6

Assessment of written word recognition and reading

Difficulties related to lexical access may prevent the reader from using strategies based on the syntax-prosody interface that are crucial for the development of reading fluency. For this reason, a written word recognition test and a reading test with isolated words/pseudo words were created and carried out. These tests aimed to:

(i) identify those students who did not exhibit difficulty at this level of reading;

(ii) verify whether the group whose behavior suggests syntactic impairment differs from the control group in the word recognition and reading abilities, in so far as there is evidence that a percentage of students with SLI also present symptoms of dyslexia.

Based on these tasks, new testing groups were defined: SI (with symptoms of syntactic impairment) and CT (control).

6.1

The word recognition test

A lexical decision task was used in which participants should press either a YES or a NO key at a computer keyboard as soon as they recognized or not the word/pseudo word presented on the computer screen as being a Brazilian Portuguese word.

6.1.1

Experimental design

- Independent variables

The design consisted of three independent variables:

- *Grou*p (SI; CT);

- *Type of orthography* (regular; rule-based and irregular) – these different types of written forms were presented in order to assess proficiency in both the phonological and the lexical routes;

- *Type of item* (real[1] and pseudo word[2]) – so that it would be possible to assess the students' abilities to read novel words (which depend exclusively on the phonological route).

There were, therefore, six experimental conditions to each group, each one of them with 8 trials (4 two-syllable items and 4 three-syllable items)[3], as presented below:

- **RW** (regular word) – vida; menina; livro; produto; baile; saudade; carta; fazenda.

- **RLW** (rule-based word) – casa; cinema; braço; trabalho; bairro; tesouro; mulher; passagem.

- **IW** (irregular word) – táxi; exame; bruxa; reflexo; caixa; ameixa; sexta; laxante.

- **RP** (regular pseudo word) – lapo; sabato; tlabo; palafra; beipo; leibana; bango; tempata.

- **RLP** (rule-based pseudo word) – finho; citade; crulho; brinhalo; goisa; mofeisa; finche; mutança.

- **IP** (irregular pseudo word) – voxo; vexane; vluxo; brotixa; vaixa; exítio; mitax; loxesto.

- Dependent variables

Number of correct responses and *decision time* were the dependent variables.

---

[1] It is important to mention that only frequent real words were selected based on a distributed language resource center for Portuguese called Linguateca and on Google.
[2] The pseudo words were counterbalanced according to the similarity and lack of similarity to real words.
[3] Not only the number of syllables, but also the syllable structures were counterbalanced (CV, CCV, CVV, CVC).

6.1.2

Method

- Participants

78 students (mean age: 12; 37 girls) participated in this experiment in two groups, based on their performance in the assessment of linguistic abilities.

- *SI*: 25 participants (mean age: 12), 16 boys and 9 girls.
- *CT*: 53 participants (mean age: 12), 25 boys and 28 girls.

- Material

Different lists of the items were created and randomized by the computer software LINGER. The lists contained 48 items, with 8 trials per experimental condition.

- Apparatus

A DELL Inspiron 15 laptop and the computer software LINGER were used to develop and to present the experiment.

- Procedure

The participants were invited to take part in a task to be performed on a computer. They were instructed to decide, as quickly as possible, whether the item presented on the computer screen was a real word or not, by pressing either the YES or NO key identified at the computer keyboard. The training part included 6 items. Only those participants who had demonstrated to understand the task and were willing to continue performed the test. All participants were able to cope with the task and decided to take part in the test. The procedure was conducted in an isolated room of the school and took about 5 minutes.

6.1.3

Results and discussion

The data were analyzed using a 2×2×3 ANOVA, in which the first factor was a group factor and the other ones were repeated measures. Graphs 1 and 2 illustrate the performances of SI and CT groups according to the number of correct responses for each condition.
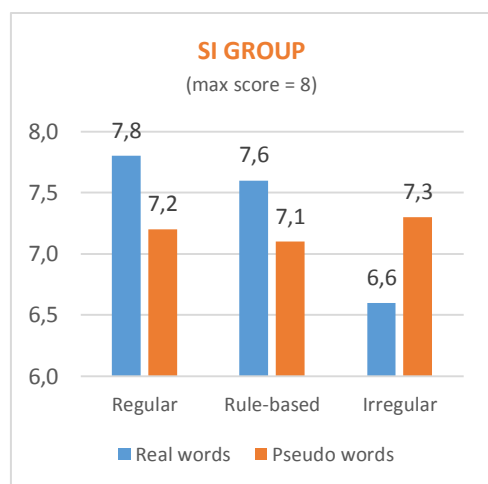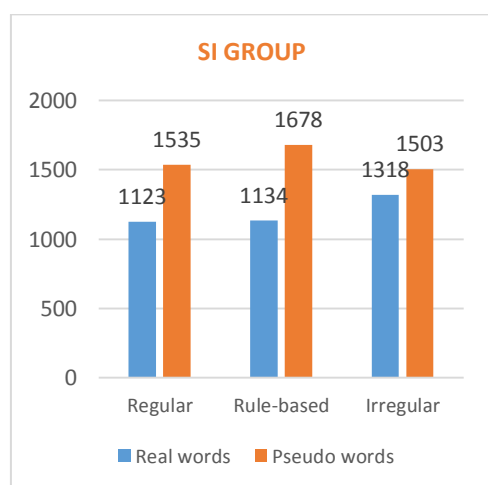
SI GROUP
(max score = 8)

