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- 1 Although the issue of developmental dyslexia subtypes as well-defined categories is doubtful (Wilding, 1989, Sprenger-Charolles et al, 2000), it seems indisputable that dyslexic children do not constitute an homogenous group from the reading process point of view (Seymour, 1986, Casalis, 1995). Based on the dual-route model (Coltheart et al, 1993), methods have been developed in order to categorise dyslexic children (Genard et al, 2000). According to this model, the pseudoword reading score is an index of the phonological procedure based on grapheme-phoneme conversion, while the irregular word reading score is an index of the lexical procedure based on the whole orthographic code. When compared with chronological-age matched children, dyslexic children are categorised as “phonological” if they display a specific impairment on pseudoword scores, as “surface” for a specific impairment on irregular words, and “mixed” for a deficit in both kinds of items (most of dyslexics). However, the comparison with chronological-age matched children is not very informative since the reading level is not comparable; more, it is methodologically biased, since the relationship between pseudowords and irregular words depends on the reading level in the developmental course (Stanovich et al, 1997). In order to analyse their reading processes impairments from a developmental point of view (deviance or delay), the categorisation of the dyslexics is based upon performance comparisons with reading-level matched (younger) children. Thus, it appears that while a subgroup of phonological dyslexics continues to emerge, practically all but few surface dyslexics could be considered as delay-type dyslexic. In this case, their level of performance in both pseudowords and irregular words falls in the normal range of the younger normal readers. Thus while the phonological subgroup appears as deviant from a developmental point of view, due to poor phonological skills (Goswami & Bryant, 1990) the reading impairment of the delay-type dyslexic may be interpreted as a developmental lag. In order to elucidate the reading impairment of the latter group, various factors have been advocated : global resources limitations problems, poor visual skills or low print exposure (Stanovich et al, 1997). It

has also been suggested that the delay-type subgroup may suffer from a mild phonological deficit. While this hypothesis has been disputed (Joanisse et al, 2000), the phonological deficit, if evidenced, is certainly not sufficient to explain the reading impairment, since dyslexic subgroups are matched for reading level.

- 2 Besides the question of the origin of differences in the dyslexics reading process, the very nature of their reading processes may be questioned. The subgroups are established on the basis of irregular words and pseudowords reading scores. But do the delay-type dyslexics read exactly the same way as the reading-level matched children? The aim of the present study is to examine in a more fine-grained analysis the reading processes of the delayed dyslexic, as compared with reading-level matched control children and phonological dyslexic. The objective is merely to examine in which extend they resemble to younger children or display specificities.
- 3 Subjects in the study were 25 dyslexic children selected from a sample of 58 dyslexic children and 15 normal readers matched on reading level. The sample of dyslexic children was narrowed to 25 subjects based on subtyping criteria specified below. Classification as dyslexic was based on teacher referral, reading age based on the "Alouette" reading test score- at least 24 months below the chronological age-, normal cognitive skills -as attested by a performance score in the Raven Progressive Matrices at or above the 25th percentile, and in the absence of extenuating factors such as neurological disease, social problems or behavioural problems. All the dyslexic children have been enrolled in a long-term speech-therapy.
- 4 As the phonological skills are central in reading achievement, a phonological awareness task was administered to children. In this task, the *phoneme deletion test*, children have to delete the first phoneme of a pseudoword -pronounced by the experimenter- and pronounce what remains. There are 10 short pseudowords (e.g. "vri") and 10 long pseudowords (e.g. "prachin"), all with initial consonant clusters. Number of correct responses are scored.
- 5 Three reading tasks were administered to the participants. The first was the *Alouette test* (Lefavrais, 1967). In this test, subjects have to read aloud a text and the final score takes into account both accuracy and speed. The second was a regular and irregular words reading test (*RIW list*) based on previous work (Casalis, 1995). A list of 60 items -40 regular, 20 irregular, such as "femme" (woman), "album"(album)- was presented to the children. The third was a words and pseudowords test (*WPW list*), also based on previous studies (Casalis, 1995). The test was separated into two separated parts, the first part contains 40 words, the second part contains 40 pseudowords. Words and pseudowords are strictly matched in terms of length and orthographic complexity, no one contained irregular patterns. Half of the items (words and pseudowords) were short (4 or 5 letters) while half were longer (6 to 8 letters).
- 6 The RIW list words are less frequent than the PWP list words. In both the RIW and the WPW lists, each item (presented in isolation) appeared in the centre of a computer screen, after a fixation point. Children are invited to press a key when they have recognised the written word, or when they are in position to give a pronunciation for the pseudoword. After the child has pressed the key, he/she was invited to give the response, and the experimenter validated it by pressing a specific key. Children were trained with the procedure for a total of 15 items for each list. Both accuracy and response latencies were scored.

