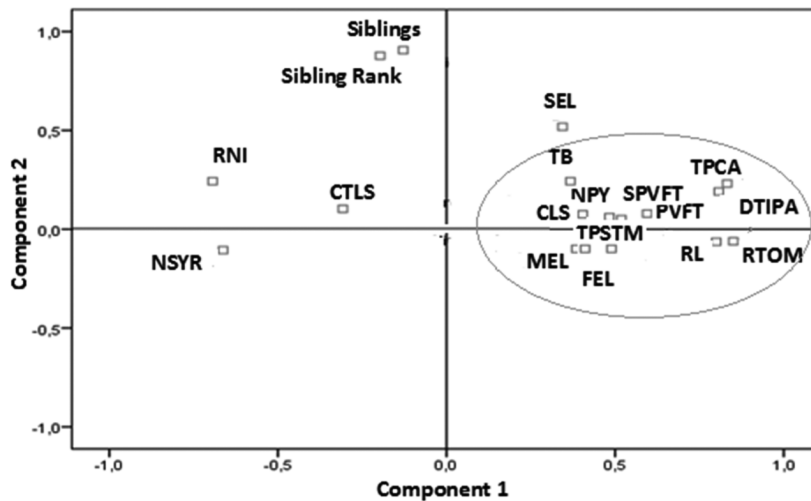


Fig. 14. Representation of interactions between cognitive and social variables in PCA. NPY: Number of pre-schooling years; MEL: The mother's educational level; FEL: The father's educational level; NSYR : Number of school years repeated; SEL : The siblings' educational level; RL: Reading levels

who have obtained poor scores at various tests (see fig. 14). This finding inform one as to the extent to which reading acquisition is a foundation for academic success, the variables studied are less sensitive to siblings.

### Analytical study

#### **Comparative study of the three reading levels on the social and cognitive plane**

In this part, we will analyze the factors related to reading performance by comparing the three level groups (GD, BR and IL) according to different socio-cultural characteristics and at the different tests evaluating verbal and non-verbal cognitive skills (Table 2), the difference between the mean age of the three groups was significant ( $p=0.046$ ;  $p=0.01$ ). Seventy-nine percent (79%) of „BR” were schooled in non-favoured areas and 21% in favoured areas.

All reading scores are significantly deficient among students in the „GR” and „IL” groups. In the case of timed reading tests, statistical analyses take into account the reading time. With the exception of the Bells' test scores ( $p>0.05$ ), the „BR” and „IL” groups had significantly lower results than the GR groups ( $p<0.001$ ) on all verbal and non-verbal cognitive tests. Thus, phonological skills are more deficient, rapid naming time (RN) is longer when the reading was low. In the domain of socio-cultural factors, „GR” children often have parents and elder siblings with a high level of education. The parents are executives or they belong to the so-called intellectual professions ( $p <0.001$ ). In the „BR” group, the number of children in families is higher ( $p<0.001$ ). Preschool attendance and especially the