Graph 1: Mean correct responses as a function of type of orthography and type of item (SI group).
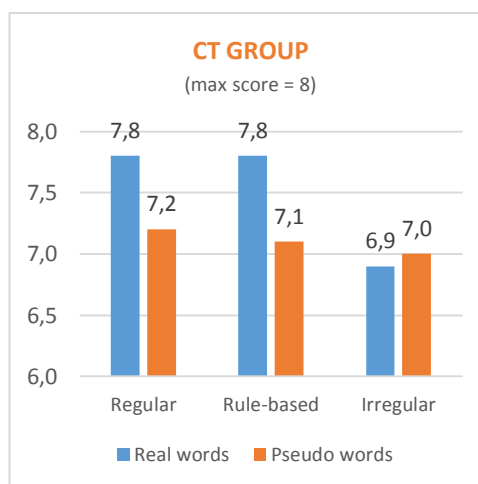
CT GROUP
(max score = 8)

Graph 2: Mean correct responses as a function of type of orthography and type of item (CT group).

The mean decision time for each condition of both groups is presented on graphs 3 and 4 below.

SI GROUP

Graph 3: Mean decision time (ms) as a function of type of item and type of orthography (SI group).
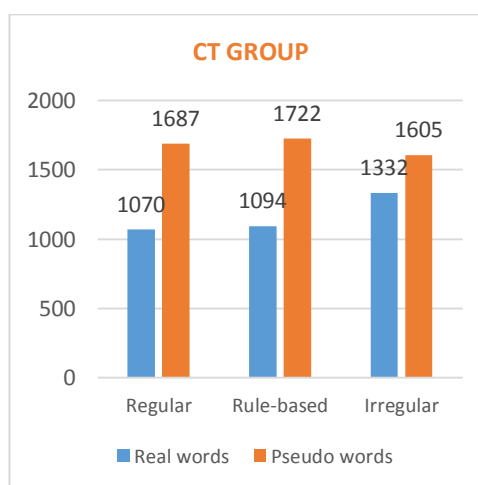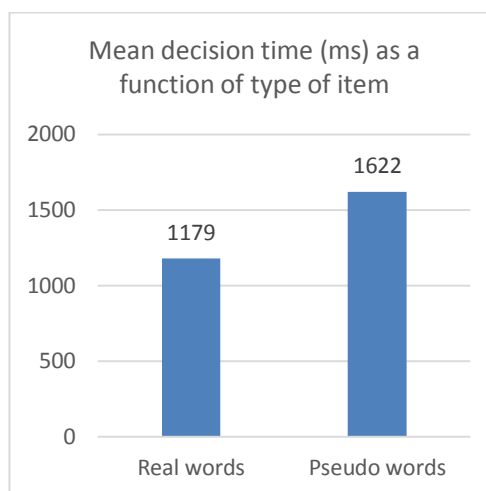
CT GROUP

Graph 4: Mean decision time (ms) as a function of type of item and type of orthography (CT group).

