

*Laboratoire de Neuropsychologie  
Hôpital de la Salpêtrière (Paris)*

## AN INVESTIGATION OF DEVELOPMENTAL DYSLEXIA

PAULETTE KOSSANYI & JALE KOREZLIOGLU

A quantitative and qualitative analysis of the reading errors of dyslexic children is presented. Particular attention is paid to the differential treatment of words according to syntactical class, visual, derivational and semantic errors, and to the production of non-words. A comparison is made between developmental dyslexia and acquired dyslexia: some significant similarities have been found between developmental and deep dyslexic behaviours.

Developmental dyslexia has often been defined by alternative terms like reading disability, reading retardation, congenital reading difficulty, e.a. Whatever the term used to designate children with reading problems or to define the causes underlying their difficulties, dyslexic children could generally be described as those who "despite conventional classroom experiences, fail to attain the language skills of reading, writing and spelling commensurate with their intellectual abilities" (Critchley, 1970). In an attempt to teach dyslexic second graders, Rozin, Poritsky and Sotsky (1971) observed that these children had particular difficulties to enunciate visually presented letters: They could not recognize such letters as representing components of their own speech, they also had difficulty in identifying words by initial or final sounds, and in combining a sequence of letters into a word. Many children did not know all the sounds corresponding to the alphabetical symbols. The same authors demonstrated that English dyslexic children, who could not read English words presented phonemically, were able to learn the logograph of the Chinese equivalent. The authors interpret this as being due either to motivation — the novelty of the Chinese characters being a further stimulation to reading — or to the fact that the characters represent words and not phonemes. This seems to point to a particular difficulty for English dyslexics to convert graphemes to phonemes. It rules out the definition of dyslexia as a visual-auditory memory deficit, at least as far as this study is concerned, and also eliminates a possible intellectual deficit since the children were tested on three subtests of the "Wechsler Intelligence Scale for Children". In Japan, where two different scripts — Kanji (close to the Chinese ideogram) and Kana (a script in which each symbol represents a syllable — are used, the rate of dyslexia is very low in children; it may also be interesting to note that deep dyslexics tend to have bigger problems with Kana than with Kanji (Makita, 1968; Coltheart, 1979).

The most common errors for dyslexic children are the following: confusion of reversible letters, substitution of a letter or several letters for another within a given word, or substitution of a word for another. In the latter case they either produce a word close in form or meaning to the target word or they introduce a nonword (Rozin, et al., 1971). On the other hand, the difficulties encountered by these children seem to present some analogies with the problems observed in a particular variety of acquired dyslexia called deep dyslexia, (Marshall & Newcombe, 1973). The main features of deep dyslexia are a production of semantical, visual and derivational errors, an impossibility of reading nonwords and a differential treatment of syntactical classes. It has already been noted, for example, that function words present greater difficulties than nouns and that abstract words receive poorer responses than do concrete words.

The present study was designed: 1. To make a quantitative and qualitative analysis of errors made by dyslexic children while reading a text. 2. To bring out eventual relations between various parameters by studying the evolution in reading within successive trials. 3. To compare developmental dyslexia with the different categories of acquired dyslexia which are described in the literature: *visual dyslexia*, which is considered as a damage to the visual word form system, *surface dyslexia*, which is largely determined by spelling the sound characteristics of the words, and *deep dyslexia*, which is related to the semantic and syntactic nature of the words.

#### MATERIAL AND METHOD

The study is based on a sample of reading errors made by 100 children under observation at the "Hôpital des Enfants Malades" (Hôpital Necker), in the Service of Psychopediatry, directed by Prof. Debray-Ritzen.

In France, school starts at the age of six, and since it is generally accepted that one cannot talk of "dyslexia" before the age of nine, we have only taken into account the reading errors of boys and girls between 9 and 14 years old.