Table 2. Cognitive and socio-cultural data of the three readers groups

Variables	Modalities	BR (N=135)	IL (N=113)	GR (N=459)	P
Reading tests	1	4,37 (2,87)	7,18 (1,81)	8,85 (1,18)	< 0,01
	2	2,69 (2,37)	5,54 (1,94)	7,37 (1,81)	< 0,001
	3	3,43 (2,86)	6,03 (1,88)	7,76 (1,66)	< 0,001
	4	4,91 (3,49)	7,92 (1,683)	8,81 (1,32)	< 0,001
	RTOM	15,55 (8,7)	31,68 (4,62)	59,97 (18,53)	<0,001
Cognitive competencies underlying reading	RNI	37,10(13,94)	24,27(6,62)	21,25 (5,12)	< 0,001
	TPSTM	2,95(0,76)	3,50(0,84)	4,43 (0,74)	< 0,001
	DTIPA	5,64(2,91)	7,06(1,85)	9,06 (1,25)	< 0,001
	TPCA	4,84(2,49)	7,26 (2,23)	8,26 (1,33)	< 0,001
	TB	27,85(3,62)	28,42 (3,75)	28,44 (3,75)	NS
	CLS	1,16(0,97)	2,37 (1,48)	18,02 (1,91)	< 0,05
	PVF	2,17(1,81)	3,76 (2,11)	3,76 (2,11)	< 0,05
SPVF	16,62(2,65)	18,02 (1,91)	2,37 (1,48)	< 0,05	
Mother's educational level (N=702)	1	123(92,5%)	90(80,4)	301(65,9 %)	<0,001
	2	9(6,8%)	15(13,4%)	106(23,2%)	
	3	1(0,8%)	7(7,3%)	50(11%)	
Fother's educational level (N=663)	1	108(83,7%)	62(73,9%)	219(50,4%)	< 0,001
	2	17(13,2%)	19(17,1%)	118(26%)	
	3	4(3,3%)	9(9%)	107(23,6%)	
Number of pre-schooling years	0	32(37,6%)	22(27,5%)	57(16,91%)	0,001
	1	38(44,7%)	36(45%)	93(27,59%)	
	2	15(17,6%)	13(16,3%)	106(31,45%)	
	3	0%	9(9%)	81(24,03%)	
Language spoken at home	Arabe	39(29,1%)	52(46%)	310(67,8%)	< 0,001
	Amazigh	95(70,1%)	61(54%)	146(31,9%)	
Gender	Girls	50(37%)	46(40,7%)	250(54,5%)	< 0,001
	Boys	85(63%)	67(59,3%)	209(45,5%)	
Educational level of older siblings	1	4(6,8%)	9(14,3%)	11(4,9%)	< 0,001
	2	32(54,3%)	25(39,7%)	104 (46,2%)	
	3	23(38,9%)	29(46%)	109(48,5%)	
Siblings	1	4,03 (1,71)	3,63 (1,50)	3,36 (1,45)	< 0,001
	2	3,24 (1,89)	2,92 (1,73)	2,55 (1,56)	< 0,001

p: Khi2 for qualitative variables, analysis of variance for quantitative variables. **Reading tests:**

1=reading simple words with diacritics; 2= reading plural words without diacritics; 3= reading pseudo-words with diacritics; 4 = reading pseudo-words without diacritics (timed tests and scores are on 10).

**Parental education level:** 1=unemployed; 2= primary and secondary college; 3= qualifying secondary and university. **Educational level of older siblings:** 1=without; 2=elementary and secondary college; 3=qualifying secondary and university. **Siblings:** 1= number of children in the family; 2= rank of birth.

number of years spent in this phase, before access to the first year of primary education, is highly significant between the „BR” and „GR” groups (p <0.0001). The percentage of students who attended preschool for three years is 0% in the deficit group (no children) versus 24% in the „GR” group. No significant difference between the averages of students who attended preschool for one year and those who did not integrate this preparatory step. About 68% of children in the group of good readers speak Arabic at home, while 32% of this group speak the „Amazigh” language. If we look at the gender of the participants, boys represent 63% in the „BR” group and 45% in the „GR” group.

**Statistical study of interactions between cognitive and social factors**

After identifying the factors that determine reading skills in both axes: the cognitive and social, in this part we will explore the interactions between these two categories of factors. This will be done to clarify the role of socio-cultural and especially socio-familial characteristics on reading competencies. Several studies have shown that phonological aptitudes and the socio-cultural environment influence decoding abilities (as confirmed by our present results). But they do not explain the interactions between the two domains. Table 3 represents the scores obtained at the subtests evaluating the reading performance according to the social factors described above.

The analyses of variance between the groups, defined on the basis of the number of years spent in preschool, shows that the differences between the average scores obtained in the tests evaluating reading skills (with the exception of BT and PSTM) are very significant between the group of students who did not attend preschool and that of those who integrated at preschool for 3 years ( $p = 0.000$ ). No significant difference exist between the averages of students who did not have access to preschool and those who benefited from a year of learning at this step. A significant difference ( $p < 0.05$ ) is noted between the performance of the Group „g2” and Group „g3”. With regard to gender, from the analyses of the T-test for independent samples, it is found that the average scores of girls are higher than those of boys with a very significant difference in the DIPA ,CPA and BT (  $T = 4.07$  ;  $p < 0.000$ ,  $T = 4.81$  ;  $p < 0.000$ , and  $T = 3.52$  ;  $p < 0.000$  respectively). Concerning the bilingualism factor, statistical analyses show that students who speak Arabic at home are better at phonological skills and fluency than those who speak „Amazigh.” The latter students take a long time to perform the rapid naming test (RNT) ( $T = -6.06$ ;  $p < 0.000$ ). In terms of non-verbal cognitive skills (BT and CTLS) there is no significant difference between the two sub-populations.