Type of item gave rise to significant main effects for both *number of correct responses* (F(1,76) = 5,6 p<.02) and *decision time* (F(1,76) = 108,4 p< .001), as indicated in graphs 5 and 6.
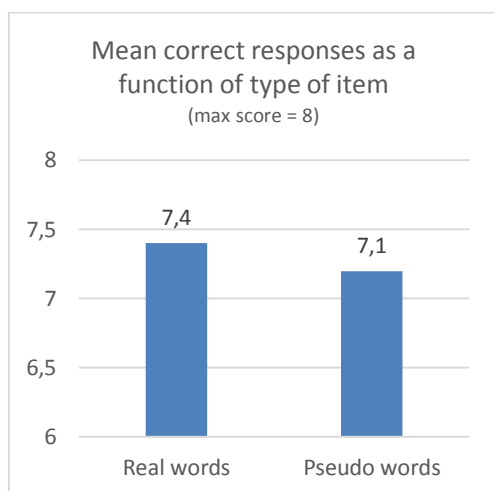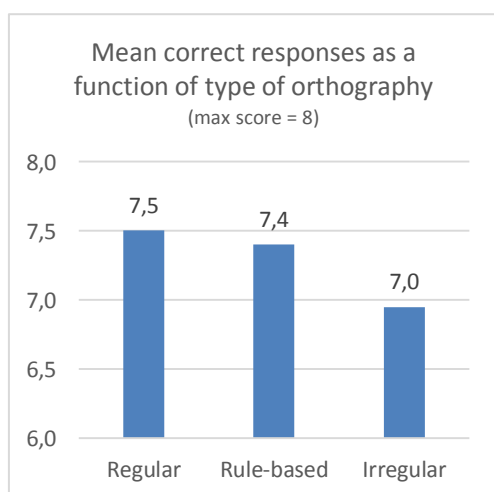

Graph 5: Mean correct responses as a function of type of item.
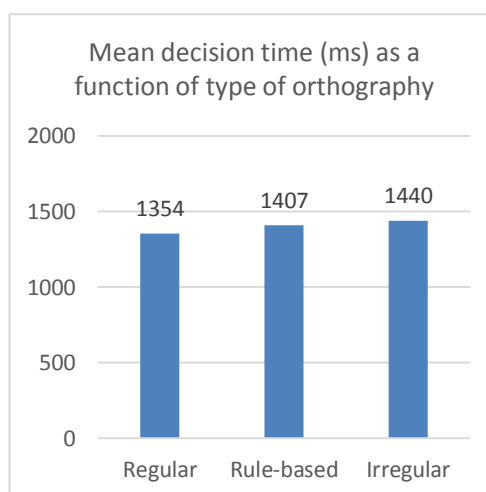

Graph 6: Mean decision time (ms) as a function of type of item.

There was a significant main effect of *Type of orthography* for *number of correct responses* (F(2,75) = 23,8 p< .001) and for *decision time* (F(2,75) = 5,2 p< .007) (cf. Graphs 7 and 8). The greatest number of correct responses was obtained in the regular condition, followed by the rule-based condition and irregular items had the poorest performance, as expected. As for decision time, the longer the recognition time, the hardest the task was. The reverse pattern of measure was then obtained in comparison with correct responses: the longest decision time was obtained in the irregular condition and the shortest time in the regular one.
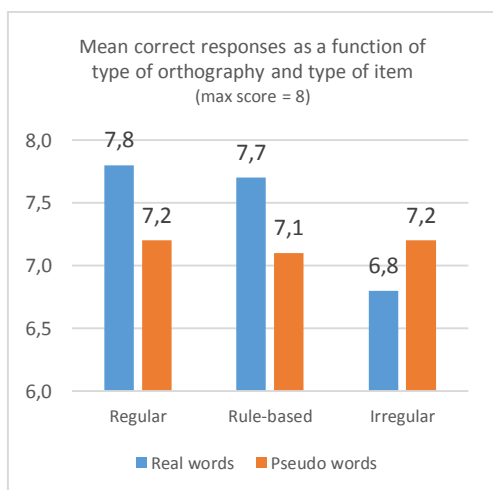

Graph 7: Mean correct responses as a function of type of orthography.
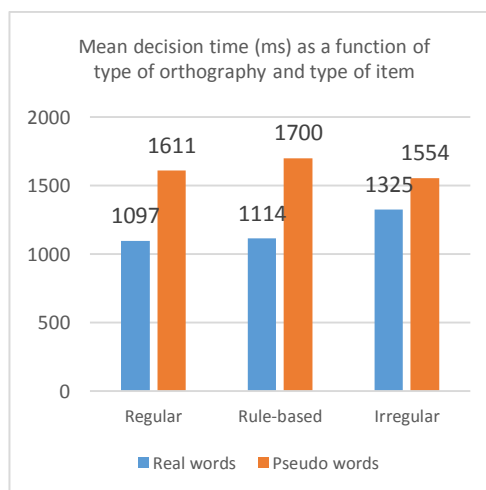

Graph 8: Mean decision time (ms) as a function of type of orthography.

A significant effect was also obtained of the interaction between *Type of item* and *Type of orthography* for both *number of correct responses* (F(2,75) = 16,4 p<.001) and *decision time* (F(2,75) = 31,7 p<.001) (cf. Graphs 9 and 10). For regular and rule-based orthography, real words gave rise to more correct responses and smaller decision time than pseudo words.