A 265-word French text — entitled "l'Alouette" (Lefavrais, 1963) — is used to assess the reading abilities of the dyslexic children. This text is rich in poetic imagery and metaphors, with a relatively high amount of unfrequent words and unusual figures of speech. The comprehension of the text is rather difficult because of frequent inversions of word order and the presence of "traps", i.e., words or phrases in contradiction with what the reader is expecting. For example: The sentence from the very familiar French nursery rhyme "Au clair de lune mon amie Annie" is presented as "Au clair de lune mon amie Annie", with an omission of the article "la" and a replacement of "Pierrot" by "Annie", which is close in sound to the word "amie" preceding it.

The reading trials were spaced at intervals of six months. During each trial, the child was asked to read aloud as correctly and as fast as possible for three minutes, while the orthophonists marked every error. As compared with the standardized results of "normal" children, the number of words read within three minutes and the amount of errors constituted the "degree of dyslexia" (Debray, Binoche & Nebout, 1972).

#### PROCEDURE

##### SYNTACTICAL ERRORS

In our analysis four different syntactical classes of words were distinguished: nouns, adjectives, verbs, and function words (articles, conjunctions, prepositions, e.a.). There is an equal repartition of each class of words throughout the text with approximately 40% nouns, 7% adjectives, 13% verbs, and 40% function words (60% content words versus 40% function words). The syntactical analysis gives five error percentages: on nouns, adjectives, verbs, the sum of these content words, and on function words. The percentages are the ratio  $a/b$  where (a) is the total number of errors bearing on the words of a given category, and (b) the total number of words of this category read during the trial. This normalization allows a comparison of percentages for each child for one or several trials.

##### NOUN ERRORS

This analysis has been carried out on nouns from sentences which present neither word order inversion nor "traps". Each word is characterized by its length (number of letters and number of phonemes) and by the coefficient of usage given in the frequency dictionary of French words of A. Juilland, D. Brodin and C. Davidovitch (1970). This coefficient relies on both frequency and dispersion. If the 5.000 words are divided into ten equal classes, the percentage of the average usage of each class are:

class	percentage	average
first	82.85%	595.3
second	6.08%	43.6
third	3.42%	24.6
fourth	2.25%	16.2
fifth	1.6%	11.5
sixth	1.2%	8.5
seventh	0.9%	6.5
eighth	0.7%	5.0
ninth	0.55%	4.0
tenth	0.45%	3.3

Four categories of errors have been distinguished :

*Visual errors* : Errors for words visually resembling the stimuli, for example :

- "poison" read as "poisson" (poison-fish)
- "gaminer" read as "graminé" (to play pranks - graminaceous)
- "amie Annie" read "Annie amie" (friend Annie-Annie friend)
- "pompe" read "pomme" (pump - apple)
- "promène" read "problème" (strolls - problem)
- "viendra" read "vendrà" (will come - will sell)
- "jeux" read "yeux" or "joue" (games - eyes or plays (in verbal form)).

*Derivational errors* : Responses sharing a common root with the stimuli, where the stimulus is a "syntactic derivation from the response or vice versa" (Coltheart, 1979). These responses also include errors made on articles (which are frequent and multiple in French), on conjunctions, and so on. For example : reading "mon livre" instead of "mes livres" (my book — my books), was considered as an error made on the possessive adjective but not on the noun as well, since the latter resulted from the former. Furthermore, a separate analysis of derivational errors was made on content words, to check whether there was a notable difference between these errors in content words as opposed to function words. Some derivational error-responses are :

- "hirondeau" read "hirondelle" (young swallow - swallow)
- "buis" read "buisson" (box-tree - bush)
- "chantant" read "chanta" (singing - sang)
- "potager" read as "potage" (vegetable garden - soup)
- "fourchu" read "fourchette" (forked - fork)
- "est" read "être", or "sont" (is - to be, or are)
- "d'or" read as "doré" (of gold - golden)

*Semantical errors* : The response, though erroneous, is semantically related to the stimulus. For example :

- "sur" read as "sous" (on — under)
- "doigt" read "poing" (finger - fist)
- "hirondeau" read "alouette" (young swallow - skylark)
- "chêne" read "chataigne" (oak - chestnut)
- "rives" read "mer" (shores - sea)

*Nonword production* : for example,

- "féeries" read as "icher" (fairies —?)
- "gai" read as "zan" (gay —?)

