TACTILE AND VISUAL TRAINING IN READING: TESTING OF SPEED BY TACHISTOSCOPE / "TOUCH"-TACHISTOSCOPE USING HIGH-FREQUENCY WORDS

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SPESIALPEDAGOGISK ARTIKKELSERIE 1989
SPECIAL EDUCATIONAL SERIES OF ARTICLES 1985
Institutt for spesialpedagogikk, Universitetet i Oslo
Institut of Special Education, University of Oslo
tidligere
STATENS SPESIALLÆRERHØGSKOLE – HOSLE / NORWAY
earlier
The Norwegian Institute of Special Education – Hosle/Norway
This publication proceeds from experiments dealing with identification speed and reading speed among readers of braille (N = 17), reader/users of CCTV (N = 7) and dyslectics (N = 11), compared with a group of especially quick and accomplished readers being used as a control. The experiments have been conducted over a time-span of several years, in step with the progressively new demands for empirical findings that arose out of the author’s clinical experience in dealing with the visually and dyslectically handicapped and their reading difficulties. A primary question underlying this study has been whether it might be possible to improve the reading performance both of those who have suffered loss of vision and of those who had special reading difficulties, by focussing on speed as a critical variable generally in perception and particularly in reading. With the efficient consideration of this issue as the principal purpose of this study the results of certain previously published papers have been drawn upon in this present treatment. Among other these concern, for instance with: the optimization of sight-conditions and reading-conditions through the development of appropriate methods, measuring instruments and training apparatus; a close investigation of transfer of information from the tactile to the visual modality (cross-modal transfer of learning). Such previous findings serve as an apt set of starting points for this present analysis concerning identification speed and reading speed. The experiments reported on here are presented chronologically, and the question of their validity and the critical assessment of the problems they identify are discussed in the light of relevant theoretical models and other research on reading difficulties. An appendix presents supplementary items to augment the presently available training and testing materials.

INTRODUCTION

The reading process is a complex interaction between sense functions, sensory-motoric behaviour and the brains interpretation of symbolic information received through the senses. The degree and extent of creative interpretation and involvement in the reading material demands therefore that as far as possible the routines of the reading process should be automatic or reflex reactions. In "the olden times" reflex reactions were trained through insistent simple repetition of reading exercises. Reading, and especially reading aloud, became a goal in itself, rather than as a means of learning how to learn. The lack of reading-training might well provide some of the explanation for the deficient reading skills among so many in today’s society. In particular the lack of appropriate reading-training may lead to extreme negative consequences for those who, in one way or another, are predisposed towards finding reading difficult to master, e.g. through dyslexia, brain-damage, bilingualism, or through problems in sight and visual coordination. Slowness in reading, also, is more characteristic of blind readers of braille than of the normally sighted, since the tactile modality requires more overlearning for the achievement of more automatic reading. But it has been shown that it is precisely through overlearning that the blind may become as quick and as accomplished readers as the sighted (McBride 1974; Hunstad and Selnes 1980).
Part of the cause of poor reading performance may be found also in the choice of reading-method made at the very start of instruction in reading, and right through the years of schooling. The expectation that teachers may form of the perceptual capacity of the pupil may be so low that it is underestimated, with the result that the right demands are not made for the proper realization of the pupil's potential for quick spontaneous reading. The pupil may thus become "stuck" in a vocalization technique that restricts him to a low reading speed. (Crandell and Wallace 1974; Hunstad and Selnes 1980, pp 63-66; Troxel 1967).

Those children who either have especially good reading abilities or who have the benefit of extra encouragement for reading, for example from their parents, will gain their good reading-performance "free" and will not encounter the reading-difficulties that others may face. Such examples of "cost-free" learning may be found, for example, among certain children who already from the age of four or five learn on their own how to read, without either their parents or the school influencing them. It is most important that such special children are not considered as setting the standard for what may be expected of children more generally, and nor should examples like these distort the consideration of methods of stimulation and encouragement and reading method that would be appropriate for other children without such special pre-dispositions.

The formalistic demands that a teacher might make concerning correct sitting posture, reading distance and choice of reading material might also be inhibiting factors in learning how to read (McBride 1974; Hunstad and Selnes 1980, p 27).

Here we shall not enter the old debate concerning the choice of reading method. Surely it is now no longer a matter of "either or", but rather of "both" among specialist teachers of reading skills when they consider the balance of advantages and drawbacks of e.g. the vocalization method, the wholeword method, or the method based on accepting local dialects.

The use of the vocalization method alone may all too easily lead to low reading speed. On the other hand though, over-emphasis on the whole-word method may result in the reader encountering words and word-combinations that are not spontaneously recognized. This too may result in low reading speed, especially in the case of new or unfamiliar material. In such cases it might be appropriate that the reader masters the vocalization technique as well as possible. Generally speaking it would seem to be most important that from the beginning of instruction in reading the teacher should emphasize quick and spontaneous identification of letters, words and sentences, later also of paragraphs and even of whole pages (instruction in study-technique). This will give the pupil a general level of security, so that in his own development he might adjust to the learning process according to his individual circumstances and possibilities.

It has been made clear that users of CCTV achieve increased reading speed in continuous text when the attention and training is directed towards fast identification of whole words (Hunstad and Selnes 1980). In this investigation though, the subjects were first given some training in the identification of single letters. Increased reading speed in continuous text, in these circumstances may be due to faster combination of letters to words as whole-word comprehension. Perhaps the most reasonable inference to make is that it is due to a combination both of vocalization and whole-word comprehension.

As an apt approach towards reinforcing the processes of automation in reading, it was accepted that special over-learning with graphical word-pictures was required
for pupils with reading difficulties. \textit{Over-learning of a general character} is the steady repetition of word-pictures that all pupils get in normal reading-training and in the encounter with word-pictures in their milieu in the normal run of things. By “special over-learning” is meant here an additional systematic training which offers the pupil opportunities for getting a considerably strengthened stimulation of word-pictures. In order to achieve this effect a supplementary procedure has been developed in which 1) the development of appropriate apparatus for testing and training, and 2) the selection of a vocabulary (high-frequency words) had crucial importance for the strengthening of the automation processes in reading among the subjects:

\textbf{Regarding 1) } In the first investigation (Larsen 1975) the device employed was the well-known reading apparatus Readmaster. But it became evident that this tachistoscope was not suitable for this purpose. Its shortest exposure time was too long (approx. 0.5 sec.) and neither did it provide any facilities for testing and training the sense of touch (Braille). Accordingly, in cooperation with Siemens A/S, Trondheim, Sverre Søyseth and the present author developed a combined tactile (“touch”-tachistoscope) and visual reading-training apparatus (Braillemaster). This apparatus is used in the work of testing for the blind (braille readers) and in combination with CCTV for the partially sighted (Hunstad, Selnes and Krekling 1979; Hunstad and Selnes 1980). For the testing of other target groups (e.g. slow readers and dyslectics), through cooperation between Bernt Mannesson (Engineer) of LVI-Elektrooptikk AB, Sweden and the present author, a visual reading-training apparatus was developed that was steered by an “electronic eye” and was connected to CCTV. These two just-mentioned pieces of apparatus functioned relatively well, but became too expensive to produce to make general marketing of them a feasible proposition.

With the “data age” new possibilities opened up both for the technical and scientific development of a facility for reading-training at a price that would make it possible for a far greater number of people to make use of it. In 1988 Oddvar Haugland devised an especially effective data-controlled tachistoscope effect (for both printed text and braille), and an arrangement for producing enlarged text on the computer screen. When the Braillemaster was first brought into use (1975) the training was based on high-frequency words and the shortest tachistoscope interval was 0.2 seconds. Technical developments gave first 0.1 seconds, and then with data-control (Magnimaster) gave 1/40 second.

Regarding 2. The choice of vocabulary for the test and training programme has been developed by the present author from the basis of a computerized analysis of Norwegian undertaken in the Scandinavian Institute, University of Bergen 1971.

This Project processed 728,120 words altogether taken from texts of the three largest newspapers of Norway, and created a ranked frequency distribution of the 78,073 \textit{different} words of the material. Of this ranked frequency list, the first 201 words accounted for as much as 50.01\% of the whole material, and the first 300 words accounted for 53.93\%. In others words, the 200-300 most frequent words of the Norwegian language occur so often that the reader will encounter one of them in every other of his word-encounters in ordinary text.

Hypotheses that this material could be used for educational purposes were considered by the author in 1974. One of them was the following:

Is it possible for slow readers to read and perceive these 200-300 high-frequency
words more quickly?

The second hypothesis was:
How fast may words be identified, and is there to be found, or may there be
developed, a combined measuring and training device that could be used for
finding an answer to the first question?

The third hypothesis was:
If it is possible to learn and perceive words more quickly, would this learning be
transferable to reading of continuous text, such that slow readers could increase
their reading speed?

Only experimental investigations could provide answers to these questions. And
the answers came.

In the first investigation the subjects were pupils in a special school for the blind
(Braille readers). With this group (N=7), after a training period of 4 weeks with 15
minutes training per day a significant increase of identification speed of the high-
frequency words was found, as well as a significant increase of reading speed in
continuous text. (Larsen 1975)

The tests produced an affirmative answer to the hypotheses. But further tests
seemed to be required, for example to examine the outcome from testing other
groups with weak reading capacity, but who use sight as the information-sense in
their reading. This further work of testing and research is discussed in the chapter
dealing with the background and results of the study as a whole.

Haugland’s technical solution has made it possible now to present the Magni-
master Reading-Training Programme (Appendix 1). He has written a technical
manual that is to be published as a supplement to the pedagogical handbook
(appendix 1). We have striven in partnership to coordinate these two hand-books.

The Magnimaster Programme, in prototype form, is now available on diskette for
the two Norwegian languages. Tests and scoring sheets appear in Appendices 2-7,
11-14, 17,18. As a cooperative venture between researchers of Lancaster University
and the University of Oslo and Bergen a computer-analysis of the English language
has been made (Hofland and Johansson 1982). Using this analysis as a basis we
have made a Magnimaster testing and training programme with the 399 most
frequent English words. The Norwegian reading test have been translated into
English and appear in Appendix 8-10, 15,16.

Various publications have reported on the results of subsequent experiments and
of clinical experience as they have been gained. Thus the correlations (for
equivalence and consistency) of the various experimental tests have been examined by
means of a control group (N=72) comprising randomly selected subjects. (Hunstad and Hagtvedt 1989). It may be noted further that optimization of
sight-conditions for practically blind subjects with low residual vision (N=58) and
experimental testing of cross-modal transfer of learning among the congenitally
blind with light-projection (N=19), have been basic assumptions for the better
understanding and interpretation of possibilities and limitations
of the reading process (Hunstad 1985b, 1985c; 1985d; Hagtvedt and Hunstad 1987;
Hunstad 1988). We shall return to these assumptions in the Discussion Chapter.

The treatment of method here is, in the main, given in Appendix 1, pp. 187-205. This
practical-pedagogical method is based on the experimental method presented in earlier publications (Hunstad, Selnes and Krekling 1979; Hunstad and Selnes 1980; Hunstad 1985a). Modifications of this method are discussed in the Introduction and in the Background and Results Chapter below.