- 7 The subgrouping methodology used in the present study was intended to yield groups of children roughly similar to those in Joannis et al (2000). As such, phonological dyslexic and delay-type dyslexic groups were obtained based on pseudowords decoding (part 2 of the PWP test) and irregular words (RIW list). Z-scores for accuracy were created, based on the means and standard deviations for the RL group. Dyslexics were assigned to the phonological dyslexic subgroup if their score on pseudowords fell at or below -1.65 and at or above -1 ($n=18$) on irregular words. Dyslexic were assigned to the delay-type subgroup if their scores on both pseudowords and irregular words fell above -1 ($n=25$). Dyslexic children who score in the normal range on pseudowords but very low on irregular words are usually considered as surface dyslexic. In our sample, only two children fitted the criterion; thus they were not included in the present study. The remaining 15 dyslexic were not considered in the present study because their pseudoword reading score fell between -1 and -1.65 or because their z-score on irregular words was below -1 . Finally, in order to match the reading level of the three groups (P-DYS, D-DYS and RL), 7 P-DYS and 11 D-DYS were excluded. This resulted in three groups (14 D-DYS, 11 P-DYS, 14 RL) matched on the reading scores, as displayed in table 1. Group performance was analysed with ANOVAs conducted on both accuracy scores and latencies (for reading tests) and pair-comparisons were based on the Newman-Keuls post-hoc analyses.
- 8 Table 1 displays mean scores and levels of significance of the pair-comparisons. Groups differed in the Phoneme Deletion score ($F(2,36)=31.159$, $p<.01$), and were differently affected by length of pseudowords ($F(2,36)=8.1$, $p<.01$). Further comparisons indicated that the P-DYS group scored systematically below both the RL and the D-DYS groups, suggesting a considerable deficit in this area. However, while there was no difference between the D-DYS and the RL groups for short items, the D-DYS performed significantly below the younger children for long items. This result suggests that the D-DYS group may suffer from a phonological deficit that is comparable in nature but not in magnitude to that of the P-DYS group.

Table 1: Mean chronological and lexical ages in months and mean score in the phoneme deletion task, in percentage of correct responses (standard deviation in parentheses)

- 9 (1) P-DYS : phonological dyslexics (2) D-DYS : delayed dyslexics (3) RLC : Reading-level controls.

	Group			comparison		
	P-DYS (1)	D-DYS (2)	RLC (3)	2-3	1-2	1-3
Chronological age	137 (27)	120 (14)	87 (7)	**	*	**
Reading age	87 (4.8)	87 (2.7)	88 (6.3)			
Phoneme deletion						
Short items	35.5 (37.8)	85.7 (19)	93.5 (12)		*	*
Long items	21 (29)	55 (29)	92.5 (16)	*	*	*

- 10 Note : the comparison columns indicate the level of significance in the Newman Keuls pair comparison tests : * : $p<.05$, ** : $p<.01$
- 11 Table 2 displays mean scores (percentage of correct responses and mean responses latencies) of the RIW and the WPW reading lists. Level of significance of the post hoc pair comparisons are indicated in the last three columns.
- 12 Children read regular words more accurately than irregular words ($F(1,36)=36.6$, $p<.01$) and responses latencies were also faster for regular words ($F(1,36)=6.28$, $p<.05$). There was no difference between groups, either in the accuracy score ($F<1$) or in the responses

latencies ($F < 1$). Finally, the effect of regularity on accuracy varied across groups ($F(2,36) = 3.916, p < .05$), but not in responses latencies. Inspection of table 2 indicates that the smallest effect of regularity in accuracy was observed in the P-DYS group; the D-DYS displayed a smaller regularity effect than the RL group ($F(2,26) = 4.1, p < .05$ for the interaction involving the D-DYS and RL groups only). Additionally, no difference was found in pair comparisons tests, between groups for irregular words accuracy, while the RL group outperformed both the P-DYS ($F(1,36) = 4.8, p < .05$) and the D-DYS ($F(1,36) = 3.93, p < .05$) on regular words reading accuracy. The P-DYS and the D-DYS did not differ. In all, patterns of reading of the two subgroups of dyslexic are rather similar and display a reduced regularity effect (the RL group was more accurate in regular word reading). While the regularity effect may be seen as an index of reliance on phonological coding, the D-DYS may be considered as intermediate between the P-DYS and the RL group from this point of view. Given that words in this tasks are only moderately frequent, such a result indicates that both subgroups have poor phonological recoding abilities in word reading.