A linear regression model is explored to estimate the relative importance of each factor studied in determining the reading level. Based on reading test results in one minute, to determine students’ reading skills, we seek to specify what are the most relevant factors that can predict the performance at this reading

Table 3. Cognitive competencies related to reading by socio-family variables

Variables	DTIPA	TPCA	PSTM	RNI	PVFT
<b>Number of pre-schooling years</b>	<b>g0</b> 7 (3,2)*	6,03(3,22)*	3,34 (0,82)	29 (9,48)*	3,22(2,13)*
	<b>g1</b> 7,7 (2,75)	6,68(2,75)	3,28 (0,8)	29,28(11,43)	2,85 (1,78)
	<b>g2</b> 8,71(2,17)	8,38(2,18)	3,3(0,73)	27,62(10,3)	3,4(1,91)
	<b>g3</b> 9,7(0,66) *	9,22(1,15)	3,52(0,92)	22,95(6,38)	4,83(2,22)
<b>Gender</b>	<b>G</b> 8,75 (2,24)*	8,12(2,48)*	3,33(0,9)	26,91(10,5)	3,68(2,09) *
	<b>B</b> 7,23 (3)*	6,27(2,91)*	3,36(0,78)	28,72(9,95)	2,97(1,97) *
<b>L.S.H</b>	<b>1</b> 8,41 (2,2) *	7,30 (2,4) *	3,35 (0,77) *	25,93 (7,5)*	3,13 (1,8) *
	<b>2</b> 6,88(3,15) *	6,21(3,02) *	3,11(0,85) *	33,48(12,4)*	2,8(1,95) *

p: The difference is significant at the level: \*\* 0,05 ; \*\*0,001 ; \* 0,000. **Preschool:** g0= did not benefit from preschool ; g1= one year in preschool ; g2= two years in preschool ; g3= 3 years of apprenticeship in preschool. **Gender:** B= boys; G= girls; **L.S.H : Language Spoken at Home** ; 1= Arabic ; 2= Amazigh



Table 4. Regression coefficients of the socio-cultural factors determining the PA

Model	Non-standardized coefficients		Standardized coefficients	t	sig
	A	Standard error	Beta		
(Constant)	-0,520	0,344		-1,512	0,133
<b>Number of pre-schooling years</b>	0,194	0,094	0,183	<b>2,057</b>	<b>0,042</b>
<b>The father's educational level</b>	0,156	0,059	0,235	<b>2,632</b>	<b>0,010</b>
The mother's educational level	0,32	0,075	0,038	0,430	0,668
<b>The sibling's educational level</b>	0,181	0,071	0,217	<b>2,538</b>	<b>0,012</b>
Language spoken at home	-0,141	0,162	-0,069	-0,872	0,385
Number of children in the family	0,102	0,085	0,165	1,198	0,233
Rank of birth	-0,161	0,086	-0,274	-1,959	0,052

test on the two studied domains: the social and cognitive. Concerning the first domain, the regression (or prediction) is significant ( $F= 7.20$ ;  $p= 0.00$ ). The set of independent variables studied predict the reading level at 73.9%. Thus, the standardized regression equation is as follows: The RTOM score =  $2.82(\text{DIPA}) + 2.51(\text{PSTM}) - 4.12(\text{RNI}) + \text{constant}$ . We can therefore say that the more students are successful in the test of deleting the initial phoneme in Arabic and the short-term phonological memory test, the less their time at rapid naming is important, the more their reading level will be good. In order to predict the phonological aptitudes (PA), the most involved in the variability of reading scores (DIPA, PSTM, RNI), we proceed to a second regression analysis preceded by a grouping of these AP by the principal component analysis method (PCA). The regression was significant ( $F= 6.70$ ;  $p= 0.000$ ), the educational level of the father and the elder siblings as well as the number of years spent in the pre-school phase are the variables that determine the diversity of PA scores (see table. 4 ).