The Results Chapter includes a validity assessment (questions 1 and 2 below) of the results from the author’s own experiments in their relation to certain theoretical models and research results concerning reading difficulties (questions 3 and 4 below). The assessments are connected first and foremost with the question of what is actually being measured in the author’s experiments:

1) Is the progress in reading performance due to a placebo or a "caring" effect, in a training procedure like this one which gives the subject a better feeling of being taken seriously and of being shown more consideration and care than in other learning situations?

2) Is this progress due to an improvement in the social-pedagogical learning conditions which lead to changes in the individual's integrity and identity, in that the individual, for example through making use of modern technical resources experiences that the learning situation more closely is linked to the life of practical affairs? Is it the case that learning conditions like these give the individual better opportunities for sharpening the concentration and heightening motivation in the learning situation?

3) Can medical and/or optometric theoretical models and research findings, e.g. concerning laterality, eye-dominance and ocular dysfunctions contribute towards finding a link between the choice of reading method and the extent of achievement in reading performance.

4) Is special over-learning an essential requirement for increasing reading speed among pupils with poor reading ability? Would special over-learning of tactile and visual word-pictures (concepts) which are high in frequency lead to the individual being able both to recognize and to recall more accurately and more quickly than before such training? Is such special extra training a question only of choice of method based on treating the symptoms of reading difficulties according to, e.g., a function-analytical theoretical model from within research in educational psychology?

In the Discussion Chapter these problems concerning over-learning are critically considered in the light of recent new knowledge regarding information-processing from the point of view of theory in Educational Psychology and research on information exchange. In addition to the problems posed in the three foundational hypotheses concerning increased speed of perception (see p 109) the authors own results are discussed in the light of the following problems connected with information-processing:

1. Is speed a critical variable in reading and independent, in principle, of diverse dysfunctions (handicaps) of the individual reader.

2. Is the progress in reading performance among the subjects in the author’s experiments due to a training of memory processes? Is it a question of effective storing and deployment of information more separately connected with short-
term memory (possibly in interaction with the long-term memory)? Or is the over-learning-effect a product of a general sensory-cognitive process of automation?

3. Is the increase of identification speed and reading speed independent of increased assessability through specific modality-training? Or may cross-modal transfer of learning contribute to the possibility that simultaneous modality-training gives increased learning effect?

BACKGROUND AND RESULTS

Apparatus and the Experimental Groups.

The totally blind and the blind with low residual vision.

The first experiment using high-frequency words and with the shortest tachistoscopic interval of 0.2 seconds was undertaken with the Braillemaster on blind Braille readers as subjects (Larsen 1975). The design of the experiment was the responsibility of the author but the experiment itself was conducted and reported by the student K. Larsen, Department of Psychology, Univ. of Trondheim (1975). The experimental group consisted of 7 blind pupils - one girl and six boys - in the age-range 11-15 years. After 15 minutes training on the Braillemaster each day over four (five-day) weeks the following results were obtained:

- The mean (M) identification speed for whole words in the pretest was 2.1 seconds ranging from 0.8 to 3.0 seconds. In the post-test the mean identification speed was 1.03 seconds ranging from 0.4 to 1.5 seconds. The results were significant (see Table 1 and fig. 1).
- The mean (M) reading speed of continuous text (reading aloud) in the pretest was 43.0 words/min., ranging from 12 to 113 words/min.. In the post-test (reading aloud) the mean reading speed was 54 words/min., ranging from 18 to 133 words/min. The results were significant (see Table 2 and Figure 4).
- The mean (M) reading speed of continuous text (silent reading) in the pretest was 50.0 words/min., ranging from 17.0 to 120 words/min.. In the post-test (silent reading) the mean reading speed was 70.0 words/min., ranging from 28.0 to 181 words/min. The results were significant.

In this experiment the mean error-frequency for identification speed in the pretest was 13.4%, ranging from 4% to 22%. In the post-test the mean error-frequency was 7.0% ranging from 2% to 12%. The difference in percentage error between pretest and post-test was significant.

The results were promising. During the course of the short training period all the subjects achieved an unambiguous increase both in identification speed with single words and in reading speed of continuous braille text, without this improvement involving loss of comprehension of the material or any rise in the error rate. On the contrary, every subject managed to achieve a considerable reduction of incorrectly read words during the identification of whole words. The difference between the pretest and post-test in the comprehension of the content of the reading material was not measured, because of the requirement that for the test to be acceptably completed there should be full comprehension of the test. The best single result of
an increase from 113 to 133 words-minute in reading aloud and an increase from 120 to 181 words-minute in silent reading, shows that the training had led to real positive results for the pupil. This pupil later remarked that he "now reads much more in the evenings".

During the period 1975-1977 the Braillemaster was technically improved. One of the improvements was that the apparatus was modified to work in conjunction with CCTV, thus permitting it to be used as a visual tachistoscope. The technical improvements made it suitable for use with a new target group (Hunstad, Selnes and Krekling 1979):

Blind pupils with low residual vision (visual acuity 0.01 - 0.16). The experimental group comprised 2 girls and 5 boys in the age-range 10-16 years from a Norwegian School for the Blind (Hunstad, Selnes and Krekling 1979). This experiment employed the same high-frequency words that were used in Larsen -1975, but it used also equalized reading tests (constructed on the basis of the criteria in Danish Reading Index 1970), and visual and tactile reading performance were compared. In connection with the development in visual reading, the subjects thus functioned as their own control group., in that they were established readers of braille. The subjects were not given tactile tachistoscope training with high-frequency words.

Twenty minutes per day over 9 days of visual training with high-frequency words on the Braillemaster/CCTV gave the following results:

- Significant (Wilcoxon matched pairs signed-ranks test) increase of visual identification speed for high-frequency words (see Table 1 and fig. 1.)

- The mean (M) reading speed of continuous text (reading aloud) in the visual pretest was 18.5 words/min., ranging from 0.8 to 57.7 words/minute. In the post-test the mean reading speed for continuous text was 34.5 words/min., ranging from 5.3 to 86.0 words/minute (see Table 2 and fig 2.). The difference between the visual pretest and post-test was significant at the 0.01 level (Wilcoxon).

- The mean (M) reading speed of continuous text (reading aloud) in the tactile pretest was 38.1 words/min., ranging from 0.8- 83.2 words/minute. In the post-test the mean reading speed for continuous text was 33.4 words/min., ranging from 1.0 to 74.0 words/minute. The difference between tactile pre- and posttest was not significant (Wilcoxon).

- The difference between visual and tactile pretest was significant at 0.01-level, while the difference between visual and tactile post-test was not significant (Wilcoxon).

In the interpretation of the results (Hunstad, Selnes and Krekling 1979) it was remarked that actually it was not known what the subjects had learned in the training period, and that the mechanism (perceptual processing/brain-function) that could explain the increase in visual reading performance for the time being had to remain something of a speculative character. All the same, it was shown that the educationally blind subjects may easily respond to visual training when appropriate conditions are arranged.

The increase was also so great that after only 9 days of training the visual reading speed reached the same average-level that the subjects in tactile reading speed had after 1-8 years training on the vocalization method.

Since it was only the visual reading speed that increased during the training period, and not the tactile reading speed, it seemed that this increase was specific for the
visual modality and that no positive cross-modal transfer effect from the tactile to the visual modality could be noticed. It appeared to be rather the contrary in fact, because for some of the subjects during the course of a very short period of training their visual reading speed became even greater than the established tactile reading speed.

*It must be admitted therefore, that by directing attention to high-frequency whole words the subjects acquired a visual reading method that was in some respects different from their established tactile way of reading.*

The difference between the tactile and the visual reading modes first and foremost could be registered by the fact that the vocalization of each single letter became less frequent during the visual reading. This gave a more spontaneous visual way of reading in contrast to the more halting tactile method. The difference was interpreted as an effect of whole-word training with the tachistoscope, which in turn led to a functionally faster perception of, at least, the high-frequency words in the continuous text.

In our principal study (Hunstad and Selnes 1980) we developed further the experiment from 1979, using the same subjects. This dissertation is a comprehensive analysis of performance in perception and reading, for both the visual and the tactile modality. Although it is not appropriate to enter into too many details of this analysis here, it is worth mentioning that in this later 1980 experiment the subjects were given tactile training in braille using the Braillemaster. After the most recent improvements the Braillemaster was capable then of offering an identification interval as short as 0.1 sec. (calibrated with an electronic watch with a possible margin of error of +/- 0.04 seconds for all interval values.) Also in this case after 20 minutes of tactile training each day for 9 days the subjects achieved improvement in their reading performance:

- Significant increase (Wilcoxon) of tactile identification speed for high-frequency words (see Table 1 and figure 1).

- Mean (M) reading speed of continuous text (reading aloud) in the tactile pretest was 50.7 words/min. ranging from 10.4 to 111.6 words/min. (see Table 2 and fig. 2). The result was significant at the 0.02 level (Wilcoxon).

There was a period of almost two years between the tactile testing of 1979 and the tactile testing of 1980. Theses tests showed that during this period the subjects had increased the mean-difference for tactile reading speed by 15.5 words-min. The result was significant at the 0.5 level (Wilcoxon). In the same period the mean-value difference for visual reading speed rose by 10.1 words-min. The result was not significant.

Neither in this experiment did tactile training give cross-modal transfer of reading speed to the visual modality.

In our discussion we could once again remark that also braille readers (tactile modality) could increase their identification speed and reading speed when the subject’s attention and training was specifically directed towards faster identification of high-frequency words.

*The result is the more interesting since ordinary reading training in braille over a period of two years resulted in an average increase in reading speed of only 16.6 words/ min., while 9 days of tactile training gave an increase of 20.3 words/min.*

The result from the tactile training otherwise corresponded well with the result of Larsen (1975). The lack of significant increase in visual reading speed in this two-year
The period may be explained by the fact that, being pupils in a school for the blind, the subjects received either only minimal visual training in CCTV or none at all. All the same testing of reading performance two years after the visual training showed an average increase of 10.1 words/min. in reading speed. Those who were not given training in the school during this period nevertheless maintained their visual reading speed, while those had been given a little training with CCTV increased their visual reading speed.

The results from research conducted by 1980 were so promising that the need arose for the apparatus and method to be developed out of the laboratory stage to become a practical-pedagogical procedure which could be placed on the market. But the problem was that the production costs for the Braillemaster would have been so great that it seemed hardly feasible to make a commercial undertaking out of it. The problem was partially solved when Siemens Ltd., Trondheim produced 10 units of the Braillemaster which were loaned cost-free in a trial marketing venture. This venture was managed as an innovation project at the Institute for Special Education, Bærum, Norway. This project issued in three publications: Two teacher's handbooks, one of which (Hunstad 1981a) presented the method for the training procedure for braille users, while the other (Hunstad 1981b) presented the method for the training procedure for using CCTV for the partially sighted. The innovation report itself (Hunstad 1981c) was an organization-psychological analysis of how potential users of the apparatus and method adopted and followed up the training procedure.

