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Visual information processing as a determinant of reading speed

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ABSTRACT

50 students were presented tachistoscopically with arrays of 5 digits, followed by a masking stimulus. They were also tested for speed of reading, for speed of picking out a given digram ('tg') from an arrangement of random letters, and for duration over which material was held in their VIS (visual information store). Similar tests were given to 4 students who had been diagnosed as dyslexic.

It was found that those needing longer time to respond correctly in the digit task were significantly slower both in the reading tasks and in the digram search tasks. The 4 dyslexic subjects were the slowest of all. The slower digit processers and readers showed slightly longer VIS duration but these results failed to reach the 5% level of significance.

It is argued that speed of processing from the VIS is one determinant of speed of reading. The results are also compatible with the thesis that dyslexic-type difficulties are a manifestation of some general limitation in processing ability.

RÉSUMÉ

La vitesse de la transformation des renseignements visuels comme cause déterminante de la lecture.

La compétence en lecture est le résultat de beaucoup de fonctions sous-composantes. Pour examiner l'importance relative de ces fonctions en vue de déterminer la compétence en lecture, il faut, d'abord, déterminer les thèmes qu'on peut étudier avec le plus grand profit. On sait, par exemple, que la plupart des mesures des mouvements oculaires pendant la lecture sont corrélatives à la compétence en lecture, et par conséquent on a suggéré que des mouvements oculaires inefficaces retardent en lecture. Dans cette étude, nous démontrons que les étudiants qui transforment lentement des rangs de chiffres présentés d'une façon tachistoscopique lisent plus lentement que ceux qui transforment rapidement les chiffres. Comme ces rangs sont transformés d'une seule fixation, on peut conclure que des mouvements oculaires ne jouent pas un role causal dans la détermination de la compétence en la lecture: des 'lecteurs lents' lisent toujours lentement quand des mouvements oculaires sont impossibles. On a testé aussi quatre étudiants dyslexiques; pour transformer ces cinq rangs de chiffres ils avaient

Note: A brief résumé of some of the findings in this paper has appeared in Ellis and Miles (1977) but with no supporting detail.

besoin d'un espace de temps considérablement plus long même que les 'transformeurs lents'.

Parmi les 50 étudiants qu'on a testés, des corrélations significatives existent entre la vitesse de transformation des rangs de chiffres, la vitesse de lecture de plusieurs passages d'un niveau de compréhension variable, et la vitesse de la recherche visuelle. Par contraste avec les conclusions de Stanley et Hall (1973) on a trouvé que ni les 'transformeurs lents' ni les étudiants dyslexiques ne retenaient des renseignements visuels pendant un espace de temps beaucoup plus long que les lecteurs rapides.

La lecture des chiffres, par contraste avec la lecture des mots, n'exige pas un effort de compréhension. Ni la familiarité du sujet avec les séquences de lettres probables de l'anglais ni sa compétence à parcourir des files de lettres, ne l'aideront pas beaucoup. Ainsi, on considère la transformation des rangs de chiffres comme mesure relativement pure de 'la vitesse à transformer des renseignements'. Les résultats de cette recherche nous mènent à la proposition que la vitesse de la transformation de la réserve de renseignements visuels est une cause déterminante de la vitesse de lecture. Il est suggéré que, pour examiner des variances individuelles de la capacité à lire, on peut délimiter la recherche à l'étude de ces fonctions qui sont à la base de la transformation des rangs de chiffres, et par conséquent, nous examinons d'avantage ces fonctions.

INTRODUCTION

In this paper we attempt to test the claim that one determinant of speed of reading is 'speed of information processing'. Following the lead of Sperling (1963, 1967) we assume that, in any visual task, stimulus information is held for a limited time in a 'visual information store' (VIS) from which it is transferred in suitable form to some more central mechanism. We argue that the observed differences in performance which we describe cannot be accounted for in terms of peripheral factors, e.g. a limitation in the speed of eye movements, and we show that those who are slow at processing from the VIS, as measured by speed of identification of tachistoscopically presented 5 digit sequences, are also slow at other tasks, viz. reading and picking out a named digram ('tg'), which must necessarily involve processing from the VIS. Our subjects were 50 students with no special history of difficulty over reading or spelling. We also gave the same tests to 4 undergraduate students who had been diagnosed as 'dyslexic', our intention being to test the hypothesis that dyslexic difficulties are the result of slowness at information processing (compare Miles and Wheeler, 1974 and 1977). Moreover, since Stanley and Hall (1973b) found that VIS duration (i.e. the time during which the information remains in the VIS) was longer in the case of their dyslexic children than it was for a control group, we thought that it might be interesting to obtain a figure for each of our subjects in respect of VIS duration.