## DISCUSSION

The results obtained on reading skills, based on a sample of 754 Moroccan Arabic-speaking students attending stateschools, are in line with those of several Francophone studies (OCDE, 2004; Wagner, Torgesen, Rashotte et al, 1997; Billard, Fluss, Ducot, Warszawski et al, 2008) and other Anglo-Saxon studies (Hersent, 2000; Sénéchal & Lefevre, 2002). These studies have shown that academic skills in general and reading in particular are strongly influenced by the socio-cultural environment. Our conclusions show that the scores obtained by poor readers in reading tests are significantly lower than those of good readers, confirming the results of a Moroccan study conducted in 2008 (Badda, 2008). Our study leads to the first results available in Arabic on this subject of reading difficulties, it shows that the variability of reading performance is essentially related to phonological skills (PA), which are an essential phase in the acquisition of reading, similar to what has been described by the consensus seen in the international subject literature (Billard, Fluss, Ducot, Warszawski et al, 2008; Billard, Touzin, Gillet et al, 2004; Shaywitz, Shaywitz, Fulbright et al, 2003). Taking into account the final results of the regression, it seems that phonological skills are the only cognitive factor determining the level of reading. Socio-culturally, parents'

educational level, sibling characteristics (the schooling of older siblings, the number of children in the family, sibling rank) play an important role in reading skills. A finding that is consistent, even in part, with the conclusions of other studies (Billard, Fluss, Ducot, Warszawski et al, 2008). The preschool factor and especially the number of years passed at this preparatory stage, identified by regression analysis, is very much involved in the disparity in reading performance.

Statistical analyses of the different cognitive competences related to reading according to socio-cultural and particularly socio-familial characteristics provide additional innovative data. Indeed, students who have responded with three years of preschool attendance are performing well in different tests underlying reading when comparing them to their peers who had integrated preschool for less than two years. Similarly, when the educational level of parents and older siblings is high, the performance of students is better in various tests. This finding can be explained by the degree of exposure to written language activities from an early age, which is supposed to be higher for children whose family environment is characterized by a high level of instruction. This is consistent with the results of the study that have described the degree of home writing exposure as facilitating learning reading (Sénéchal & Lefevre, 2002).

Based on our results, we believe that there is a suitable period, from 2 to 6 years old, to learn the basic fundamentals of reading. During this period, the acquisition of basic reading skills would be optimal before being automated and perfected in the early years of the primary cycle. This interpretation is perfectly logical when we know that some important neurological changes occur during this period and seem to be the basis of the developments prodigious in language. In addition, during this preschool age the brain is very plastic and does constitute a real sponge and perceives very well the sounds peculiar to the language. These data allow us to assume that this is a sensitive and unavoidable period for the formation of new neural connections that are later involved in the automation of the reading process. The results of some studies, carried out with the advent of new brain imaging techniques, have revealed differences in brain activation structures between good and bad readers (Good readers activate three systems on the left side of the brain, while those who have difficulty in reading have less activation in two of these areas on the left back of the brain) (McCandliss, Cohen & Dehaene, 2003; Shaywitz, Shaywitz, Pugh, Mencl and al, 2002). These findings induce us to suggest that the activation of these structures involved in the reading act would be determined and reinforced by the child's early exposure to the rudimentary foundations of written language.

Family size and birth rank are also two variables that significantly influence results between reading level groups. Thus, students from families with fewer children perform better than students from large families. We think that these observed differences, depending on the number of children and the birth rank, can be explained in terms of intellectual performance which would constitute a compensatory recourse to passing the reading tests. This performance is strongly influenced by the interactions within the family environment. In the same context,

a French study found that high school students from families with one to three children are better performers in Cattell's intelligence tests than those who live with siblings of four or more in number (Alaphilippe, Sullerot & Lelasseux, 1999). The deficit performances observed in students who speak "Amazigh" at home show that this situation of diglossia makes this academic learning difficult. In this case, the student must pass from oral to written and from the Amazigh dialectal register to the standard Arabic register (the official language learned at school). The latter does not represent an extension of the spoken language, the change of repertoire from Amazigh dialectal to the standard Arabic, would constitute a potential source of learning reading difficulties.