In the innovation arrangements the Braillemaster and the teachers' handbooks were loaned free of charge to the two Schools for the Blind in Norway, and to the Low Vision Centre at Bergen. At all three places the procedure was well-received, and the innovator held short introduction courses at each of them. The institutions still possess the equipment and from all three has come oral reports that the method has been used with good results. No written reports have been made however, and so it is not possible to offer concrete results from the testing trials. The same applies in connection with the loans made to a number of low vision teachers in Sweden and Denmark and to a number of institutions for the visually handicapped in these two countries. But there are two exceptions, with written reports from Andersen (1982) at the Low Vision Centre, Bergen, and Bruteig (1984) at Huseby Centre for Education. Also Hunstad (1985a) carried out a case-study using the procedure at the Low Vision Centre, Bergen.

A specific investigation of a single Braille reader (Roar) at the beginning of the second grade of the elementary school (Hunstad 1985a) showed that he had great reading difficulties. He received 15 minutes of Braillemaster training per day, four days each week over a period of 9 weeks, giving a total of nine hours. The training comprised words of between 2 and 6 letters. In the pretest he managed to achieved a reading speed of 2.2 words/minute. The error frequency was 42% and he showed a very weak comprehension of the reading matter. The reading was very reluctant. His identification speed for letters varied from 2-10 seconds per letter, and the identification speed for whole words was not measurable since he identified only the first letters of the words.

In the post-test he managed to achieve a reading speed of 11.0 words/minute. The error frequency was 13% and he showed full comprehension of the content of all the sentences. The reading was now characterized by willingness and he remarked that he had read aloud in front of the class and that it is "important to get the homework quickly done". In the post-test his identification speed for 3-letter words was 0.6 seconds and for single letters and 2-letter words the identification was secure at 0.1
No dyslexic symptoms were found in his reading or writing. It turned out later that he has good abilities and has become a quite satisfactory reader of braille. The results are shown in tables 1 and 2 and in figures 1 and 2.

Bruteig (1984) used the Braillemaster as a measuring instrument for his principal study at the Norwegian Institute of Special Education. He undertook a comparative investigation of the significance of full spelling Braille (Grade 1) and contracted Braille (Grade 2) for reading speed among blind adults. However, since he did not use the reading-training procedure his results are not directly relevant in this connection.

Dyslectics

From 1982 to 1988 the Braillemaster was loaned to a number of school teachers and specialist teachers in order to test it more thoroughly. At the same time a special teachers's handbook and training procedure based on high-frequency words was prepared with the testing of dyslectics specially in mind. The training as to proceed with the Readmaster. This handbook and training procedure was distributed to more than 100 teachers and specialists in educational services. No publications or written reports are available from this period, whether from training using the Braillemaster or using the Readmaster. But, nevertheless, nearly all those who received the training procedure have indicated orally how they assessed it. With the exception of two teachers they all declared that their pupils had shown good, and sometimes excellent, progress in reading (and spelling) after having gone through the training procedure. This was despite the fact that the Readmaster gave no possibility for identification speed faster than 0.5 seconds. It is especially interesting that also dyslectic pupils managed to make good progress according to these assessments. The two teachers who stated that their pupils did not find the procedure to be of any use (one pupil in each case) judged that the method did not offer the pupil enough motivation. On further questioning though they admitted that in their eagerness to obtain quick results they had used training sequences considerably longer than the 20 minutes recommended in the handbook. This might be the explanation for the lack of training effect. It might also be possible though, that for certain types of dyslexia (Gjessing 1977, pp. 115-132) this training procedure might not be appropriate.

Only systematic testing and further research can resolve this issue. As a first experiment, 11 dyslectics in a Junior School in Bergen were tested and trained with the Magnimaster in the Spring term of 1989 (Hunstad 1989c). The progress in identification speed and reading speed of this dyslectic group is shown in tables 1-3 and in figures 1 and 2.

Since the experiment with the dyslectics group (N=11) has not previously been published, some of the details might be provided here, especially those concerning the design of the experiment, a number of results that do not appear in Table 1, and a comparison in the Discussion Chapter of the results obtained from the dyslectic group with those obtained from the various groups of the visually handicapped.

The subjects of the dyslectic group (3 girls and 8 boys) were distributed as five pupils of the 7th grade, five pupils of the 8th grade and one pupil in the 9th grade.
of a Junior School in Bergen. Through all their previous years of schooling all the pupils had been given special help with their difficulties in reading and writing. One month before the pretest in the Magnimaster training they were all tested by a speech-therapist who, in individual reports, concluded that 10 of the pupils showed various types and degrees of auditory, visual, and audio-visual dyslexia.

Table 1. Results from Training with the Braillemaster / Magnimaster.
Mean (M) Identification Speed of High-Frequency Words (seconds/word).

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<td>Larsen 1975</td>
<td>7</td>
<td>2,1</td>
<td>1,03</td>
<td>1,07</td>
</tr>
<tr>
<td>Hunstad, Selnes &amp; Krekling 1979</td>
<td>7</td>
<td>1,0</td>
<td>1,0</td>
<td>0,3</td>
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<td>Hunstad and Selnes 1980</td>
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<td>3,3</td>
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<td>1,5</td>
</tr>
<tr>
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<td>2,0</td>
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<td>9</td>
<td>0,075</td>
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<td>0,05</td>
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</table>

For one of the pupils (subject nr. 7) the diagnosis was unclear, in that according to the judgement of the speech-therapist he showed reluctance in speech and reading that were psychological in origin. His writing performance though was fairly good.

One project-group which consisted of 7 teachers was given instruction in the use of the method and apparatus. Using a Commodore 64 micro-computer, the training programme based on high-frequency words was presented to the subjects with a linear magnification of 15x on the 8-point print-size basis. The reading tests were given on ordinary test-sheets in a print-size of 8 points. The teachers controlled and encouraged their pupils during the training procedure. Through a revision of the school's time-abling priorities, the experiment was conducted without requiring extra resources. After 20 days of effective training with 15-20 minutes per day, a mid-way test (interpolated) was conducted, in that the training procedure is meant to continue during the Autumn of 1989 and the post-test will be made on completion.

The experimental group achieved the following results:

- The difference between identification speed (4-letter words in the pretest and 6-letter words in the interpolated test) was significant at the 0.03 level (Wilcoxon matched-pairs signed-rank test).

Table 2. Percentage progress in reading speed (words/min.) through using the Braillemaster and the Magnimaster. Reading of continuous text measured before and after training.
<table>
<thead>
<tr>
<th>Investigation:</th>
<th>Number of subjects:</th>
<th>Pupil category:</th>
<th>Training period 15-20 min./day over:</th>
<th>Pretest in words/min. (M):</th>
<th>Distribution word/min. Pre-and posttest respectively:</th>
<th>Posttest Percentage * increase in reading speed (M):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larsen 1975</td>
<td>7</td>
<td>B</td>
<td>20 days</td>
<td>49,3</td>
<td>12,0-113,0 18,0-133,0</td>
<td>26,0 %</td>
</tr>
<tr>
<td>Hunstad, Selnes &amp; Krekling 1979</td>
<td>7</td>
<td>S</td>
<td>9 days</td>
<td>19,1</td>
<td>0,8-57,7 5,3-86,0</td>
<td>80,6 %</td>
</tr>
<tr>
<td>Hunstad and Selnes 1980</td>
<td>7</td>
<td>B</td>
<td>9 days</td>
<td>50,7</td>
<td>7,4- 79,3 10,4-111,6</td>
<td>40,0 %</td>
</tr>
<tr>
<td>Andersen 1982</td>
<td>2</td>
<td>B</td>
<td>18 days</td>
<td>40,8</td>
<td>40,0-41,5 57,5-60,5</td>
<td>45,0 %</td>
</tr>
<tr>
<td>Hunstad 1985</td>
<td>1</td>
<td>B</td>
<td>36 days</td>
<td>2,2</td>
<td>11,0</td>
<td>400,0 %</td>
</tr>
<tr>
<td>Hunstad 1989c</td>
<td>11</td>
<td>D</td>
<td>20 days</td>
<td>96,6</td>
<td>43,3-136,8 73,0-204,0</td>
<td>40,5 %</td>
</tr>
</tbody>
</table>

**COMMENTS ON TABLE 1:**

Codes: B = Blind/Braille-readers.
S = The socially blind, with slight residual vision / first trial with CCTV
D = Dyslectics.

* Since percentage units are used as a measure of progress here, it should be observed that relatively small numerical values would be obtained at levels of high reading speed, with correspondingly higher percentage numerical units in cases of low reading speed.

Table 3. Results from the Reading-Performance Training in the Dyslectic Group (N = 11)
The Control Group

In order to compare the identification speed among the group of subjects who were weak readers with those subjects who were strong readers, and experiment was conducted (1989) with a control group (N = 30). At a Junior school in Bergen having altogether 122 pupils from the 4th to the 6th grade, 30 pupils were selected to form the control group. From each grade 10 pupils were chosen, who, according to the estimate of their teacher in Norwegian, were the quickest and most accomplished readers in the class. None of these pupils (N = 30) had any kind of vision problem, but three of them were fully
corrected with spectacles. The identification speed for each subject was measured by the Magnimaster method using a Commodore 128 with the following parameter settings:

- linear magnification 15X (basis 8-point type size)
- black letters on a red background (the red colour dampens a possible dazzling effect from the background field).
- the light-intensity somewhat reduced in the background colour (to approx. 3/4), but with full contrast between figure and background.
- word-type: 6-letter high-frequency words, phonetically regular words (phonetically regular words were chosen to avoid possible distortion due to unnecessary demands).
- reading distance 230 cm

Figure 1. Increase in identification speed (words/sec) from pretest to post-test (N = 33) after training with the Braillemaster/Magnimaster *

* Fastest identification speed for Braillemaster: 1/10 second
Fastest identification speed for Magnimaster: 1/40 second
Results:
1. All the subjects (N = 30) spontaneously identified all the words in the word-programme (24 different words) in 1/40 second, without having been tested with a greater identification speed beforehand.

2. The error-frequency of the words was distributed thus:
   - 4th. grade: Mean (M) error-frequency 3.3%, ranging from 0 to 28.8%
   - 5th. grade: Mean error-frequency 0.4%, ranging from 0 to 4.2%
   - 6th. grade: no error.

The results from the control group of clever readers (N = 30) provides an unambiguous confirmation for the three hypotheses that there is a connection between high identifi-
The lower error-frequency the higher the grade reached in school, shows that general over-learning over time is important for ensuring reliable and accurate identification. That some of the 4th-grade subjects nevertheless had no identification errors shows that the training-requirement for achieving a sufficient over-learning effect is possibly an individual matter.

Assessment of Empirical Basis and Validity in Relation to Reading and the Reading Processes.