## RESULTS

One hundred and twenty eight observations were taken into account (36 observations within age group 9-10; 30 within age group 10-11; 28 within age group 11-12; 20 within age group 12-13, and 14 within age group 13-14). The histograms of error percentages, traced in terms of age, indicate certain tendencies: diminution with age of errors made in content words, and not in fonction words; diminution of visual errors and less so of derivational and semantical ones. In view of quantifying the results, we calculated a mean error percentage on the basis of the different age groups and the different items considered in the analysis: Table 1 presents the results with regard to nouns, adjectives, verbs, the sum of the three, and function words; while Table 3 presents visual, semantical, and derivational errors as well as nonword production.

TABLE 1. AVERAGE PERCENTAGE OF ERRORS IN NOUNS, ADJECTIVES, VERBS, CONTENT WORDS AND FUNCTION WORDS

age of subjects (A)	nouns	adjectives	verbs	content words	function words
$9 \leq A < 10$	$0.16 \pm 0.02$	$0.09 \pm 0.02$	$0.12 \pm 0.01$	$0.14 \pm 0.01$	$0.05 \pm 0.01$
$10 \leq A < 11$	$0.12 \pm 0.01$	$0.07 \pm 0.02$	$0.10 \pm 0.01$	$0.12 \pm 0.01$	$0.05 \pm 0.01$
$11 \leq A < 12$	$0.12 \pm 0.01$	$0.08 \pm 0.02$	$0.11 \pm 0.02$	$0.11 \pm 0.01$	$0.04 \pm 0.01$
$12 \leq A < 13$	$0.13 \pm 0.02$	$0.07 \pm 0.02$	$0.10 \pm 0.02$	$0.12 \pm 0.02$	$0.07 \pm 0.02$
$13 \leq A < 14$	$0.09 \pm 0.01$	$0.04 \pm 0.02$	$0.06 \pm 0.01$	$0.08 \pm 0.01$	$0.05 \pm 0.01$

As can be seen in Table 1, the percentage of errors between the different categories of content words decreases from age groups 9-10 to 13-14 at a rate of 16 to 9% for nouns, 9 to 4% for adjectives, 12 to 6% for verbs, and 14 to 8% for the sum of the content words. In all three classes progress is analogous (errors decrease by approximately 50%). On the contrary, the percentage of errors for function words is the same in age groups 9-10 and 13-14. These results point to differences in word-reading according to the syntactical class to which these words belong. They indicate that among content words children seem to read most easily adjectives, then verbs, and, finally, nouns. This unusual inversion may be due to the fact that most of the "traps" in the text concern the nouns. The main result in Table 1 is certainly that the percentage of the errors made in function words seems rather independent of the age of the children.

Table 2 presents the results of the noun errors analysis in terms of usage, word length, and abstractness. For short concrete nouns the number of errors decreases when the frequency of the words increases (6 first lines in Table 2). From the very few examples of long words, it seems that for a given frequency (rare) the number of

TAB. 2. EFFECT OF WORD USAGE, WORD LENGTH AND ABSTRACTNESS

	number of letters	number of phonemes	coefficient of usage*	number of errors	words
concrete nouns	4	3	rare	15	buis
	4	3	15	7	toit
	4	3	25	2	bois
	4	1	3	15	haies
	4	1	145	0	cause
	5	2	40	2	sang
	5	3	rare	10	chêne
	5	3	rare	7	biche
	6	3	rare	7	mousse
	6	4	rare	16	pinson
9	7	rare	15	égantier	
abstract nouns	7	5	4.6	37	féerie
	5	4	6.0	37	ennui
	5	3	7.0	22	penne
	4	4	177	0	soir
	5	2	464	3	temps
	9	6	29	2	printemps

\* For the words which are not mentioned in the dictionary the word "rare" was used to characterize the coefficient of usage.

errors increases with word length (number of letters) and number of phonemes (lines 7 to 11 in Table 2). The lines 12 to 17, concerning abstract nouns, show a higher percentage of errors on abstract nouns (even when fairly frequent) than on concrete nouns and word frequency (usage) does seem to have an effect.