- 13 The lexicality effect was examined through 2 (words, pseudowords) * 3 (D-DYS, P-DYS, RL) ANOVAs. Length effects were separately examined for words and pseudowords with 2 (short, long) * 3 groups (D-DYS, P-DYS, RL) ANOVAs.
- 14 In the WPW whole list, there was a main difference between groups both for accuracy ($F(2,36) = 19.921, p < .01$) and for latencies ($F(2,36) = 4.042, p < .05$). Words were read more accurately ($F(1,36) = 29.74, p < .01$) and more quickly ($F(1,36) = 47.84, p < .01$) than pseudowords. There was an interaction between groups and lexicality for accuracy scores ($F(2,36) = 10.09, p < .01$) as well as for latencies ($F(2,36) = 6.28, p < .01$). Further analyses indicated that while there was no difference between groups for words ($F(1,36) < 1$ on both measures), differences emerged for pseudowords. While the P-DYS were less accurate and slower than the other groups, the D-DYS was also less accurate and slower than the RL group. Thus, our data suggest that the lexicality effect is the largest in the P-DYS group; however, it is more important in the D-DYS than in the RL groups.
- 15 The length effect ($F(1,36) = 5.51, p < .05$) was comparable for all the groups in the accuracy scores ($F(2,36) < 1$ for the interaction) but approached the level of significance in the latencies analyses ($F(2,36) = 2.43, p < .10$). Further comparisons conducted on latencies indicated that the D-DYS group was slower than the RL group on short words reading, while the P-DYS was slower than the RL group on long words reading. Other differences were not significant.

Table 2 : Mean reading scores (accuracy in percentage and latency in milliseconds) for the dyslexic groups and RL group (standard deviation in parentheses).

- 16 P-DYS : phonological dyslexics (2) D-DYS : delayed dyslexics (3) RLC : Reading-level controls

	Group			comparison		
	P-DYS (1)	D-DYS (2)	RLC (3)	2-3	1-2	1-3
RIW test						
Regular						
Accuracy (%)	82.3 (13)	84.5 (9)	94.3 (7)	*		*
Latency (ms)	2094 (787)	1681 (859)	1473 (873)			
Irregular						
Accuracy (%)	55 (23)	63.6 (17)	58.6 (11)			
Latency (ms)	2128 (940)	1806 (873)	1797 (1136)			
WPW test						
Short Word						
Accuracy (%)	94 (8)	95.8 (7)	95.7 (8)			
Latency (ms)	1356 (795)	1715 (840)	1104 (489)	*		
Long words						
Accuracy (%)	88 (12.3)	86.7 (12)	92 (15)			
Latency (ms)	2031 (936)	1828 (717)	1453 (830)			*
Short Pseudowords						
Accuracy (%)	50 (19)	80.3 (14)	88.6 (8)		**	**
Latency (ms)	3716 (2622)	2121 (756)	1741 (1237)		*	*
Long pseudowords						
Accuracy (%)	42 (21)	65.8 (17.3)	87.9 (6)	*	*	**
Latency (ms)	3680 (1346)	2689 (992)	2100 (1349)	*		*