The two main factors which we set out to study were thus: (1) the duration over which material was held *in* the VIS and (2) the speed at which information was processed *from* the VIS. Our theoretical standpoint was that these processes are necessarily involved in reading. We therefore wished to investigate to what extent each of these processes determines efficiency at reading, and the part played by them in visual search. For example, is it the case that speed of processing from the VIS is the rate limiting step of the reading process?

To obtain estimates of 'speed of processing' it was decided to measure how quickly the subjects could correctly identify a 5-digit sequence from a single fixation. This procedure was adopted on the grounds that it would yield a relatively 'pure' measure of speed of information processing; in particular the results would not be affected, as the reading of words is affected, by individual differences in speed of eye movements, by comprehension load, by familiarity with the material to be read (since all subjects could be assumed to be familiar with the Arabic digit notation), nor by 'chunkability'.

Speed of processing, so defined, is thus the main independent variable in the study. Our subject population is then split into fast and slow processers, whose ability in reading and visual search tasks is then compared.

Our design was therefore influenced by the following considerations:

(i) *Digit processing time.* It was important to ensure that the results of this test could not simply be explained in terms of eye movements. Since eye movements are involved both in visual search and in reading, it could be argued, in the absence of any control procedures, that any correlation which occurred between the two was the result of the ability of the fast readers to make quicker or more efficient eye movements. Now it is true that speed of eye movements bears some small relationship to speed of reading, but the main differences between good and poor readers have been found to lie in duration of fixation and in span of recognition (Anderson, 1937; Tinker, 1946; Gruber, 1962); and these functions are clearly of central origin. Any correlation that was found, therefore, could not be attributable simply to an anatomical limitation at the periphery. To forestall any possible argument, however, it was decided in the case of tachistoscopic presentation of digits to use exposure times which, at least in the case of most students, permitted only one fixation. In conditions designed to approximate to the eye movements of reading with no information uptake Walton (1957) found that the mean reaction time of the eye for movements varied in the case of adult readers between 170 and 309 ms., with a group mean of 219 ms.; and as 90% of the subjects in the present experiment were responding correctly at exposure times of 100 ms. or less, it follows that the processing involved one fixation only, no eye movements being possible in this time.

One of the advantages of using digits as stimulus material is that, provided they are randomised, the subject can do very little by way of chunking; and with this source of 'learning overlay' eliminated, the time taken to respond to digit arrays can perhaps be regarded as a relatively 'pure' or 'basic' measure of speed of information processing in contrast with reading or searching for digrams. For convenience, therefore, we have operationally defined the terms 'fast processer' and 'slow processer' in terms of their performance on the digit task; and with this definition it becomes an empirical question whether fast and slow processers are or are not fast and slow readers respectively.

In the present experiments the earlier procedure of the pilot study (Miles and Wheeler, 1977) was modified by the introduction of a masking stimulus (MS) at varying inter-stimulus-intervals (ISIs) after presentation of the test stimulus (TS). In the light of evidence supplied by Sperling (1963) it seems that, in the absence of the MS, one is studying what the subject can do in exposure time *plus* VIS time. The time interval between onset of TS and onset of MS has been referred to by Kahneman (1968) as 'stimulus onset asynchrony' (SOA). In general the SOA is equal to the duration of the TS plus the duration of the ISI.

There is controversy about the level at which the pattern acts, the two traditional theories being the integration theory (Kahneman, 1968; Coltheart, 1972) and the interruption theory (Sperling, 1963, 1967). New work by Marcel (1976) and Allport (1976) suggests that the mask may limit the formation of a conscious percept, while having no effect on unconscious dictionary access and linguistic/semantic analysis. However that may be, it is known that masking limits the processing of information, at least at the conscious level. It follows that if one determines the minimum SOA necessary for correct responding one is thereby obtaining an indication of the speed at which the TS is being processed. Confidence in the validity of this procedure is increased by the finding of Dember and Neiburg (1966) that individual differences in susceptibility to backward masking are highly reliable; their test-retest rank order correlations were found to be between 0.79 to 0.92.