Graph 9: Mean correct responses as a function of type of orthography and type of item.

Graph 10: Mean decision time (ms) as a function of type of orthography and type of item.

The main effect of *group* was not significant for both *number of correct responses* (F(1,76) = 0,163 p =.688) and *decision time* (F(1,76) = 0,089 p =.767). It suggests that reading abilities of students in the SI and in the CT group are similar as far as word recognition is concerned.

6.2

The isolated words/pseudo words reading test

A single word/pseudo word reading task was conducted in which participants should read aloud the items presented on the computer screen. They should press a key at the computer keyboard to continue the activity. Their responses were recorded for analysis.

6.2.1

Experimental design

- Independent variables

The design of this experiment consisted of the same independent variables, the same experimental conditions and the same items as the word recognition test.

- Dependent variables

The dependent variable was the *number of items read correctly*. Paused and syllabic reading, as well as self-corrections, were considered to be incorrect.

6.2.2

Method

- Participants

All participants who had previously participated in the word recognition test took part in this experiment.

- Material

The material was the same described in the word recognition test.

- Apparatus

The apparatus was the same as the one described above (in the word recognition test) with the addition of a Panasonic MP3 player that was used to record the participants' responses.

- Procedure

At first, participants were asked whether they would like to take part in a task[4] different from the previous one. The experimenter explained they should look at a computer screen and read aloud the items (words / pseudo words) that would be presented, while their responses would be recorded. They should press a key at the computer keyboard, in order to continue the task, after reading aloud each word presented. The training consisted of 6 items. All participants understood the task and decided to proceed. The test took about 5 minutes and was carried out in an isolated room of their schools.

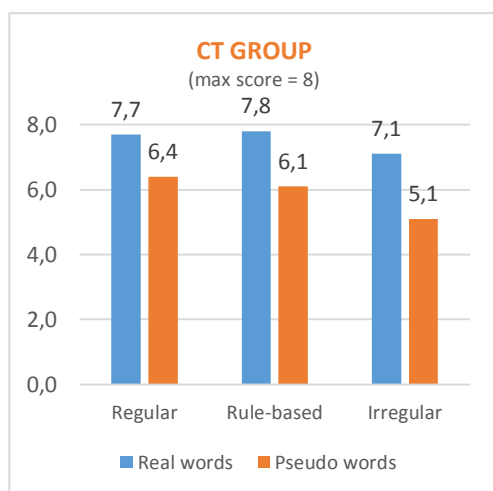**6.2.3**

Results and discussion

Graphs 11 and 12 present the distribution of correct responses for each condition.
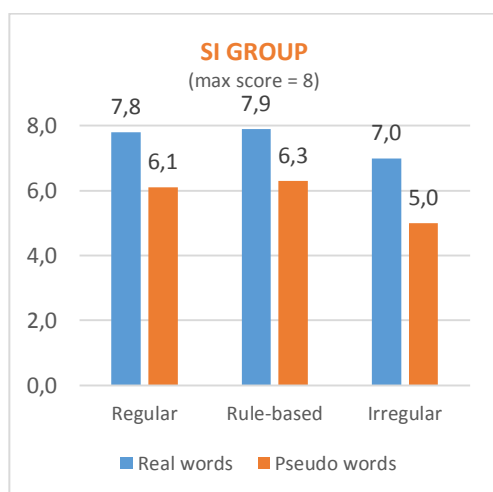
Graph 11: Mean correct responses as a function of type of item and type of orthography (SI group).

---

[4] The word recognition test and the isolated word/pseudo word reading test were conducted on different days.
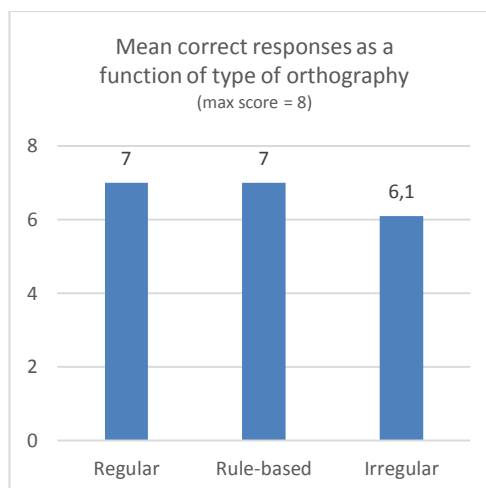
Graph 12: Mean correct responses as a function of type of item and type of orthography (CT group).