- 17 Note : the comparison columns indicate the level of significance in the Newman Keuls pair comparison tests : * : $p < .05$, ** : $p < .01$
- 18 The interaction between groups and lexicality was significant for accuracy scores ($F(1,36)=12.3, p < .01$) and approached the level of significance in the latencies ($F(1,36)=3.32$). As displayed in table 2, the difference in short and long pseudowords accuracy was larger in both DYS groups (who displayed the same length effect in pseudoword accuracy) than the RL group. In the latencies analyses, while the D-DYS were comparable to the RL for short items, they were slower for long items. In all, this indicates that a specific pseudoword deficit appears in the D-DYS group for long items, while it is already evidenced for short items in the P-DYS group.
- 19 The delay-type group is characterized by a level of performance on both pseudowords and irregular words falling within the normal range given their reading level. As such, the D-DYS deficit could be characterized by a developmental lag in word recognition. The aim of the present study was to examine in more detail whether the reading process of this subgroup was really comparable to that of the RL matched control, or evidenced some differences. In all, it appeared that, in accordance with our group classification, the P-DYS group showed an important phonological deficit. Indicators were poor phoneme deletion scores on both short and long items, poor accuracy and slowness on pseudowords and on long words reading, and a reduced regularity effect. The latency analyses were only moderately conclusive, since there was a large variance in the data (although outliers were excluded). Did the D-DYS group evidence, in a milder form, some of those signs? The response was positive for the phoneme deletion task, but for long items only. More, D-DYS were poorer in the long pseudoword reading, although they performed well on short pseudowords. Finally, they displayed a reduced lexicality effect, comparable to that of the P-DYS group. These effects indicate that there are some differences between the D-DYS group and the RL group, differences that resemble in nature, but not in strength, those shown by the P-DYS group. This evidence favours the

“severity hypothesis” (Griffith and Snowling, 2001). According to this hypothesis, the phonological deficit is the core of most reading impairments: the severity of the phonological deficit will determine the reading profile (phonological or delay-type). In our study, the D-DYS deficit with pseudowords appeared only with long items, and not with short items, in the phoneme deletion task as well as the reading tasks. For the latter, this impairment with long items occurred for pseudowords but not for words. However, another difference has been noted, which differentiates the D-DYS from both the P-DYS and the RL groups. Indeed, D-DYS were found to be slow in reading short words. Such short and frequent words are usually read very quickly. While no difference emerged between the P-DYS and the RL groups, this slowness displayed by the D-DYS may indicate that they may have, in addition to mild phonological impairments, a specific difficulty in establishing quick or automatic whole-word recognition.

- 20 In all, our data suggest that the reading processes of the D-DYS are not completely comparable to those of the RL group when examined in details. The differences found plead in favour of mild phonological impairments in addition to a slowness in reading short frequent words.

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ABSTRACTS

Methods used in subtyping developmental dyslexics and based on reading-level matched children statistics (mean and standard deviation) define two main categories : phonological dyslexics whose performance in pseudowords reading accuracy is specifically impaired and delay-type dyslexics (D-DYS) whose performance in both pseudowords and irregular words accuracy scores falls into the normal range for their reading level. Thus, the delay profile is usually considered as similar to that of younger normal readers. The aim of the present study was to examine more in detail the reading process of the D-DYS group. Effects of regularity, lexicality, and length for both words and pseudowords were examined -on both accuracy and processing times scores- in reading aloud tasks. The results indicated that the reading process of the D-DYS are slightly different to that of the RL group and suggested a mild phonological deficiency, as evidenced by an impairment with long pseudowords processing.

Les méthodes utilisées pour catégoriser les dyslexiques, basées sur la comparaison avec les contrôles de même niveau en lecture (utilisant les statistiques de moyenne et d'écart-type), définissent deux catégories principales : les dyslexiques phonologiques, dont les performances en précision de lecture de pseudomots sont spécifiquement faibles et les dyslexiques de type "retard" dont les performances en précision de lecture de pseudomots et mots irréguliers correspondent aux valeurs attendues pour leur niveau en lecture. Ainsi, le profil de type retard est considéré comme similaire à celui de jeunes normolecteurs. Le but de l'étude présente est d'examiner plus en détail les procédures de lecture du groupe de type retard. Les effets de régularité, de lexicalité et de longueur pour les mots et les pseudomots ont été étudiés, sur les scores de précision et de rapidité, dans des tâches de lecture à voix haute. Les résultats indiquent que les procédures de lecture des enfants du groupe "retard" sont sensiblement différents de ceux des jeunes lecteurs de même niveau, et suggèrent un léger déficit phonologique, mis en évidence par une difficulté dans le traitement des pseudomots longs.

INDEX

Keywords: developmental dyslexia, phonological dyslexia, delay-type dyslexia, phonological skills, reading process

AUTHOR

SÉVERINE CASALIS

URECA, EA 1059, Université de Lille 3, Villeneuve d'Ascq