(ii) *Reading.* It was decided to test speed of reading over different types of material and with different typographies. These included:

Condition 1, light fiction, with instructions to read for gist;
Condition 2, non-fiction, with instructions to read for comprehension at normal textbook speed;
Condition 3a, light fiction with normal typeface;
Condition 3b, light fiction with novel typeface and 4 spaces between each word; and
Condition 4, light fiction with very short (10 pica) line widths.

Conditions 3b and 4 were introduced to impose extra difficulty not through complexity of reading matter (as in Condition 2) but through type face novelty and the necessary increase in number of saccadic movements.

(iii) *Visual Search Tasks.* These were devised on the basis of procedures suggested by Neisser (1963, 1967) and Neisser and Beller (1965). The subjects were required to search for the digram 'tg' in passages of randomly generated lower case letters. 6 passages were used, in which there was systematic variation of (a) typography and (b) 'word length' (i.e. number of letters appearing together without a space).

(iv) *VIS Duration.* This was measured by means of a variant of procedures already in use (Eriksen and Collins, 1968; Haber and Standing, 1969; Haber and Nathanson, 1968; Jackson and Dicks, 1969; Stanley and Hall, 1973b). The subjects were presented with two distinguishable stimuli separated by very small time intervals, and were asked to say whether those two 'elements' were perceptually continuous or discrete.

SUBJECTS

50 students took part in the experiment. 26 were psychology undergraduates at university and 24 were from the local Technical College. 27 were female and 23 male, the age range being 17-25 years.

The rate of reading of these subjects on a non-fiction article (condition 1) ranged from 146 words per minute (w.p.m.) up to 613 w.p.m. The group mean was 310 w.p.m. with a standard deviation of 104 w.p.m.

4 male dyslexic students were also tested. All 4 had been assessed at the Dyslexia Unit attached to the University Psychology Department. They were of university standard intellectually; but still had appreciable difficulty with spelling and many of the other typical symptoms described by Miles (1975). The rate of reading in condition 1 ranged from 127 to 202 w.p.m., with a group mean of 152 w.p.m. and standard deviation of 35 w.p.m.

MATERIALS AND PROCEDURE

(i) Digit Processing Time

Up to 30 different cards of 5 quasi-randomly generated digits (no digit could appear more than once on any card) were presented successively in an Electronic Developments 3-field tachistoscope. The digits were printed on white card with 28 point Helvetica light Letraset. Cards were presented at a distance of 508 mm. from the subjects' eyes, which gave an illumination at the eye of about 1 lux. Each trial was started with the word 'ready' followed by a fixation cross (illumination at the eye of about 0.15 lux) for 2 seconds. The digits followed the fixation cross immediately. On the first trials, where TS exposure time was determined, the digits were followed by darkness. On later trials, where 5 digit processing time was determined, a pattern mask present for 200 ms. and with illumination at the eye of about 3 lux, followed after a given ISI. The effectiveness of the mask was established by the fact that when both mask and digits were presented simultaneously for 2 sec. the digits could not be reported. The subjects were instructed beforehand to repeat as many of the digits as possible upon TS offset, or, in the case of the masking trials, immediately upon MS onset.

To determine TS exposure time the subjects, after a short practice session, were tested with digit stimuli which were presented for 100 ms. with no MS following. If they were correct on two consecutive trials they were then given the digit stimuli for 50 ms. If they were again correct on two successive trials at 50 ms. then 50 ms. would be the TS exposure time throughout the experiment, but if they were incorrect the exposure time was set at 100 ms. If their responses were incorrect at the initial 100 ms. presentations, they were presented with test stimuli at exposure times increasing in 50 ms. steps (two trials per step) until the criterion of two correct responses on consecutive trials was satisfied.

For 70% of the subjects the TS was exposed for 50 ms., for 20% it was exposed for 100 ms., and for only 10% was it exposed for over 100 ms.

The procedure for determining the subjects' 5-digit processing time was then as follows: a masking stimulus was brought in after an ISI of 100 ms, the ISI then being either decreased in 10 ms. steps until there were two consecutive errors or increased until two consecutive answers were correct. When results for all 50 subjects were pooled, median SOA was 128 ms. This was made up of 50 ms exposure time, with an ISI of 78 ms. The durations ranged from 50:10 (SOA 60) to 800:100 (SOA 900).

(ii) Speed of Reading Tests

For measuring speed of reading over different types of reading matter the following passages were used:

In *condition 1* the material was an adult level non-fiction article of 337 words. The subjects were instructed to read for gist at their normal reading speed.