There was a significant main effect of *Type of item* (F(1,76) = 157,77 p < .001) (cf. Graph 13) and *Type of orthography* (F(2,75) = 46,3 p <.001) (cf. Graph 14). The greatest number of correct responses was obtained in both regular and rule-based orthography. The irregular condition, however, gave rise to less correct responses. Participants had a better performance with real words than with pseudo words.
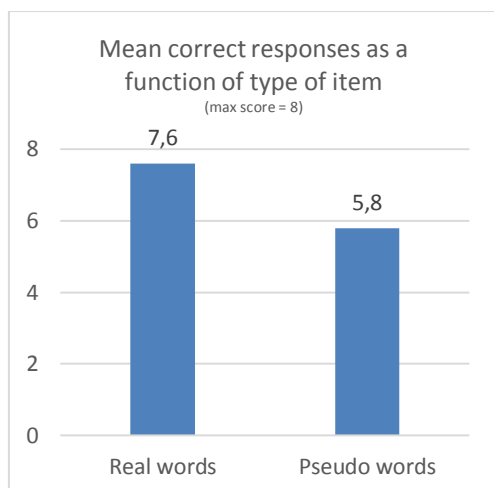
Graph 13: Mean correct responses as a function of type of item.

Graph 14: Mean correct responses as a function of type of orthography.

A main effect of *Group* was not obtained (F(1,76) = 0,003 p = 954) and there was no significant interaction between the variables.

The results obtained in the tests described above are along the lines of the research on word recognition (Dehaene, 2012; Coltheart, 2013) and indicate that the lists of words and pseudo words created for these tests can be taken as a

reliable means of evaluating written word recognition in Portuguese.

6.3

## Reading abilities in the 6th grade students

The reading abilities of participants in SI and CT groups seem to be similar in terms of word recognition and isolated word reading. There is therefore no relationship between language difficulties suggestive of SLI (syntactic) and difficulties in recognizing and reading written words in the researched population.

The performance of these 6th grade students was compared with the performance of graduated adults, who, in principle, have achieved proficiency in both routes. It was intended to evaluate the extent to which the performance of 6th grade students approaches a (supposed) reading proficiency standard.

Graphs 15 and 16 exhibit the *number of correct responses* of teenagers and adults for each condition in the word recognition test.
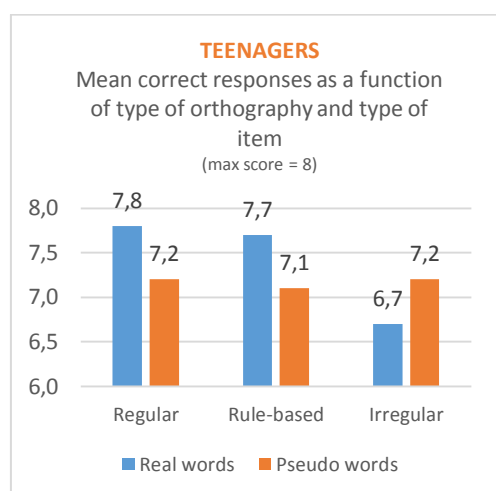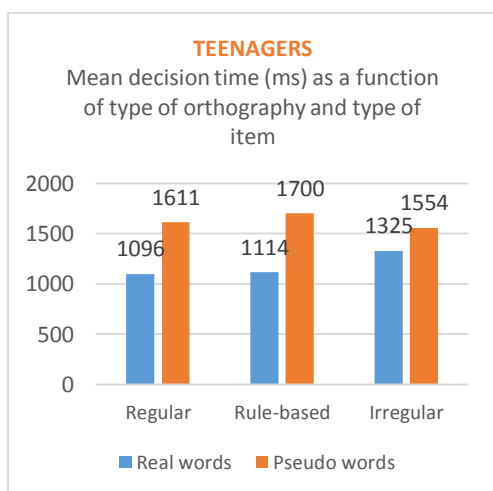
Graph 15: Mean correct responses as a function of type of orthography and type of item (teenagers).
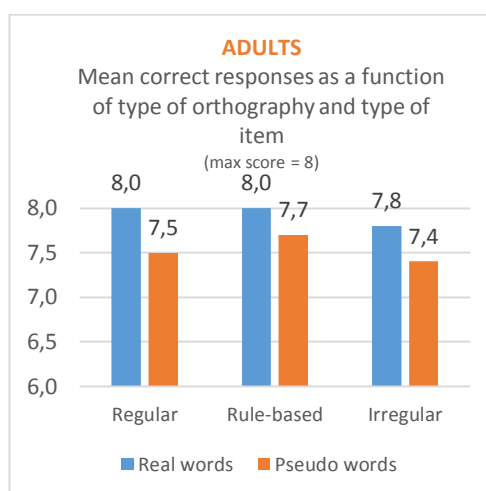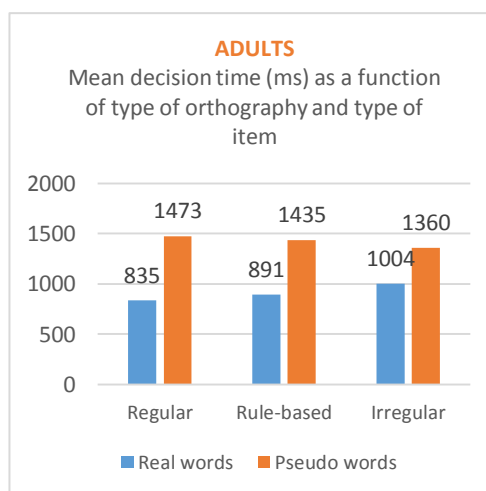
Graph 16: Mean correct responses as a function of type of orthography and type of item (adults).