Teachers and others who have developed, practiced and undertaken research on reading methods (e.g. system for the blind, or other reading techniques using a changed script-image for the partially sighted), clearly have all had the goal of developing the reading-performance of the pupils. This goal involves both the initial stages of reading-instruction and the treatment of reading difficulties of pupils who have not made the expected progress in reading skills, taking into account their age, level of ability, and extent of reading-training in terms of time and intensity. All the above-named reading methods are being used and are well-established in the systems of education of those countries that use the grapheme (written representation of the phoneme or language-sound) that the smallest written character or combination of written characters that makes a difference of meaning in the written language. Since these reading methods are being used in almost all instruction in reading, it must be that they are appropriate methods for achieving good reading-performance, at the same time as they offer possibilities for differentiating according to the individual capacities and needs of pupils. And the majority of people learn to read by the aid of one, or a combination, of these methods, even if there are many who judge their own reading-performance to be not good or effective enough in relation to their requirements for written information. The latter relates especially to the variability in reading-performance in regard to the quick acquisition of the content of reading-material, or said in other words, to the need for greater reading speed especially in connection with studies.

However, there are those persons who encounter very real difficulties in reading even if they are well-motivated for learning and reading, have normal abilities (or better), and who have good teachers who apply their method of reading-instruction in the best way. Here it is a matter of persons who have specific reading and writing difficulties. Statistically, in every class of 30 pupils there will be 2-3 who despite receiving the same reading training as the others in the class do not learn to read, or who come up against great difficulties in reading. Both on the national and international scale statistics show that 8-10% of the so-called normal population have specific reading and writing difficulties (Gjessing 1977, pp 31-32). Persons with specific reading and writing difficulties account for a certain percentage of the normal distribution of reading-performance in every population and language-group. The extent and degree of difficulty is dependent on many variables, but all the same, the degree of likeness between the grapheme and phoneme (phonetically regular and irregular word) in a culture’s written language plays an important, and perhaps a decisive, role in the occurrence of reading difficulties. Certain cultures with typical non-phonetically-regular written language will therefore have a greater percentage of the population affected by reading and writing difficulties than those cultures in which the written language is more phonetically regular.

Both for the visually handicapped and for the section of the population with specific reading and writing difficulties the Magnimaster may serve as a helpful device and as a supplementary reading method for eliminating or reducing reading difficulties. Secon-
Darily, the device and the method will probably be serviceable also for persons who think they read too slowly seen in relation to their needs for the intake of written information.

In the following an assessment will be made of the validity of the Magnimaster programme as a reading-diagnostic device and as an aid in reading training, in connection with some foundational theory and published research results dealing both with the visually handicapped and those with specific reading and writing difficulties.

There exists a most extensive research literature on reading and reading-difficulties.

"Reading has always occupied a central position in the school. The same is true for reading as an object for research. In the present century multi-volumed textbooks and thousands of research reports have seen the light of day. Already before the 1950’s, for the English-speaking countries there existed a list of over 300 scientific investigations, and this interest became greater and greater. In addition to this there is a considerable number of reports in German. The fields of research have been many and shifting" (Gjessing 1977, p. 13).

Theories and research on reading and writing difficulties that attempt a causal analysis and systematic analysis of symptoms, by and large, have been concentrated on 4 major areas or categories:

1. **Dyslexia or specific reading and writing difficulties.**

2. **Braille reading.**

3. **Reading problems among the partially sighted.**

4. **Ocular reading difficulties (e.g. sight-coordination problems).**

These references are to the work of some representatives of this research in the Scandinavian countries. The discussions and the bibliographies of these publications contain also references to a large number of theories and research findings on a more international basis. The division into categories is not absolute of course, in that some individuals might be affected by 2 or more categories of difficulty, e.g. a Braille reader with reduced tactile capacity may also have auditory dyslexia, or an audio-visual dyslectic may also have problems in sight coordination. The authors own clinical experience suggests that those with good mental abilities, but who e.g. are afflicted with the combination of audio-visual dyslexia/ocular reading-difficulties are commonly rejected from normal basic schooling, being regarded as illiterates and often also with serious behavioural anomalies that result from this, because we still have not yet had good enough knowledge-standards of differential-diagnosis for giving appropriate reading-training and treatment for such persons (or because in practice we have not managed to take proper care of method in treatment procedures ?).
Areas and categories that otherwise are not included in this connection are reading-difficulties that wholly or partly are due to e.g. loss of hearing, mental retardation, behavioural problems and multiple mental and physical handicaps.

The results from the experimental investigations (Table 2) in reading training using the BrailleMaster/Magnimaster showed significant progress in reading-performance after short intensive training periods for the pupil category of Braille readers (N = 17) and users of CCTV (N = 7). Also the practical/clinical trials for these two categories of pupils (see pp. above) according to oral reports from teachers have shown that over 90% of the approx. 40 visually handicapped pupils who have tried the training procedure accomplished marked good progress in reading speed. In this connection it is worth noting that 23 of the subjects in the experimental groups of visually handicapped (N = 24) did not have other visual handicaps besides loss of vision. One of them had Spielmeyer-Vogt's disease (a strongly progressive brain damage), but achieved all the same good progress in reading-performance (Anderson 1982). For the approx. 40 visually handicapped pupils in the practical/clinical investigations there are no data available concerning any possible additional handicaps.

Especially against the background of the experimental investigations of the visually handicapped, but also with definite clear support in the results from the practical/clinical trials (with the visually handicapped), it appears that the reading training procedure represents an educational effect that leads to rapid increase of reading speed and therefore also to a general improvement of reading performance.

The increase (Table 2) was indeed so great that, from experience, using general and/or special-educational reading methods it would have taken several school-years for achieving the same percentage increase and significant progress that this experimental group achieved with only 15-20 minutes of tachistoscope training per day over 9-36 days. Many of these pupils would probably have otherwise failed to achieve functional reading capacity with traditional special-educational methods of treatment.

As far as we have been able to trace the development of some of the pupils in the mentioned experimental group, it seems that the progress lasts, even over several years.

Because there are so many factors (both in the individual pupil and in his milieu) that influence the learning situation, it is difficult to show which method or methods are the ones that give the best results. On the basis of findings in the theory of learning and with the, despite everything, limited opportunities that analysis of the many influencing variables permit, we shall nevertheless attempt to estimate the progress of the subjects according to the four questions concerning what actually is being measured in the author's own experiments, formulated p. above.

A number of the questions are discussed in earlier publications (Hunstad, Seines & Krekling 1979; Hunstad and Selnes 1980; Hunstad 1985a; 1985c; 1985d; Hagtvet and Hunstad 1987; Andersen and Hunstad 1988; Hunstad and Hagtvet 1989). Recent research and clinical experience, though, makes it possible to place the question of validity in a frame of reference that is somewhat wider than the earlier one. In particular it seems that research on dyslexia is able to contribute towards understanding performance-training with new perspectives and theoretical explanatory models. This will be considered later in this chapter in connection with the 4 questions concerning what is being measured (pp above) and in relation to the 4 most relevant pupil-categories. But first we shall consider the most concrete results from the trials with the dyslectic group (tables 1-3 and figs 1 and 2.)
As Table 3 shows, one of the subjects in the dyslectic group showed a decline both in reading speed and in the error-frequency in reading, but two of the subjects had so little progress in reading speed that the result, in any case, must be regarded as being of little practical consequence for the two pupils. But with an increase in reading speed among the other 8 subjects of 26.7 - 102.1% the result must be regarded as being of good or very good practical significance for each of these pupils. This assessment of the progress of these eight pupils is further strengthened by significant results in that identification speed for high-frequency whole words increased, the error-frequency in reading continuous text declined, and the comprehension of the text from the pretest to the interpolated test remained constant or improved. The lack of significance for error-frequency in the identification of 4- and 6-letter words in respectively the pretest and post-test may be judged against the following circumstances:

- The subjects increased their identification speed significantly, but did not get enough special over-learning for the error-frequency to be correspondingly reduced. Further training during the autumn of 1989 will conceivably show the tenability of this suggestion.

- The pretest and interpolated test for error-frequency are not of equal difficulty, in that it is more difficult to identify 6-letter words than 4-letter words. However, when, all the same, it was decided to use 6-letter words for the interpolated test it was in order to keep control also over this variable, something that had not be done in earlier experiments. Further training in the autumn of 1989 will probably show also if this is so.

The other measurements from the pretests to the interpolated tests showed, though, significant results, such that the subjects progress for the most critical variables identification speed and reading speed remains firm.

With such a comparatively small group of subjects as the dyslexia group (N = 11), it is not possible to maintain that this experimental group is fully representative for the distribution of symptoms and causes in the whole population of dyslectics. The experimental group was randomly selected all the same, such that the result ought to be capable of being interpreted tentatively. We know from earlier investigations (Gjessing 1977, pp. 11-32) that dyslectics are very heterogeneous in regard to etiology and symptoms. This is also made clear by the results with the experimental group (N = 11 ), since 27.3% did not profit from the training procedure, showing either a decline in reading-performance or no change in it. This is in contrast to the significant results with the experimental group of visually handicapped subjects (N = 24). Also these subjects were randomly selected, but in their case there was used the selection criterion that they should not have other functional handicaps besides their visual handicap, including not having dyslexia. Then, when the sight-conditions were optimized by using electron-optics, and when both those subjects who used CCTV and those who used braille went through the training procedure, good and even very good results were obtained at all levels of reading-performance. Regarding these results, the same might be said about eight of the dyslectic subjects (72.7%) in the experimental group of dyslectics. If the result from the experimental group of dyslectics should be representative for the dyslectic population more generally, we would estimate that approx. 70% of dyslectics would have good or very good profit from reading-training with high-frequency words using the Magnimaster. The estimate must be taken with all due reservation of course, because of the tiny experimental group, but it does seem to correspond well with achieved results in the author’s own clinical practice with dyslectics (N = approx. 60), see pp. 120-121 above) who have been given training with high-frequency words on the Readmaster.
Concerning the fourth category of persons with reading and writing difficulties, as far as the author is aware, there has never been conducted an experimental training procedure using tachistoscope/high-frequency words with subjects who have reading problems due to so-called ocular dysfunction. However, in clinical work the author has some experience of advising teachers who have then gone on to use the training procedure for pupils with sight-coordination/reading problems (N = 10). Oral reports from these teachers seem to suggest that also persons with ocular difficulties manage to achieve at least a temporary improvement in reading-performance by the help of this method. Since also this group of persons with reading difficulties are very heterogeneous both etiologically and symptomatologically there seems to be a demand for thorough testing and further research on a differential-diagnostic foundation.

As a provisional conclusion a metaphorical application of the proposition: "The driver’s quick reaction hindered an accident", may perhaps illustrate how training with high-frequency words using the Magnimaster method may be a method for preventing "accidents" in the learning of reading among persons who, in one way or another, are predisposed towards having reading difficulties:

A driving instructor will not advise his pupils to present themselves for the driving test before, for example, their eye, foot, and hand reflexes have become automatic, both with regard to precision and the necessary speed. Only when such precision and speed are trained through over-learning would a driver have the mental surplus for "reading", and thereby to master, the traffic scene without an all too great a risk that faulty reactions or reactions that are too slow might lead to an accident.