## CONCLUSION

At the end of this research, which concerned 754 Moroccan primary and secondary school pupils, we have been able to reveal that learning-to-read difficulties are particularly frequent in non-favourable socio-cultural environments. The results of this study also found that phonological awareness and rapid naming are the most implicated factors in the disparity of reading skills. These phonological abilities are highly influenced by integration at preschool at a very early age and by the degree of exposure to written language activities. The failure of these cognitive skills can be a powerful tool for the early identification of students with reading deficits. The conclusions of this work call on all the responsible persons and interveners in the education domain to intervene in order to propose adequate care for learners with reading difficulties. These findings also encourage the implantation and generalization of pre-school education. In addition, the data derived from this study underline the need to plan preventive actions, based on playful exercises, aiming to improve phonological skills from the pre-school period. The adoption of these preventive programmes, particularly indispensable in precarious environments, could help learners from an early age to automate the reading process by exploiting brain sensitivity to learning at this age.

## REFERENCES

- Achouri, I., Aboussaleh, & Y., Ahami, A., (2016). Etat nutritionnel et consommation alimentaire des enfants scolaires de Kenitra (Nord-Ouest du Maroc). *Antropo*, 35, 111-117. [www.didac.ehu.es/antropo](http://www.didac.ehu.es/antropo)
- Alain, S. (2009). *La Lecture et ses Neurones*.
- Alaphilippe, D., Sullerot, S., and Lelasseux, V. (1995). Intelligence, rang dans la fratrie et taille de la famille . Univ. F. Rabelais, équipe temps développement processus cognitifs,
- Alegria, J., Leybaert J., et Mousty. P. (1994). „Acquisition de la lecture et troubles associés” dans *Évaluer les troubles de la lecture, De Boeck Université*, , p. 105-126.
- Arnold, E. M., Goldston, D. B., Walsh, A. K., Reboussin, B.A., Daniel S. S. and Hickman E. (2005). « Severity of emotional and behavioural problems among poor and typical readers.» *Journal of abnormal Child Psychology*, no 33, , p. 205-217.
- Badda, B. (2008). Apprentissage de la lecture, dyslexie phonologique et remédiation par le logiciel « Itinéraire Combinatoire » chez l'enfant marocain. Thèse de Doctorat cotutelle. Université Ibn Tofail Maroc – Université de Rennes 2 France.
- Badda, B. (2008). *Dyslexie au Maroc : Constat et interrogations légitimes*.