The mean decision time of such groups for each condition in the same test is presented on graphs 17 and 18 below.
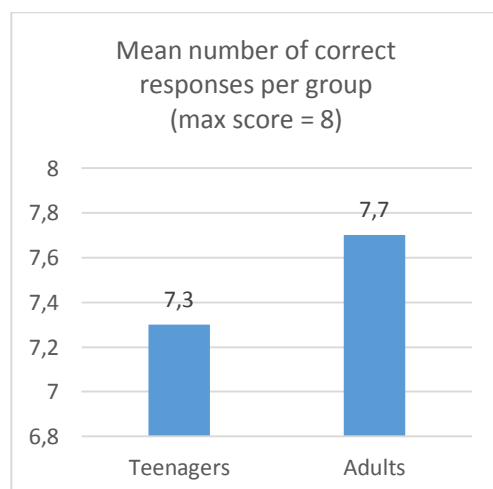
Graph 17: Mean decision time (ms) as a function of type of orthography and type of item (teenagers).
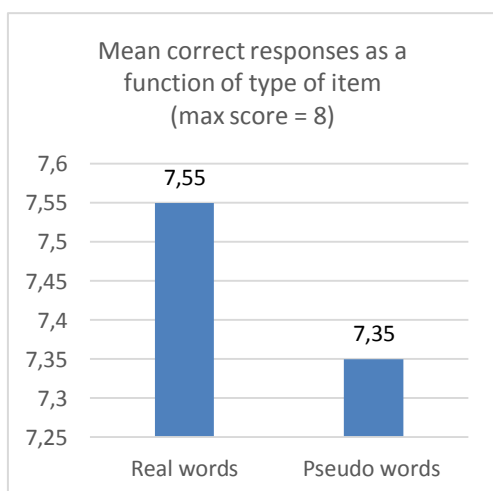
Graph18: Mean decision time (ms) as a function of type of orthography and type of item (adults).

In the word recognition test, there was a significant difference between teenagers and adults for *number of correct responses* (F(1,86) = 8,014 p<.006) (cf. graph 19), but not for *decision time* (F(1,86 = 2,177 p=.144).
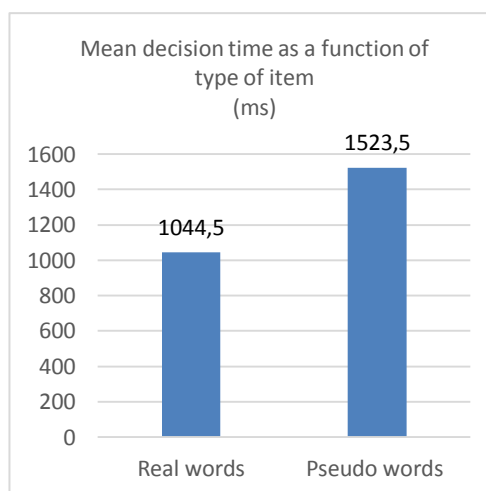

Graph 19: Mean correct responses as a function of group.

Type of item gave rise to significant main effects for both *number of correct responses* (F(1,86) = 5,375 p<.019) and *decision time* (F(1,86) = 66,340 p<.001) (cf. graphs 20 and 21).

Graph 20: Mean correct responses as a function of type of item.

Graph 21: Mean decision time as a function of type of item.