*The same principle of an automatic pattern of behaviour with a certain minimum level of precision and speed seems to be a necessary condition for mastering the "traffic scene" in reading, ie. the content of the material.*

Most persons, through normal teaching, manage this necessary automation, e.g. of eye-movements and quick perception, for mastering the reading process in a functionally appropriate manner. But 8-10% of persons seem to require a degree of extra over-learning in this acquisition of automation that our school system does not manage to give them. Thus far, the experiments dealing both with the visually handicapped and dyslectics seem to confirm the three hypotheses that the treatment of reading difficulty might be a problem of method (see p. above).

*In addition to the results dealing with tactile and visual reading among the visually handicapped, the Magnimaster method seems to be a "catalyst" that triggers appropriate and quick automation also among persons with specific reading difficulties. Since increased identification speed is an effect that is transferable to reading speed in continuous text it seems that the Magnimaster method therefore could be an effective supplement to the traditional reading methods.*

With the metaphor that focussed on the automatic processes of reading we have returned to the four questions regarding what, actually, is being measured in the author's experiments. The questions will be considered in the light of a number of relevant theoretical models and research findings in the field of reading difficulties.

Let us first consider a possible placebo-effect which is perhaps that objection that is most to be expected when results from such investigations are presented.
In earlier papers (Hunstad 1985a, p. 8; Hunstad and Hagtvet 1989, p. 24) it has been concluded that even if one may neither prove nor disprove that a placebo-effect might directly or indirectly be the cause of the training results, the pupils have nevertheless achieved useful improvement through the training procedure. And that is something of use in itself. Even if with such a purpose one might work with pupils without being able to explain the causal educational mechanism, just to win the results, it is still of vital theoretical interest to be able to see a connection between cause and effect. In the very least case, theoretical reflections may lead to new educational approaches being tried out and developed further, at the same time as the theoretical models might form the basis for generating ideas within differential-diagnostics where one has to deal with complexes of possible causes. It is therefore interesting to observe that the placebo-effect, especially within medical, psychological or sociological research, may show significant results with conspicuous improvement in both the subjects' physical and mental state (Hilgard & Atkinson 1967, pp. 566-568). In the main, two methods have been used. One method measures the placebo-effect through the patient being given a medical preparation that does not contain any kind of pharmaceutically effective substance. The other method measures the so-called "Hawthorne-effect" (Mayo 1931), where also a series of later investigations have shown that by altering the organizational circumstances of a teaching situation, or at a work-place (e.g. lighting conditions, duration of rest periods, distribution of tasks, system of payment, etc.) it was possible to achieve increased productivity (Viddal 1972, pp. 218-220). It is characteristic of both methods, as methods of research, that a control group is used (the double-blind procedure) in which half of the group is given a placebo, or is otherwise given attention without any real change in the teaching or work situation being made, while the remainder is given relevant medication, or new methods or procedures are used on them.

It would have been quite possible, from the point of view of research, to have conducted the Brailemaster/Magnimaster experiments also with control groups. The experiment could be conducted then e.g. with the control group receiving the same form of training as the experimental group, but with the difference that the control group would train using a fixed identification speed interval (e.g. the subject's own identification speed in the pretest). With such a design one would obtain a certain check that training in identification of whole words is independent of increased identification speed for giving transfer-effect to increased reading speed in continuous text. Since the visually handicapped are a very low-frequency group it would be difficult in practice (not to say impossible) to obtain homogeneous, commensurable experimental and control groups in such a small country as Norway. The number of dyslectics however is considerably greater, such that a "double-blind procedure" would be practicably feasible for dyslectics, in Norway too. But there are a number of objections of a research-ethics nature that arise from using subjects who in one way or another are deceived into thinking they are to be motivated for a training procedure that the researcher does not believe will personally profit them.

Against this background, and even if it might have been desirable, control-groups have not been used with the Brailemaster or the Magnimaster. But all the same, it is unlikely that the "caring effect" produces a greater outcome here than in other training and treatment procedures for pupils with reading difficulties. But it is clear, meanwhile, that the extra attention that the subject is given during an experiment, in which they might feel that they are at the centre of an important research-project, might give especially favourable learning conditions. In connection with the experiments it is difficult to avoid, and in the testing of the visually handicapped using the Brailemaster it cannot be excluded that this variable in the learning procedure can have had an effect. The subjects were very well motivated and willing participants throughout the experiments, and they
were given new, exciting and expensive equipment that they had never seen before. In the experiment with dyslectics, on the other hand, the amount of care and attention was probably not greater than what had been involved as a natural and necessary part of their normal teaching. They had had many years of experience as losers at school, in regard to reading and writing, and they had been through many different special-educational training procedures with many different teachers, from the first school years and subsequently. The experiment with the Magnimaster was also arranged such that it should enter only as a small part of the timetable that the pupils already had at school. The pupils were followed up by their teachers in the usual way, and the pupils were also so familiar with computers that even this equipment had no novelty interest. Nor were the pupils especially geared up with high motivation, but all the same theyloyally followed the training procedure they were taken through. Concerning the conditions for learning in this training procedure, one of the teachers put it like this: “This has not been research, but rather a natural and valuable part of the school's regular teaching”.

That the dyslectic group nevertheless to such a degree achieved in some cases very good progress makes it seem that the caring-affect at any rate had not been a critical variable or a direct cause of the good results.

The next variable we shall consider relates to the social-educational conditions for learning (p. 111 point 2 above). In many ways the placebo-effect and the Hawthorne-effect are a part of the social-educational conditions for learning.

But within sociological and social-psychological research a number of other regularities are analyzed and charted. These regularities influence the individual's behaviour, especially within groups. Such variables in the learning process may be values, norms, social position, status, influence and prestige, rank, group pressure, form of leadership, exercise of authority, laissez faire attitudes, democratic attitudes, external discipline and self-discipline, attachments, involvement and personal responsibility, role-conflicts, conflict-resolutions, aggression, humility and subservience, dependence and independence, ability to communicate, interests, all-roundness and specialization, setting limits, wealth, public esteem and power, sickness, guilt feelings and myths, punishment and reward (Aubert 1979; Sjølund 1968; Smith and Bjerke 1974).

The foregoing list could have been considerably longer, but the variables are general and they affect everyone. Persons who belong to minorities or deviant groups will often in addition suffer a strengthening of the negative variables and a weakening of the positive ones, both within their own minority group and within the so-called normal-group (Andersen and Hunstad 1988). In particular, personal integrity and the development of identity among the handicapped might be negatively affected in regard to the variables; dependence, communication loss and missing "sense of belonging". For the visually handicapped and dyslectics the high incidence of such social-educational negative effects has been shown in abundance, both in professional literature and in the literature of fiction (Carrol 1961; Dellgren 1979; Freiberg 1977; Warren 1979; Lowenfeld 1973; Gjessing 1977; Gjessing et al. 1982; Høien 1982a; Carling 1962; Hocken 1978).

In the present connection the question now becomes whether such social-educational variables could have been so radically changed during the training periods that they came to have decisive positive effect on the subjects’ motivation, effort and ability to learn? The answer must be based more or less on subjective judgement, since method and instruments for measuring the social-educational variables did not find a place in the author's experiments. Those who conducted the experiments, though, were experienced teachers who in any case were likely not to have reinforced the negative aspects of the learning situation. On the contrary, one might well expect that they did their best to make the results as good as they in fact became. If the subjects, or some of them, really had
been burdened with personal problems, it is still rather unlikely that the influence from those who conducted the tests should make itself significantly felt in just precisely this training situation. This is especially so for the dyslectic group, since there the experiment was arranged to be so closely similar to and anonymously integrated into the regular lessons.

In the same way as for the "caring-effect" it therefore seems a ready inference to conclude that neither could changes in the social-educational learning conditions have had any decisive significance for the good results.

Within theories and research traditions of medicine and educational psychology various symptom/causal models have been developed and utilized for the testing and treatment of reading and writing difficulties (Gjessing 1977, pp. 33-60).

The classical model in medicine operated with one symptom (reading/writing difficulties or word-blindness) and two causes (inherited and acquired word-blindness).

"With a basis in the theories of cerebral localization of function and a number of findings concerning acquired word-blindness, one has counted that also inherited word-blindness was caused by a neurologically conditioned symbol-disturbance. This symbol-disturbance was of a specific "written-language" character, and had its seat in "the visual memory center", localized at the cortex's gyrus angularis." (Gjessing 1977, p. 33).

With reference to Rabinovitch (1968) among others, according to Gjessing (1977) the causes of retarded reading are classified into two principally different main groups within medical research:

1. Primary retardation of reading (developmentally conditioned).
2. Secondary retardation of reading.
   a. Other brain pathology; specific language handicap, motoric handicap and disturbances in concentration.
   b. Emotional disturbance.
   c. Motivation and situation factors.
   d. Deprivation and lack of language experience and stimulation.

Gjessing (1977) emphasizes further that:

"Today there is hardly any doubt that there is a clear etiological connection between lesions in the gyrus angularis and alexi (acquired word-blindness). This has been shown quite concretely through a large number of posthumous dissections. But there is no scientifically acceptable reason for counting on corresponding causation in the pathology of the brain among those with reading and writing difficulties who do not have apparent brain damage. This clear acknowledgement from within medicine's own circles, all the same, do not exclude the maintenance of the hypothesis of such a connection, also in these cases, between a functional deficiency in the gyrus angularis and reading and writing difficulties." (Gjessing, 1977, p. 33-34).

It is characteristic for this type of neurologically conditioned symbol-disturbance that it is localized in specific regions of the brain, without it being possible to undertake either surgical intervention or biochemical medication to treat the cause or causes. The
proposing of foundational hypotheses and classical medical research have sought to analyze the etiology and the symptoms more differentially than localization to the gyrus angularis. Thus, Orton (1928) was the first more systematically to take up the question of a possible connection between anomalous laterality and specific reading and writing difficulties. Delacato (1959; 1963; 1966) further developed and defined symbol-disturbance as a result of neurological delayed maturation and early faulty neurological development, while Ranschburg (1928) thought he had found the explanation of dyslexia (legasthenie) in a delayed development of the blood arteries of the brain. The endocrine theory (Smith and Carrigan 1959) postulates that reading and writing difficulties are due to a biochemical imbalance between acetylcholin and cholinester which mediate cerebral nerve-impulses. As a comment on the endocrine theory Gjessing (1977, p.36) states:

"Even if the majority seem to have little trust in the endocrine theory as a common etiological basis, the contribution that modern endocrinic research may come to offer is not overlooked."

Orton's and Delacato's "hemisphere" theory of laterality and symbol-disturbance in the brain required that when the sub-cortical process of integration does not develop in the usual manner, integration has to develop later, through a systematic but all the same simple training programme that is similar to the child's motoric stage of development during the very first year(s), e.g. stretching, rolling over, worming around and creeping across the floor. Delacato's theories and not least his practical method of treatment has been strongly criticized by the majority of specialists in the field (in medicine as well as among psychologists and teachers) (Gjessing 1982; 1983). Nevertheless, this has not stopped such training procedures based on coarse and fine motoric training from being marketed as a means of remedying reading and writing difficulties. Such an example of an imitation of Delacato's theories and patent-solutions in Scandinavia is Parlenvi's (1980; 1982) marketing of a combined theory and treatment-method for reading and writing difficulties. Parlenvi (1982) asserts that motoric training and e.g. reading with the book upside down will, quite generally, help to deal with reading and writing difficulties, without the assertion being documented with empirical research findings. But nevertheless, with its neuromedical terminology and apparently thorough knowledge of brain functions, it has seemed to inspire confidence and has gained a certain measure of popularity, perhaps indeed at the expense of other more tested and appropriate methods.