- Bender, W. N., C. B., Rosenkrans, et Crane, M. (1999). « Stress, depression, and suicide among students with learning disabilities: Assessing the risk », *Learning Disability Quarterly*, no22, p. 143-156.
- Billard, C., Delteil-Pinton, F. (2010). Clinique de la dyslexie. *Archive de pédiatrie* 17 p. 1734-1743 .
- Billard, C., Fluss, J., Ducot, B., Warszawski, J., Ecalle, J., Magnan, A., Richard, G., and Ziegler, J. (2008). Etude des facteurs liés aux difficultés d'apprentissage de la lecture. À partir d'un échantillon de 1062 enfants de seconde année d'école élémentaire.
- Billard, C., Fluss, J., Richard, G. et al. (2007). Résultats préliminaires d'une étude épidémiologique transversale des apprentissages en lecture, orthographe et calcul au CE1.
- Billard, C., Touzin, M., Gillet, P., et al. (2004). Le Langage écrit. Les troubles des apprentissages, l'état des connaissances. *Signes éditions*.
- Brooks-Gunn, J., Duncan, G. J. (1997). The effects of poverty on children. *Future Child*;7:55–71.
- Daniel, S., Adam, K., Walsh, and David, B. (2006). Goldstone, Elizabeth M. Arnold, Beth A. Rebus-sin et Frank B. Wood. Suicidality, school dropout, and reading problems among adolescents, p. 507-514.
- Delahaie, M., Billard, C., Calvert, C., Gillet, P., Tichet, J. et VOL. S. (1998). « Un exemple de mesure du lien entre dyslexie développementale et illettrisme », *Santé publique*, vol. 10, no 4, , p. 369-383.
- Fiorello, C. A., Hale, J. B., et Snyder, L. E. (2006). « Cognitive hypothesis testing and response to inter-vention for children with reading problems », *Psychology in the Schools*, vol. 43, no 8, p. 835-853.
- Hale, J. B., and Fiorello, C. A. (2004). « *School neuropsychology: A practioner's handbook* », New York: Guilford.
- Hersent, J. F. (2000). Sociologie de la lecture en France : Etat des lieux (essai de synthèse à partir des travaux de recherche menés en France). Direction du livre et de la lecture;.
- URL : <http://www.culture.gouv.fr/culture/dll/sociolog.rtf>.
- Inserm, (2007). Dyslexie, dysorthographe, dyscalculie. *Bilan des données scientifiques*. Paris:, p. 175–90.
- Jaquier-Roux et al (2005). Outil de Dépistage des Dyslexies (ODEDYS). *Academie de Grenoble*.
- Khomsi, A. (1999). Lecture de Mots et Compréhension, forme révisée. Paris, *Éditions du CPA*.
- LABEL: Langage Assessment Battery : Batterie d'Evaluation de Langage  
<https://www.gerip.com/evaluation-positionnement/57-labbel.html>
- McCandliss, B. D., Cohen, L., and Dehaene, S. (2003). The visual word form area: expertise for reading in the fusiform gyrus. *Trends in Cognitive Sciences*;7(7):293-299.
- Noble, K. G., McCandliss, B. D. (2005). Reading development and impairment: behavioral, social, and neurobiological factors. *Le Journal of Developmental and Behavioral Pediatrics* 26:370–8.
- OCDE. (2004). Profil de performance des élèves en compréhension de l'écrit et en sciences. Ap-prendre aujourd'hui, réussir demain. *Etude PISA*. Paris:
- Sénéchal, M., & Lefevre, J. A. (2002). Parental involvement in the development of children's read-ing skill: a five-year longitudinal study. *Child Development*. 73:445–60.
- Shaywitz, B. A., Shaywitz, S. E., Pugh, K. R., Mencl, W. E., Fulbright, R. K., Skudlarski, P., Constable, R. T., Marchione, K. E., Fletcher, J. M., Lyon, G. R., and Gore, J. C. (2002). Disruption of posterior brain systems for reading in children with developmental dyslexia. *Biological Psychi-atry*;52(2):101-110.
- Shaywitz, S. (2005). Overcoming dyslexia: A new and complete science-based program for read-ing problems at any level. *Vintage*.
- Shaywitz, S. E., Fletcher, J. M., Holahan J. M, et al. (1999). Persistence of dyslexia: the connecticut longitudinal study at adolescence. *Pediatrics*;104:1351–9.
- Shaywitz, S. E., Gruen, J. R., Shaywitz, B. A. (2007). Management of dyslexia, its rationale, and underlying neurobiology. *Pediatric Clinics of North America*; 54:609–23.
- Shaywitz, S. E., Shaywitz, B. A., Fulbright, R. K, et al. (2003). Neural systems for compensation and persistence: young adult outcome of childhood reading disability. *Biological Psychi-atry*;54:25–33. 37041 Tours, France.
- Stanovitch, E.K., Nathan, G. R., et Vala-Rossi, M.(1986). « Developmental changes in the cognitive correlates of reading ability and the developmental lag hypothesis », *Reading research quar-terly*, vol. 21, no3, p. 267-283.

- Vellutino, F. R., Fletcher, J. M., Snowling, M. J., et al. (2004). Specific reading disability (dyslexia): what have we learned in the past four decades? *Journal of Child Psychology and Psychiatry*;45:2–40.
- Vellutino, F. R., Fletcher, J. M., Snowling, M. J., et al. (2004). Specific reading disability (Dyslexia): what we have learned in the past four decades? *J Child Psychological Psychiatry*; 45:2–40.
- Wagner, R. K, Torgesen, J. K, Rashotte, C. A. et al.(1997). Changing relations between phonological processing abilities and word-level reading as children develop from beginning to skilled readers: a 5-year longitudinal study. *Developmental Psychology*;33:468–79.
- Ziegler, J. C, & Goswami, U. (2005). Reading acquisition, developmental dyslexia, and skilled reading across languages: a psycholinguistic grain size theory. *Psychological Bulletin* ;131:3–29.

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