Table 3 presents percentages of visual, derivational and semantical errors, and the percentage of nonword production. This latter percentage decreases strongly with age (from 4 to 1%). For visual errors, the decrease is from 11 to 4% (for age groups 9-10 and 13-14,

TAB. 3. AVERAGE PERCENTAGE OF ERRORS VISUALLY, DERIVATIONALLY, AND SEMANTICALLY RELATED TO THE TARGET WORD AND OF NONWORD PRODUCTION

age of subjects (A)	visual errors	all derivational errors	derivational errors on content words only	semantical errors	nonword production
9 ≤ A < 10	0.11 ± 0.01	0.02 ± 0.002	0.003 ± 0.001	0.004 ± 0.001	0.04 ± 0.01
10 ≤ A < 11	0.08 ± 0.01	0.02 ± 0.002	0.004 ± 0.002	0.003 ± 0.001	0.02 ± 0.01
11 ≤ A < 12	0.05 ± 0.01	0.03 ± 0.003	0.007 ± 0.003	0.007 ± 0.002	0.02 ± 0.01
12 ≤ A < 13	0.06 ± 0.01	0.03 ± 0.003	0.007 ± 0.003	0.004 ± 0.001	0.03 ± 0.01
13 ≤ A < 14	0.04 ± 0.01	0.02 ± 0.002	0.008 ± 0.003	0.001 ± 0.001	0.01 ± 0.01

respectively). Derivational errors seem to be independent of age. Their percentage is low in absolute value and close to 2.5%. However, the syntactical nature of the words inducing derivational errors does seem to change with age: younger children seem to make fewer errors in content words (only 10% of all derivational errors), whereas children between 13 and 14 tend to make far more errors in content words than in function words (approximately 50% of all derivational errors enter into this group). However, the low percentage of derivational errors made in nouns, for example, prevents any conclusion on the eventual evolution of this parameter with age. Semantical errors appear to be 15 or 20 times less frequent than visual errors. Their existence is nevertheless undeniable in the analysed sample and cannot be explained by guessing behaviour.

TABLE 4. IN SEARCH OF RELATION BETWEEN EVOLUTIVE PROFILES RELATED TO THE DIFFERENT CATEGORIES OF ERRORS. In our description +, - and = correspond respectively to improved, regressive and stationary results.

errors in function words	errors on content words			derivational errors	visual errors		
	+	-	=		+	-	=
+	16	6	10	+	12	4	7
-	7	11	6	-	15	9	10
=	2	4	1	=	4	2	0
	4a: $\chi^2 = 5.98$ n.s.				4b: $\chi^2 = 3.04$ n.s.		

The analysis of the subject's development, i.e., the comparison of the subject's results at different ages, offers another approach. The different evolutive profiles, referred to in Table 4, deal with subjects who present either progression (+), regression (-) or stagnation (=). In Table 4a, among 63 cases, evolutive profiles do not point to a relation between processes which are implicated in the reading of content words and those implicated in reading function words ( $\chi^2 = 5.98$ , n.s.). In Table 4b, evolutive profiles related to visual errors and derivational errors show also a great dispersion ( $\chi^2 = 3.0$ , n.s.). Both results are in good agreement with the earlier observed general tendencies: see the results in Table 4a and 4b as compared to the results from Table 1 and Table 3.