This example of treatment of neurological faulty development is included here in order to emphasize that it does not appear appropriate to discuss the author's own empirical findings on the basis of hemisphere-theoretical causal connections, even if the Braillemaster and Magnimaster theoretically could have affected e.g. the subjects eye and hand-motoric functions.

The problematic nature of reading and writing difficulties is considerably more complicated than the psychologist Paul Parlenvi seems to suggest. The following may perhaps illustrate how complicated the diagnosis and treatment of reading and writing difficulties probably are:

When the neurobiologist Roger Sperry received the Nobel prize in Physiology and Medicine in 1981 he was interviewed by the Swedish Television Service. He shared the prize with the doctors David Hubel and Torsten Wiesel who also took part in the interview. When the interviewer asked Sperry whether he was the one who knew the most about the brain, Sperry replied "yes", and Hubel and Wiesel nodded in agreement. But suddenly Sperry said that actually he knew nothing about the brain. When the interviewer asked him to explain how at one and the same time he was the one who knew the most and the one who knew nothing, Sperry replied that he knew very much concerning what goes on in the brain and something of where it goes on, but in regard to the processes of
how the activity of the brain goes on, we still know very little about at the present time.

Here Sperry, in fact, has given expression to the hemisphere-theory's dilemma as a basis for practical methods of treatment. Of course we might possess knowledge about lesions and dysfunctions of the brain, something that is documented both through a large number of posthumous dissections and physical measurements (e.g. electroencephalography/EEG, visual evoked potential / VEP and data-based x-ray techniques or datamography, by which it is possible to obtain pictures of the brain divided horizontally in various sections/CAT-scan.), but since we do not know anything about the processes of the brain, we cannot know whether such lesions and dys-functions are causes of reading and writing difficulties. Besides, among the majority of persons with reading and writing difficulties one does not find measurable or clearly evident brain damage (Gjessing 1977). The localization hypothesis is weakened still further by Sperry's assertion (1984) that the brain probably functions as an integrated whole.

A more interesting side of medical research on reading and writing difficulties today is that part of the endocrine theory that deals with the connection between dyslexia and ailments of the immune system. This research takes its starting point in the so-called "testosterone-hypothesis" that was put forward by Geschwind and Behan (1982). Even if the testosterone-hypothesis still lacks clear empirical support, it has awakened great interest internationally. In the attempt to see if it might be possible to find such empirical support for it, a project was undertaken in Bergen in which 105 dyslectics were compared with a control group of 105 children who read normally (Hugdahl, Synnevåg and Satz 1989). The result of this investigation showed that ailments of the immune system were more than twice as common among the dyslectic group as among the control group. Left-handedness, on the other hand, did not produce a difference in the first analysis, but when the data was recombined such that dyslectic children with at least one immune ailment were compared with the children of the control group who also had at least one immune ailment, there were significantly more lefthanded subjects in the sub-group of dyslectics. However, in a lecture at Bergen, after the study was completed, Professor Hugdal clarified the point that this type of research was not yet well-developed, and he advised against exaggerated optimism regarding clinical methods of treatment for dyslexia. (Dyslektikeren No.3, 1989 p. 19)

Also the classical medical research-model has been strongly orientated towards other causal-connections concerning reading and writing difficulties.

"Often it is the ophthalmologist who is the first to be consulted by the parents of children who have reading problems, or he is asked by the school. Since it concerns reading-difficulties it is normally supposed that there is something wrong with the eyes." (Aasved 1982, p. 118).

Certain medical investigators have found that various conditions of the eye may have some significance for reading and writing difficulties, such as extra-long sightedness, unequal refraction in the two eyes, latent squinting, wandering of the one eye during fixation at close quarters (convergence-insufficiency) and weak fusion-amplitude which is defined as the weak ability for merging the two pictures from the eyes into a single visual impression. (Eames 1948; 1955; 1959; Park 1948; Benton 1968; Dunlop, Dunlop & Fenelon 1973:). The majority of relevant medical investigations show however that no direct connection can be shown to exist between reading difficulties and eye conditions, including laterality problems such as right/left dominance (dominating eye, sighting eye, controlling eye), crossed dominance and saccadic eye movements (Hallgren 1950; Goldberg 1959; 1968; Shearer 1966; Bishop et al. 1979; Norn, Rindziunski and
The lack of connection between eye conditions and reading function corresponds too with the author's own clinical experience and findings from empirical investigations. Thus, e.g., the 7 extremely weak-sighted subjects from 1979 had pronounced ocular dysfunctions without this hindering them from achieving good reading performance with CCTV (Hunstad, Selnes & Krekling 1979). Further, among some of the dyslectic subjects some ocular dysfunctions could be observed without this apparently influencing reading-performance.

The provisional conclusion here must be, therefore, that either the subjects's eye conditions have not had any connection with the reading difficulties, or that the Braillemaster and the Magnimaster completely or partially have eliminated the influence of eye dysfunction among the subjects in regard to their reading.

Later in this chapter we shall consider whether the training procedure might perhaps involve a critical variable, associated with speed, that effectivates the reading and writing function despite ocular sight anomalies.

Optometry, orthoptics and sensory psychology are independent fields of expertise, but which overlap each other and border onto medicine in regard to problems, research traditions, clinical methods of treatment, and terminology in dealing with reading difficulties and eye conditions. It is not unusual for the various fields and disciplines to cooperate or refer to each other in clinical work, and one finds also examples of lines of research that build on this kind of interdisciplinary interaction (e.g. teachers, psychologists, ophthalmologists in the Bergen-Project 1978-1988). Such interdisciplinary activity is also characteristic of cooperation between orthoptists and ophthalmologists both clinically and in research. (e.g. the investigation conducted by the ophthalmologists Norn and Skydsgaard together with the orthoptist Rindziunski 1969).

The relation between ophthalmologists and optometrists has been more controversial. Originally this started as a conflict over competence in the USA during the debate concerning the authorization of optometrists (summarized by Arrington 1929), but "the theme and the actual substance of the argument has changed very little until the present day." (Lie 1986, pp. 97-98). In Europe this conflict has been continued, but here it has proceeded on a more professional basis. At the Opticians Institute, Berlin, a method has been developed that involves the use of prisms for the correction of latent and manifest squinting (Haase 1973; 1980). The method has been used during the course of the last 12-15 years, especially in Germany and Switzerland.

The professional disagreements have resulted primarily in different views on threshold-values concerning what should count as sight-anomalies, and when they lead to sight ailments, especially for example, reading-performance problems, problems in perseverance in reading, and both general and specific strain disorders connected with reading and writing. There is also disagreement on how sight anomalies should be treated. There has been uncertainty over especially the significance of sight-coordination in connection with reading.

In Norway an investigation has been completed, which takes up the issue of the effect of the prism method of treatment using Haase’s method. The main conclusion of the investigation was (Lie and Opheim 1982):

"A principal objection against prism-corrections has been that the strength of the prism increases in the course of time, because the muscular control of the coordination (fusion) is weakened through
the use of prisms. This "crutch-theory" lacks empirical documentation, but nevertheless has attracted considerable support, especially from ophthalmologists. Undoubtedly it is a fairly widespread clinical experience that the prism power must often increase with time, but an alternative explanation has been formulated in what we call the "disclosure-theory". According to this theory, squinting may lead to tensions being built up in the musculature of the eye, which keeps parts of the squinting-angle hidden (latent) during attempts to measure the angle. Through prism-correction of the measurable angle, some of the basis of the development of tension is reduced, and the prism power can be increased in keeping with the normalization of the level of tension, until the "true" angle of squint has been fully "disclosed".

The previous results from prism-correction of approx. 60 clients provide full support for the "disclosure-theory". Not a single case provides support for the "crutch-theory". The concern that prism-correction might cause the client to have angles of squint that are not really present is therefore unfounded. (p. 101)

In his summary of sight anomalies and reading difficulties, Lie maintains (1976):

"The common view that sight anomalies play a modest and peripheral role in reading difficulties seems both unfounded and unreasonable. Sight anomalies make an important contribution towards reading-refusal and towards the reduction of reading effectiveness in the form of intermittent disturbances of the visual image. Depending on the frequency of the disturbances, also comprehension of meaning in reading is made more difficult. It is further possible that sight anomalies are partially the cause of forms of eye movements that disturb the basic integration of sight and comprehension-processes during reading" (p. 90).

It is very difficult to judge the value of such reports as this. According to the way the results are presented and interpreted in the report (Lie and Opheim 1982), the investigations battery of tests has been used to measure optometric changes in fusion and accommodation after prism-correction (and, when relevant, also spherical and cylindrical correction). Also presented at the same time are the results of reading-related subjective changes (diplopi, mistiness, alternating, headache, eye discomfort, reading distance, tiredness, line shift, head position, disturbance-trembling, fixation problems and suppression) evaluated only on the basis of interviews in which the subjects were asked whether they thought they had become better or worse (e.g. "she reported that the headache had got very much better"; "he reported that while reading he experiences using both eyes"). With this method of measurement the subjective changes should not be interpreted as proof and then used as cause of the measured optometrical changes. Here it is worth noting that subjective ailments are resultant conditions also where e.g. dyslexia and motivation-loss are the cause of the reading problems. Since dyslexia probably has a cognitive cause connected with the dysfunction in the information-processing of the brain, it seems hardly reasonable to suppose that it might be alleviated by prism-correction. On the other hand, it is quite conceivable that the caring effect might have had an influence on the general loss of motivation for reading, so that possibly prism-correction might also function as a contributory placebo-effect.

Nor was the investigation (Lie and Opheim 1982) arranged so as to make it possible to produce statistical data on the incidence of persons having sight-anomalies as a cause of
"Concerning the prevalence of problem-creating anomalies, as of today we know nothing with reasonable certainty;" (p.103)

On the other hand there is a German investigation (Günthert 1980) which reports that 43% of the 18,000 clients it dealt with were given full prism-correction because of sight-coordination related problems. However, there are reservations concerning the representativeness of this study, since it was first and foremost persons with this type of problem who visited Günthert's clinic.

The deficiencies of the methods of investigation notwithstanding, there is little doubt that a certain percentage of causes for reading and writing difficulties must be ascribed to sight-coordination problems. The subjects’s subjective statements about various ailments cannot be disregarded as made up, or as the expression of the need for caring attention. For that, the number of persons who seek help for such problems is far too great and homogeneous (e.g. Günthert 1980). The widely general referral of problem-pupils with sight coordination problems to educational-psychological services (PPT) in Norway and other countries further confirms that here we face a real problem.