In *condition 2* a more complex non-fiction article of 292 words was used, which discussed air pollution. The subjects were instructed to read at their normal speed for textbook material and were told to expect a comprehension test after completing the article. Any subject scoring less than 60% on the comprehension test was excluded from the study.

Both conditions 1 and 2 were photocopies taken from popular paperback books. They were of common line length, typeface and leading.

For *condition 3* a passage from the *Neale Analysis of Reading Ability* (Neale, 1958) was retyped on an I.B.M. electric typewriter with black carbon ribbon. The first half (condition 3a) was typed with 1 space and 1 degree of leading, and the second half (condition 3b) with 4 spaces and 1 degree of leading. Conditions 1 and 3a were similar light reading material;

and the correlation between these two tests was .84. This indicates a reliability sufficiently high to justify their use as group tests.

Another passage from the Neale test was used in *condition 4*, retyped with 1 space and 1 degree of leading, but with a maximum of 3 words per line: the maximum line length was 10 picas.

In all conditions the first and last words were underlined and the subjects were instructed to read these words aloud for purposes of timing them. On this basis, reading speeds, expressed in words per minute, were calculated for each subject in each condition.

(iii) Digram Search Test

There were six conditions in the visual search experiment. Each subject was given a short practice session, which was followed by the six conditions in random order of presentation. They were instructed that immediately after the command 'now' they were to search through the passage counting to themselves the number of 'tg's and to report how many there were as soon as they had reached the end. Search times were measured with a stopwatch.

The six conditions all contained 240 randomly generated letters, among which there were 10-15 target digrams. They differed in respect of 'word length' of non-target letters among which the digrams were hidden, which ranged from 30-letter 'words' to 3-letter 'words', and typography.

Search time over all six conditions was calculated for each subject.

(iv) Procedure for Obtaining Estimates of VIS Duration

Two part displays—either a cross and a square (Stanley and Hall, 1973b) or a man and a hat were presented in the tachistoscope. They were presented in different fields in such a way that, if both fields were on, the two parts of the pair produced a spatially composite percept, i.e. the cross was in the square or the hat was on the man.

For determining VIS duration, one of the pair was presented for 20 ms., illumination at the eye being approximately 1.5 lux. This was followed, after a period of darkness during the ISI, by the other member of the pair, which was presented at the same exposure time and the same intensity. This sequence took place in a continuous cycle. Initially the ISI was 10 ms., and at this exposure time when the subjects were asked if the parts formed a composite (e.g. 'Is the cross in the square all the time now?'), they all reported 'yes'. When the ISI was changed to 1000 ms. and the question repeated, all of them reported 'no'. An ISI of 100 ms. was then used. If the subjects answered 'no', it was decreased in 5 ms. steps, with approximately 3 sec. interval between each step, the subject being asked to report when the two parts became a composite. Once this had been reported, the ISI was increased, the subject being asked to state when, for instance, 'the cross was no longer in the square all the time'. This latter procedure was repeated 3 times and an ISI mean was taken over all 6 observations. If, when the ISI of 100 ms. was used, the subject answered 'yes', the ISI was increased in 5 ms. steps until he reported that the two parts were no longer composite. It was then decreased until the 2 parts again appeared composite. This was also repeated 3 times and an ISI mean taken from all 6 observations. The procedures in obtaining this mean constitute the operational definition of 'VIS duration'.

This technique, which is a variation of the procedure adopted by Stanley and Hall (1973b), resulted in a mean duration, in the two conditions and for all 50 subjects, of 70 ms., the range being 27 to 140 ms. Correlation between the scores in the two conditions was 0.81.

All subjects were tested singly in 40 minute sessions, the tests being given in the following order: (1) 5 digit processing time; (2) reading speed; (3) digram search; (4) VIS duration.

RESULTS AND DISCUSSION

The reading speeds of the 50 subjects are given in table 1.