The main effect of *type of orthography* was significant for *number of correct responses* (F(2,85) = 5,307 p<.007) (cf. graph 22).
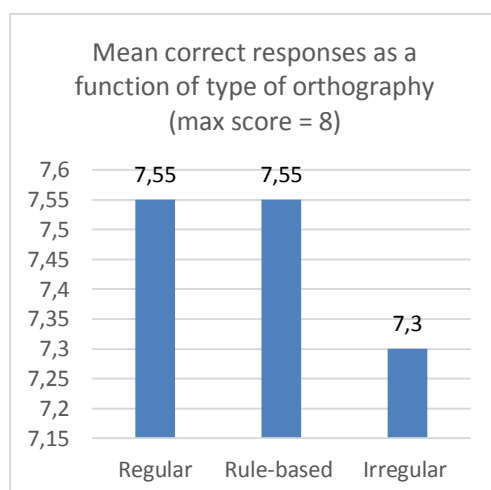
Graph 22: Mean correct responses as a function of type of orthography.

The interaction between these variables (*type of orthography* and *type of item*) was significant for *decision time* (F(2,85) = 10,184 p<.001).

The distribution of correct responses for each condition for the isolated words/pseudo words reading test is presented on graph 23.
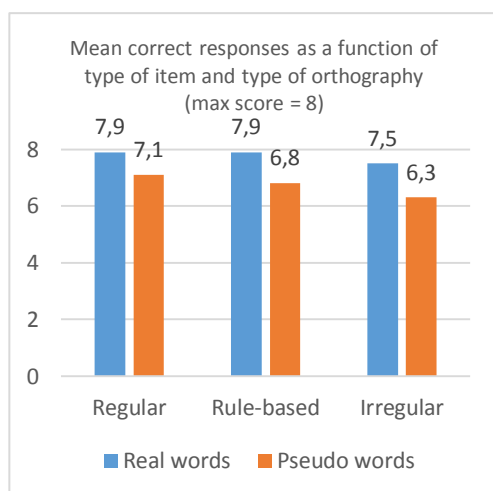
Graph 23: Mean correct responses as a function of type of item and type of orthography.

In the isolated words/pseudo words reading test, there was a significant difference between teenagers and adults ($F_{(1,86)} = 19,348$ $p<.001$) (cf. graph 24).
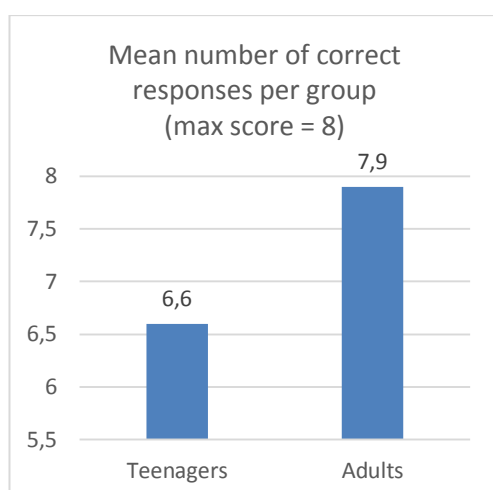
Graph 24: Mean correct responses as a function of group.

Type of item ($F_{(1,86)} = 29,899$ $p<.001$) and *type of orthography* ($F_{(2,85)} = 8,821$ $p<.001$) also gave rise to significant main effects (cf. graphs 25 and 26).

Mean correct responses as a function of type of item (max score = 8)

Real words: 7,8
Pseudo words: 6,5
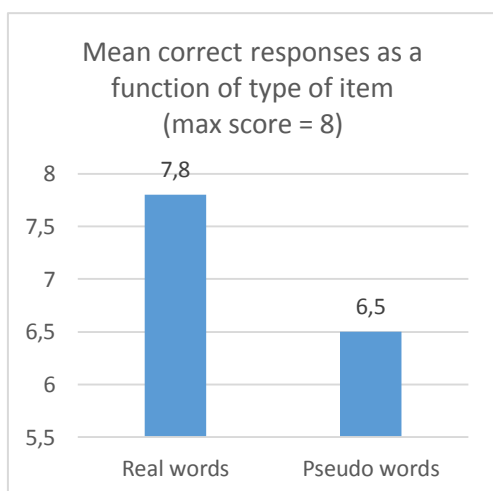
Graph 25: Mean correct responses as a function of type of item.