The problem of research meanwhile has been, and still remains, to find differential-diagnostic criteria that as far as possible may distinguish different types of, and possibly also causes of, reading and writing difficulties. As things stand today, it seems that the most important task of teachers is to teach the pupil to live with his difficulties, since there are no satisfactory methods for the treatment either of symptoms or of causes. The situation is made more difficult since in this field there are probably many gaps in the statistics, in that pupils with reading-difficulties connected with sight-coordination (in the same way as with dyslectics), often try (cleverly too, in many cases) to hide their problems (e.g. dyslectics who sit and "read" the newspaper upside down when he tries to give others the impression that he can read).

The results of e.g. the investigation by Lie and Opheim (1982), could be evaluated through using more adequate methods of measurement, e.g. by measuring reading-performance (reading speed, error-frequency, text-comprehension, reading-distance) employing equalized tests before and after prism-treatment. Variables such as perseverance (reading over time, e.g. reading aloud or silent reading for 1-2 hours with a check on text-comprehension and observation for possible astenopiprobлем) and persistence over time (in months/years) of possible improved reading-performance, were not measured either.

Some of these same objections may also be made against the experiments using the Braillemaster and the Magnimaster. Neither in these experiments were perseverance in reading and persistence of the results measured with the same adequate battery of tests as was used in the experimental groups pretest and post-test. One might raise especially the question whether even good reading-performance in reading-tests with a text-length of about 500 words matches the great demands upon perseverance in reading that are made by school, work and leisure in modern society.

Nor was the variability of the progress through reading-training "objectively" measured, but was built, rather, on subjective impression since some of the earlier subjects later read aloud for us (see p. 133 above). In order to find out how effective the experimental reading-training is, or may be, it seems that systematic longitudinal studies in which the after-effects of training tested after a minimum of 2-3 years, are required.

That we here have so amply discussed reading-related medical and optometrical models and results is for the purpose of being able to compare the Braillemaster and the Magnimaster training with the accepted findings that these two fields represent.
But as the situation appears today, it seems that medical research-models and results can neither explain the mechanism(s) behind the relatively successful tachistoscope training, nor can make any substantial contribution to the pragmatic clinical treatment procedure for reading and writing difficulties.

But this does not prevent the possibility that teachers might obtain useful and fitting knowledge from medical investigators concerning e.g. pathological conditions of the eye among pupils/subjects, that ought to be taken into consideration, in cooperation. Without having scientific justification for such optimism, it seems that it is also possible that research in endocrinology may sometime in the future progress so far that it becomes possible to prevent reading and writing difficulties, through treatment involving the administering of hormones or medicinal preparations.

Optometry has long traditions in refractive treatment that makes a considerable contribution towards reducing the incidence of reading and writing difficulties, e.g. among persons with diminished vision due to faulty refraction in the eye. Today it would be unthinkable to carry through a research-project or a procedure for clinical treatment for those who are retarded in their reading, without starting by (or during the process) correcting faulty refraction in the eyes. Optometry too, is in a period of vigorous expansion in regard to the development of technique, apparatus, and methods both for diagnosing and for treating reading-difficulties. This serves to make optometrists relevant partners for cooperation, also in connection with research.

Thus it could be interesting to see if specific steps connected with refraction (here including prism-correction) could contribute towards making tachistoscope training with the Magnimaster more effective.

The conclusion must be, meanwhile, that if we are to find further solutions for the complicated and complex methodical problems raised by reading and writing difficulties, closer interdisciplinary cooperation between the professional groups discussed here seems to be necessary.

It seems, though, that educational-psychological theories and research-models are better able, today, to explain the methodical ways of working behind the perceptual training effect from the use of the method of the Braillemaster and the Magnimaster. We shall therefore close this empirical study, and this assessment of validity, with an analysis of what these disciplines might offer (see point 4, p. 112).

The educational-psychological model (from circa. 1930) operated with one symptom, but with several causal connections.

As in the medical model (see p. 112 above), the symptom was terminologically defined, but now with the concepts of dyslexia, specific reading and writing difficulties or more generally only reading and writing difficulties. The choice of terminology had its background in the, sometimes, serious dysfunctions among many schoolchildren, and was justified by " ... the almost unbelievable difference in reading-ability that might well be found in one and the same class-level. And not least was it alarming to see the considerable incidence of normally-gifted children who had reading and writing difficulties ... " (Gjessing, 1977, p.42)

The analysis of symptoms in educational-psychological methods of research and treatment for reading and writing difficulties thus became based and developed primarily on:

1. "Theories produced from deviant function, behaviour and development in reading
But deviant symptoms must deviate from something if they are to be used comparatively. The educational-psychological model includes therefore also research based on:

2. "Theories produced from mature, well-developed reading", e.g. in Gray, W.S. 1920; Lied, N. 1940; Chomsky, C. 1972; Goodman, K. 1974; Leimar, U. 1974; Edfeldt, A. 1982 (ref. from Gjessing 1985, p. 14). The premise for these theories is that reading as a process is similar at all levels, and the theories build on basic hypotheses concerning a "Top .... Bottom" model, in which the word-deduction techniques are based on understanding and details deduced from the text considered as a whole (read in order to get information, instrumental reading).

3. "Theories produced from the foundational stages of normal-reading", e.g. in Bond, G.L.K. and Dykstra, R. 1966; Chall, J. 1967; Vormeland, O. 1972; Skjellfjord, V. 1976; Lundberg, I. 1978; Aga, E. 1981 (ref. from Gjessing 1985, p. 15). The premise for these theories is that reading as a process is different at the different stages in its development, and they build on basic hypotheses concerning a "Bottom-Top" model, in which word-deduction (coding) leads to understanding, and the analysis of detail leads to the understanding of the text as a whole (read for learning how to read, pre-instrumental reading).

Even within the frame of these three theory-developments, generated from different stages of development in reading, the need for the use of the Magnimaster may be assessed.

Persons who have attained good instrumental reading do not require this form of reading-training, since they have already fulfilled the goals that the Magnimaster has been developed to fulfill: fast and informative reading.

They have attained this goal during the normal instruction at home and at school, and through their individual abilities and needs for fast information-exchange, which they have, in turn, realized through techniques of word-deduction based on the understanding of the integrated whole.

The results for identification speed in the control group of clever readers in the Junior School, seems to confirm this interpretation of good, instrumental reading (see above).

A pre-condition for the individual, through this easy method, being able to attain good reading-performance, meanwhile, is that she/he is not encumbered with physiological or psychological handicaps that could have a negative influence on the reading-development.

Through the usual methods of teaching reading, persons without native reading-difficulties can attain the general over-learning that is necessary for quick and reliable identification of text images, something that in turn seems to be a pre-requisite for good reading-performance.

Persons at a pre-instrumental reading level (usually pupils at the first grade of Primary School) may probably derive benefit from the Magnimaster-method as a supplement to the ordinary beginning instruction in reading. Firstly, it is because speed is a contributory factor in instrumental reading, such that training in fast comprehension of high-frequency words in the beginning stages of instruction may therefore promote the reading-
performance of all pupils in the class. Secondly, the training method works preventively for the pupils in the class who are predisposed towards reading difficulties. From visual training with partially sighted pupils we know that early perceptual stimulation is important, and that in certain cases it might be decisive for the achievement of function (Barraga 1977, p. 77; Hunstad 1988, p. 54-55). It seems reasonable therefore that the same perceptual state of affairs for early stimulation will also apply to the fully sighted who are predisposed towards reading difficulties, and where perceptual-speed is a contributory variable in the reflex-steered or automatic part of the stage of beginner-instruction of instrumental reading.

We may therefore advise that the Magnimaster-method should be taken into use for all pupils during the beginning stage of instruction in reading. With the recommended period of 15 minutes per day the training will not be at the expense of time for other training in reading, but rather would be a variation and a motivating element of the normal schooling.

For purposes of further interpretation of the results with the Magnimaster-method, it meanwhile seems that the part of the educational-psychological model that is based on "theories developed from deviant reading and writing functions" (p ?? above) is the most relevant part. To begin with, the theories proceed from the part of the population where the problems are really present, namely those persons who are deviant on account of reading and writing difficulties. Next, the theories are differentiated in several different models which attack the problems from several angles:

1. Neurological models/theories, in which localization of brain function continues to be relevant, but with great flexibility in the direction of an integrated, holistic brain function. The premise for the research-models is central-neurological symbol-disturbance in reading, e.g. Orton, S.T. 1928; Hermann, K. 1955; Delacato 1959; Preston et al. 1977; Duffy et al. 1980 (ref. from Gjessing 1977; 1985).  


3. The psychodynamic and social-educational models/theories, in which reading difficulties are classified primarily as a result of psychodynamic fault-development, e.g. Ephron, B.K. 1953; Pauss, K. 1970; Ericson, B. 1980; (ref. from Gjessing 1977; 1985).  

4. Models/theories for information-exchange, in which reading difficulties are seen e.g. in connection with a too long or too short storing in iconic and echoic memory. The premise for the research-models is that reading is a hierarchical or simultaneous process (bottom-up), e.g. Neisser, U. 1967; Sperling, R. 1970; Standley, G. 1975; Massaro 1975; Bandler & Grindler 1975; Goodman 1976; Høien, T. 1979; Lundberg, T. 1982; Edfeldt 1982 (ref. from Gjessing 1977; 1985; and Høien 1979; 1983).  

5. The developmental models/theories, in which the premise is the understanding of reading's general levels of development. The individual goes through the same phases (the global stage / analysis-synthesis stage / totality stage) and in the same sequence, such that "there is only one way towards reading", e.g. Biemiller 1970; Goodman 1973; Report from the Lyngby-Taabæk project 1979 (ref. from Gjessing
6. Typological models/theories, in which the studies comprise direct, criteria-based symptoms and indirect prediction-based symptoms. The premise here is that reading and writing difficulties (dyslexia) is a collective name for many various disturbances of function in written language, that can be distinguished and understood only on the basis of nuanced observation and analysis of error reactions and behavioural forms in written language (intra-individual interaction) e.g. Gjessing 1953; Johnson & Myklebust 1967; Boder 1968; Dencla 1972; Malmquist 1974; Fletcher & Sats 1980; Aron & Baker 1982 (ref. from Gjessing 1985).

Here it would be excessive to discuss all six theory models in connection with the Magnimaster-method. We shall therefore confine the empirical study and assessment of validity to a short review of the typological models/theories point 6 above), and then return to a more substantial analysis of the models for information exchange (point 4 above) in the Discussion Chapter.