	Condition	Mean reading speed in w.p.m.	s.d.
1	Light non-fiction, reading for gist	310	104.2
2	Non-fiction, reading for comprehension	234	78.7
3a	Light fiction, reading for gist	229	77.2
3b	As 3a but with 4 spaces between words	199	49.7
4	Light fiction, 10 pica line width	238	61.8
	Mean over all conditions	241	65.3

Spearman's Rank correlations:

Condition 1	: Condition 2	rs=.77
Condition 1	: Condition 3a	rs=.84
Condition 1	: Condition 3b	rs=.81
Condition 1	: Condition 4	rs=.83

Table 1: *Reading Speed Data for the 50 Students on Different Passages.*

Next, the subjects were divided into two populations on the basis of digit processing time. The 20 subjects with the fastest digit processing time are referred to as 'fast processers' and the 20 subjects with the slowest digit processing time are referred to as 'slow processers'. For the purpose of this analysis the mid range 20% of students were considered not to fall clearly with either of these categories and were therefore not included. Table 2 shows the reading speed in condition 1, the overall reading speed, the digram search time and the VIS duration for both these fast and slow processer groups. In addition a correlational analysis (table 3) was also performed on the results of all 50 students on the tasks studied.

	Mean 5-digit processing time in ms.	Mean reading speed in w.p.m. (Condition 1)	Mean reading speed in w.p.m. (all conditions)	Total digram search time in ms.	VIS duration in ms.
Fastest 40% of digit processers N=20	X 82.35 s.d. 15.11	X 359.05 s.d. 117.78	X 274.95 s.d. 80.01	X 160.05 s.d. 16.75	X 64.00 s.d. 28.59
Slowest 40% digit processers N=20	X 264.00 s.d. 167.12	X 260.00 s.d. 82.32	X 204.20 s.d. 50.15	X 188.40 s.d. 28.16	X 73.95 s.d. 22.92
Mean difference		99.05	70.75	38.35	9.95
t		3.083	3.351	3.603	1.557
p		$p<0.005$	$p<0.005$	$p<0.005$	ns

Table 2: *Performance of fast and slow processers on 5-digit processing, reading, and digram search tasks, with figures for VIS duration.*

		A	B	C	D	E
A:	Time taken to process 5 digits	1.00				
B:	Time taken to read, condition 1	.47***	1.00			
C:	Time taken to read, all the conditions	.48***	.95***	1.00		
D:	Total digram search time	.64***	.47***	.49***	1.00	
E:	VIS duration	.11***	.32*	.37**	.24*ns*	1.00

Key: ***=significant correlation at the .001 level

**=significant correlation at the .01 level

*=significant correlation at the .05 level

n.s.=not significant correlation

Table 3: *Spearman Rank-Order Correlation Matrix for the performance of the 50 students on the various tasks.*

From Table 1 it can be seen that reading is fastest in the case of gist light non-fiction material (Condition 1), and that it becomes slower if one increases the 'load' with comprehension requirements (Condition 2) or if one demands wasteful eye movements by the introduction of a 'non-hygienic' (Tinker, 1963) and novel typography (Conditions 3b and 4).

However, the inter-condition correlations range from 0.77 to 0.84. These high values suggest that a fast reader is a fast reader whatever the materials used in the experiment. The highest correlation, that of 0.84, is between Conditions 1 and 3a—both light reading for gist. In addition correlations of 0.83 and 0.81 are found between conditions 1 and 4 and between conditions 1 and 3b respectively, which show that a fast reader relative to the population is still fast, whatever the typography. The lowest correlation, 0.77, is between reading conditions 1 and 2 (reading for gist and reading for comprehension). This is not unexpected, since reading for comprehension places a large cognitive demand on the subjects, and efficiency must depend on intelligence, familiarity with the material, etc.

Table II shows that the results obtained by Stanley and Hall (1973a, 1973b) can be roughly generalized to the adult non-dyslexic reading population, and that the results obtained by Gilbert (1959a, 1959b) are a foundation for new work, in that not only are the 'fast processers' fast at reading but are also fast at processing a wide range of stimuli. The top 40% of the subjects, as determined by speed of processing 5 digits, are significantly faster at both reading the condition 1 passage ($p<0.005$) and at reading all the passages ($p<0.005$) than are the 40% of the subjects who were slower processers. They are also significantly faster at the digram target visual search task ($p<0.005$).

In addition, although the trend is towards the faster processers having a shorter VIS duration than the slower processers (64 ms. on average, as compared with 74 ms.), this difference fails to reach the 5% level of significance; and our results, though in the same direction as those obtained by Stanley and Hall (1973b), must be regarded as inconclusive.

A similar picture is seen from the correlational analysis in table 3. These are generally high correlations between information processing ability, as measured by 5 digit processing time, and reading and digram search ability. Reading ability and visual search ability also correlate. Once again, however, VIS duration fails to correlate significantly with either digit processing time or digram search time, and only just produces a significant correlation with the reading performance.