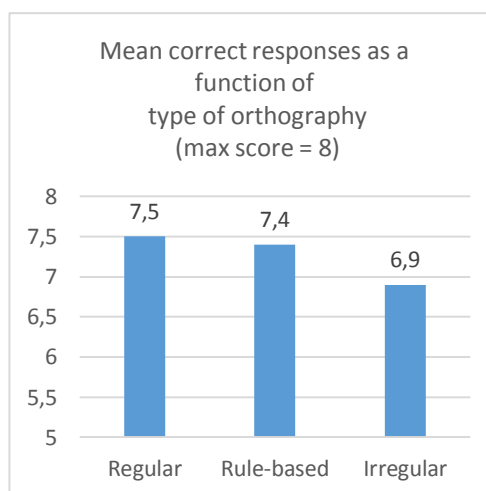**Mean correct responses as a function of type of orthography (max score = 8)**

Regular: 7,5
Rule-based: 7,4
Irregular: 6,9

Graph 26: Mean correct responses as a function of type of orthography.

As it was assumed that fluent readers are able to use both the lexical route and the non-lexical route (Dehaene, 2012; Snowling & Humes 2013) automatically and effortlessly, only those participants who had demonstrated ability in both routes were invited to participate in the subsequent steps of the research. Therefore, the criteria for proceeding in the study were the following:

- The participant should have had:
  - at most 3 errors in a given condition or 7 errors at most, in the word recognition test[5];
  - no errors in the reading test for regular or rule-based word , up to 2 errors for irregular words, up to 3 errors in a same condition for pseudo words, and 7 errors at most in the whole test.

In table 1, it is possible to observe the number of participants who have passed the tests at stake. It should be noticed that the percentage of students who passed the reading and the word recognition tests is similar in the SI and in CT groups.

---

[5] It is relevant to mention that only the number of correct responses was considered as an elimination criterion.

DISTRIBUTION OF PARTICIPANTS WHO HAVE PASSED THE TESTS PER TASK[6]		
	WORD RECOGNITION TEST	**ISOLATED WORDS/PSEUDO WORDS READING TEST**	**BOTH TESTS**
SI (n=25)	21 participants (14 boys and 7 girls) (84%)	12 participants (8 boys and 4 girls) (48%)	12 participants (8 boys and 4 girls) (48%)
CT (n=53)	46 participants (21 boys and 25 girls) (86,8%)	24 participants (13 boys and 11 girls) (45,3%)	23 participants (13 boys and 10 girls) (43,4%)

Table 1: Distribution of participants who have passed the tests.

Based on the participants' performance in the experiments just reported, new testing groups were defined: a group of 12 (possibly) syntactically impaired (SI) students (8 boys and 4 girls); and a control group (CT) with the same number of participants (8 boys and 4 girls). Their abilities to read fluently and to comprehend isolated sentences were tested, as described in the following chapter.

As discussed in chapter 2, one of the main characteristics of dyslexia is the difficulty related to the lexical recognition ability. The word recognition and the isolated word/pseudo word reading tests enabled not only to identify the participants that should continue to be tested for fluency in reading but also those 6th grade students who show symptoms of reading difficulty that may be suggestive of dyslexia[7]. There were 43 students (13 within the SI group and 30 within the CT group) in this condition. As indicated below, two levels of difficulty related to recognizing and reading written words have been defined based on participants' performance in the tests at stake.

[6] 10 participants (4 within the SI group and 6 within the CT group) have failed both tests. Except for one participant (from the CT group), all participants who have failed the word recognition test have also failed the isolated words/pseudo words reading test.
[7] Additional tests may be conducted in order to determine the percentage of dyslexic individuals in such group.

READING ABILITY IN WRITTEN WORD RECOGNITION AND READING			
	SI GROUP (n=25)	**CT GROUP (n=53)**	**TOTAL (n=78)**
No difficulty (Participants who have passed both tests)	12 participants (8 boys and 4 girls) (48%)	23 participants (13 boys and 10 girls) (43,4%)	35 participants (21 boys and 14 girls) (44.9%)
Moderate difficulty (Participants who have failed one of the tests)	9 participants (6 boys and 3 girls) (36%)	24 participants (8 boys and 16 girls) (45,3%)	33 participants (14 boys and 19 girls) (42,3%)
Severe difficulty (Participants who have failed both tests)	4 participants (2 boys and 2 girls) (16%)	6 participants (4 boys and 2 girls) (11,3%)	10 participants (6 boys and 4 girls) (12,8%)

Table 2: Reading ability in written word recognition and reading.

These results indicate that the investigated students are still below the reading proficiency standard established by the adults' performance. According to these data, they still show difficulty when dealing with pseudo words (and thus with novel words), as well as with rule-based and irregular words. The school was notified so that particular attention could be given to reading impaired 6th grade students.