#### DISCUSSION

Newcombe and Marshall (1973) identified three forms of acquired dyslexia: *deep dyslexia*, characterized by severe problems in grapheme-to-phoneme conversion (nonwords cannot be uttered, semantical errors exist, and reading abilities depend on the syntactical class of words); *visual dyslexia*, characterized by purely visual errors, and *surface dyslexia* for which most of the errors can be described as partial failure of grapheme-to-phoneme conversion with errors such as assignation of

a phonetic value to silent graphemes. Studies by Holmes (1973, 1978), Jorm (1977, 1979) and Ellis (1979) are concerned with analogies between these kinds of dyslexia and developmental dyslexia. Holmes argues that the misreadings of developmental dyslexics are closely comparable to the errors made by surface dyslexics. Jorm proposes resemblances between developmental dyslexics and deep dyslexics. For Ellis, reading is a skill which may be affected in a wide variety of ways by brain damages which may produce clinically some "pure forms" of acquired dyslexia but, most of the time, brings about a mixed symptomatology. He concluded, by analogy, that deep dyslexia can also be developmental.

In the present study, the following characteristics were observed: words are treated differently according to syntactical class, errors derivationally and/or semantically related to the stimulus do exist, and a difficulty in grapheme-to-phoneme conversion probably exists since there is an important nonword production, particularly for unfamiliar content words. Usage effect as well as abstractness affect the performances of developmental dyslexics. As compared to acquired dyslexia it appears that only a few visual errors in this study could be called surface errors: for example, the word "geai" (jay) [ʒɛ] pronounced "gai" (gay) [gɛ], and the word "gîte" (resting place) [ʒit] pronounced "guite" (nonword) [git]. The majority of observed errors are visual, but no child under study produced only visual errors.

Most deep dyslexic patients produce semantical errors (Marshall & Newcombe, 1966; Shallice & Warrington, 1975; Patterson & Marcel, 1977). the present study shows the same tendency and this is in contrast with the study of Ellis (1979) who — because of the absence of semantical errors in Jorm's observation (1979) — contests any claim of analogy between developmental and deep dyslexia. Our observations seem to be rather in favour of Jorm's assumption (1977; 1979) that developmental dyslexia has certain functional similarities with deep dyslexia. Moreover, deep dyslexics have greater difficulties with function words than with content words (Coltheart, 1977). Correlatively, most of our dyslexic children's performances do not improve in function word reading: percentages of errors in these words are constant for age groups 9-10 and 13-14, while their performances improve for content words. As to nonwords, the test did not allow to make any comparison between developmental and deep dyslexia since the children were not asked to read nonwords aloud. At least, usage and abstractness certainly affect the performance of developmental dyslexics.

Boder (1971) and Vernon (1979) suggest that reading involves the acquisition of a succession of skills. A breakdown in any of these stages entails different reading disorders in children. They can be grouped according to the level of reading behavior. One important element could be that of age.



## CONCLUSION

Different evolutive profiles are established: Some subjects progress much more for content words than for function words, while the reverse, though more rare, may be the case for some others; both classes of words may be in progress, stagnation or regression for still other groups of children.

Some characteristics of developmental dyslexia are stated: differential treatment of words according to syntactical class, production of derivational and semantical errors, usage effect and abstractness effect.

Another purpose of our study was to examine whether significant similarities exist between developmental and deep dyslexia. There are some similarities, but the results call for further observation. Extensive study of the acquisition of reading is necessary.

Appropriate measures of reading ability and, consequently, of developmental as well as acquired dyslexia, should jointly include a quantitative and qualitative analysis of the errors made by the patients and a measure of their comprehension of the reading material. This last aspect is missing in our study, as well as a comparison with the results of normal children on the same text. It calls again for further observation.

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P. Kossanyi  
Laboratoire de Neuropsychologie  
INSERM U 84  
Hôpital de la Salpêtrière  
47, Bd. de l'Hôpital  
75634 Paris Cedex 13  
France

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