We would consider it surprising, however, if further studies did not demonstrate an inverse correlation between VIS duration and 'speed of processing from the VIS'. This would be a sort of compensation by nature whereby the slow processers could hold information in the VIS for a relatively longer period to allow their slower processing functions to work on this information. Indeed if this were not the case, then with the fast processers there would be little advantage resulting from being fast at processing from the VIS, since new incoming visual information would be forwards masked by that still held in the store, even though the latter had already been processed.

Two practical results appear to follow from our findings. In the first place, since the differences between fast and slow readers are still found even in situations where no eye movements are possible, it follows that any policy of *training* subjects to make quicker eye movements appears to be misguided (cf. De Leeuw and De Leeuw, 1965). Secondly, it seems important that in any teaching situation the subject should be allowed plenty of time. For example, in the BBC television programme, *On the Move,* it seems important that the presented material should remain on the screen for an appreciable length of time; this is true not only of letters and words but also of the telephone number which viewers are invited to ring if they need help.

Finally, in Table 4, we compare the performance of the slowest 40% of the digit processers with that of the dyslexic subjects. Although the sample was small (since relatively few dyslexic sufferers reach university) clear cut differences are nevertheless seen. The slow processers are significantly faster than the dyslexic subjects at 5 digit processing ($p<0.025$), reading in Condition 1 ($p<0.01$), reading over all the conditions ($p<.005$) and visual search ($p<0.001$). VIS duration is slightly longer for the dyslexic subjects than for the slow processers, but this difference once again fails to reach an acceptable level of significance.

	5 digit processing time. S.O.A. ms.	Reading speed (Condition 1) in w.p.m.	Reading speed (all conditions) in w.p.m.	Total digram search time in w.p.m.	VIS duration in ms.
Slowest 40% of digit processors N=20	X 264.00 s.d. 167.12	X 260.00 s.d. 82.32	X 204.20 s.d. 50.15	X 198.40 s.d. 28.16	X 73.95 s.d. 22.92
Dyslexic students N=4	X 450.00 s.d. 100.00	X 151.50 s.d. 34.56	X 123.80 s.d. 39.85	X 250.50 s.d. 15.78	X 75.00 s.d. 22.92
Mean difference	186.00	108.50	80.40	52.10	
t*	2.128	2.554	3.00	3.55	
p	$p<.025$	$p<.01$	$p<.005$	$p<.001$	

* A variance ratio test showed that the homogeneity of variance assumption was upheld in all four conditions.

Table 4: *Performance of slow processers and dyslexic students at 5-digit processing, reading, and digram search tasks, with figures for VIS duration.*

The results given in tables 2 and 3 are compatible with the hypothesis that one determinant of reading speed is speed of processing from the VIS. If this conclusion were based solely on the existence of significant correlations it would, of course, be invalid. Reading ability, however, is clearly the result of many different subcomponents, and whereas there can be no reading without processing from the VIS, efficient processing from the VIS does not necessarily result in ability to read. Similarly there can be no correct identification of digrams without processing from the VIS, but efficient processing from the VIS does not necessarily result in correct identification of digrams. The fact, therefore, that speed of processing from the VIS correlates significantly with both speed of reading and speed of digram search makes plausible the view that speed of processing from the VIS is one of the factors which imposes a limit on speed of reading. It is, of course, the case that these components of 'speed of processing' require to be broken down further.

The results shown in table 4 are compatible with the hypothesis that dyslexic subjects are handicapped by some special limitations in the speed with which they can process information. Ellis and Miles (1977) report that when they used the same procedure with 41 dyslexic *children* (ages 10.4 to 14.4) the mean processing time was 1331 ms., in contrast with a mean of 289 ms. for 41 matched controls. It follows that the 4 dyslexic *undergraduates,* though considerably quicker processers than the dyslexic children, were nevertheless slower than the non-dyslexic *children.* They also report that 15 other dyslexic children, average age 12, performed less successfully at recall of tachistoscopically presented digits than 15 control children, average age 8 and matched for spelling age. This finding appears to confirm the idea that dyslexia involves some kind of distinctive limitation. We are not suggesting that dyslexic subjects are the *only* people who are slow at processing information; what is puzzling is their inability to *learn* to do so despite ample opportunity.

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