Research within the typological models has yielded that development of theory that probably has led to the most, and perhaps also the best, results-directed procedures for treatment of persons with reading and writing difficulties. Gjessing’s function-analytical treatment model (1953) is a good representative for the typological models and, through several decades, seems "to have passed its practical test". All the same, there is great qualitative variation in the results of the methods of treatment that are evaluated through research. As early as 1974 Gjessing pointed out the need for the overhaul (not scrapping, but "getting into a healthy state) of special education (Gjessing 1974). The results from the Bergen-project (Gjessing «MDRV» et al.«MDNM» 1988) show that even the most recently revised methods of treatment do not offer help to all pupils with reading and writing difficulties:

"Our apparently good results notwithstanding, (cf. Satz review), we continue to face a considerable problem. Even if we are able to document considerable progress for some of our dyslectic pupils, we still also have, despite all our efforts, quite a large number of cases with a negative development." (Gjessing «MDRV» et al.«MDNM» 1988 p. 354)

The statistical data of the Bergen-project (N = 3090) is very comprehensive and has a number of differentiated results to show. The project was a longitudinal investigation in which the pupils were followed in their school development from the second to the ninth grade of the Primary School. The results build on evaluations from parents and teachers and on the project’s own tests. The results are also compared with results from other investigations (e.g. Monroe 1932; Kline & Kline 1975).

As a summing-up of the results of the Bergen-project, we note:

"In our project we have a number of different results to present, with the results of the evaluations from parents being the most positive ones. With regard to reading-development, according to the parents’ view only 9% of the dyslectic pupils had great or very great reading-difficulties in the 9th grade, while the teachers estimated this incidence to be 20%. On the basis of this latter estimate we arrived at the judgement that 3 out of 5 dyslectic pupils with serious reading-difficulties had reached a functional reading level by the 9th. grade" (Gjessing «MDRV» et al.«MDNM» 1988 p. 354).
It is pointed out in Project Report III (Gjessing «MDRV» et al. «MDNM» 1988, p. 353) that it is not unproblematic to draw comparisons with other investigations. Assessed as an effect-study, and with e.g. stanine-scores with complete year-class as the norm, the results of the Bergen-project, on the average and on a general basis, were approximately the same as those of other studies, with the exception of Monroe's group 1, treated in a clinic and Kline and Kline's clinic-treated groups, where the results were very good and quite alike. "In the Bergen-project we did not have such an intensive procedure, but neither did we have such correspondingly good results." (Gjessing «MDRV» et al. «MDNM» 1988 pp 353-354).

The main impression we remain with is that national and international investigations show that with the function-analytical treatment-models used, there are still many pupils (up to 2 out of 5) who remain without treatment or who do not attain a reasonable functional reading level commensurate with their general level of ability. Thus it is reasonable to assume that in the practical special-educational service that does not have the professional and economic resources possessed by the research-projects, one will find even more pupils who, at the end of their 9-year long school-career have great or very great reading problems. The causes for this may be many. The complexity and variety of the etiology and symptomatology of reading difficulties do not exclude the possibility that one or more sub-groups of dyslectics are extremely resistant to treatment, especially when considered in relation to the fact that the most commonly used treatment-method (the typology model) is a treatment of symptoms, not of causes. It will also be a question (in addition to the lack of formal professional competence and economic resources) whether the poor results are due to the lack of commitment and proper following of the procedure in a certain number of pupils and teachers. Even the most relevant and best methods of treatment may be sabotaged or made to suffer in an unhelpful set of priorities.

It is a characteristic feature of the functional-analytic models of treatment that they are time-consuming. Often, all of the time at the primary school is used before dyslectic pupils attain functional reading and writing. It is not unreasonable that this is the case.

Dyslectic pupils require meticulous over-learning if they are to reduce or eliminate a great variety and number of faults in their comprehension and mastery of written-language. Even though the functional-analytic models of treatment call for the special-educational schooling being varied and pleasurable, often it cannot be avoided that the continual repetitions and the slow progression little by little begins to erode the motivation and self-confidence of the pupils (and perhaps of the teachers too). It is precisely because the pupil has such great problems in interpreting symbol-information correctly, that it is difficult for the teacher to make demands on the pupil for fast reading and writing. The dyslectic pupil may thus stay stuck in a slow method of reading and writing that in itself is different from the methods used by the other pupils.

The experiment with the dyslectic group (N = 11) using the Magnimaster-method showed strong indications that it is possible to increase the reading speed at the same time as reducing the reading errors. The same point has been observed in the authors own professional practice in dealing with a number of dyslectic pupils, in which also errors in the pupils' own written work have been reduced considerably, conceivably as a transfer-effect from the identification-training in high-frequency words. With the Magnimaster-method this improvement can be attained with a minimum of expenditure of time in relation to the traditional method of treatment for dyslectics.
However, it must be emphasized that it is unreasonable to suppose that dyslexia can be treated only by the use of the Magnimaster-method.

In the first place, the research data that would permit presenting the Magnimaster-method as an independent reading-method is not available. Secondly, the complexity of the symptomatology of dyslexia is probably too great for allowing the problems to be solved in such a "simple" manner. These are the reasons for why the Magnimaster-method will not be marketed as a free-standing reading method, but rather as a supplementary method.

But all the same, it does seem that the results both from the Braillemaster-method and the Magnimaster-method strongly indicate that speed is a general critical variable for the attainment of good reading-performance. Even if it has not been shown experimentally for the whole distribution of pupils who have reading-difficulties, and even if the total number of subjects in the authors own experimental groups is not large, it seems that this critical speed-variable in principle is independent of the pupil's particular type of reading problems or sensory dysfunction.

The significant results of the authors's experiments indicate, at any rate, that a considerable number of visually handicapped (also including braille-readers) and a considerable number of dyslectics can increase their reading-performance through training with high-frequency words using the Magnimaster-method.

All the same, in our view, therefore, it seems that e.g. Gjessing's functional-analytic model still remains the most reliable approach for the treatment of dyslexia problems, but the Magnimaster-method can be an effective and appropriate supplement for getting the required over-learning more quickly.

It seems that Braille-readers without dyslexia can profit in the form of greater reading speed from training by the Magnimaster-method more directly together with ordinary reading methods used in the education of the blind, while the visually-handicapped with residual vision have to have their sight conditions optimized both for using the Magnimaster-method and during reading-training along the lines of other alternative reading methods.

DISCUSSION

IDENTIFICATION SPEED AND READING SPEED

Research and Information-exchange

In the Results Chapter (pp 158) we concluded that the Magnimaster-method appears to offer strong indications that speed is a critical variable for the attainment of good reading-performance. In that connection identification speed and reading speed were considered as a problem of validity in the choice of reading method. But we have not yet solved the problem of what are the perceptual or cognitive causes for the increased reading-performance arising from the use of the Magnimaster-method. That is why we shall now return to the educational-psychological theories/models for the exchange of information (pt. 4, p 154 above) and proceed to discuss these in the light of the problems that are formulated in the Introduction Chapter concerning conscious and unconscious memory-processes at work in reading. What is information?
The question may be answered perhaps with new questions:

"Where is the wisdom lost in knowledge? Where is the knowledge lost in information? (From the poem: "From the Rock" by T.S. Eliot 1933).

Here in these lines is expressed an implicit call for us to reconsider what we mean by information, what we lose as well as gain from it, and how we apply our concept of information. One essential aspect of information is that it draws knowledge out from the contingencies of life. Information thus becomes attitude-related and situation-related bits of reality that have been torn loose from, or may be placed in, a large information complex. The amount of information in our culture (and in our "data age") is conspicuously increasing without it being made clear that the information-needs of the individual have increased at the same rate. The information-exchange is often so great that persons consciously or unconsciously shut out some of the influences. The tasks of everyday life thus involve a matter of establishing priorities concerning when and where information is most important. The promoters of scientific theories/models generally, and of educational-psychological theories/models for information-exchange in particular in our case, must be clear about their priorities in the information-complex that we and our milieu consist of.

One of the priorities and a fundamental problem of educational-psychological theories/models has thus been to consider what occurs during information-processing while reading.

But educational-psychological theories/models for information-exchange have not led to practical treatment-models to any noteworthy degree:

"From being a relative atheoretical discipline, research on reading became marked by persistent attempts to develop relevant theories of the foundational processes of reading .... In the footsteps of theorizing there followed a host of models (hypothetical constructions) many alike but some unalike. ... But so far this theory and "boxology" has hardly had any great significance for the practical teaching of reading, at any rate not concretely or directly (Lundberg 1981b; Doering 1983). Theories and models have not lent themselves to being operationalized and empirically tested apart from the most peripheral stages of information-processing chain. Nevertheless this work of producing models has created more understanding of the complicated nature of the reading process; an understanding of the point that reading and other written-language skills interact with, one is tempted to say, the whole of our perceptual, cognitive, language-motoric and socio-emotional system. But how this complicated interaction proceeds is something about which we still reliably know very little." (Gjessing et al. 1988 pp 91-92)

Memory processes.

One of the investigators involved in the work of articulating educational-psychological theoretical models for information-exchange who has dealt with the question of information processing is Torleif Høien. In two dissertations (Høien 1979; Høien 1983) he has shown relatively significant correlation between special reading difficulties and deviant iconic memory, as well as significant positive correlation between the durability
of echoic and iconic memory. A method of treatment for persons with reading difficulties has been developed with these findings forming a part of its background (Høien «MDRV»et al.«MDNM» 1982; Høien and Lundberg 1984).

In the attempt to seek some explanation for the cause-effect in the Magnimaster-training using high-frequency words, we shall focus meanwhile especially on Høien’s theory/model concerning iconic persistence (Høien 1979).

With reference to e.g. Treisman «MDRV»et al.«MDNM» (1975) Høien asserts (1979, pp. 24) that "the existence of a so-called iconic memory is, empirically speaking, well-founded", but reminds also that "there are some researchers too, who adopt a sceptical attitude towards the existence of an iconic memory"

Still with reference to Treisman «MDRV»et al.«MDNM» (1975) Høien (1979, pp. 23-25) points out three different factors that show that "iconic memory is a reality:

1. However short a light-signal may be, it seems all the same to the perceiver to last perceptually for at least 120 milliseconds.
2. When two separated stimuli are presented with short inter-stimuli intervals they are seen as one signal.
3. Information can be read out from a stimulus up to one second after the end of the exposure."

Isolated from other cognitive memory-functions, Høien (1979, p. 11) defines iconic persistence thus:

"Iconic persistence is used about the after-effect, the icon, which becomes manifest after short exposures of light. "The term icon is used to describe this photograph-like internal representation of a no-longer present visual stimulus" (Hoving, Spenser, Robb & Schulze 1978 p. 22). The visual effect that occurs when the light-stimuli meet the eyes, does not stop immediately the external influence ceases. It is this persistence of light stimuli that causes a rotating light source to be comprehended as a light-line and a blinking light perceived as shining continuously if the blink-frequency is high enough."

Gjessing «MDRV»et al.«MDNM» (1988 p. 193) place the iconic memory in a larger cognitive and memory-functional frame:

"Through cognitive-psychological research in the field of information-treatment of recent years, the memory-functions have been put under the magnifying-glass far more than previously, and more distinctions have been made. For the very shortest memory-span, in which the sensory impression last only for fractions of a second before it ceases, one speaks, e.g. of iconic memory. Considerable experimental-psychological research has provided this interesting contribution (Neisser 1967; Riding & Pugh 1977; Sperling 1960; Høien 1980). One uses, further, such distinctions as short-term memory (which lasts some seconds) and long-term memory, which is the information-mediating "lexical" memory. The nature and distinctive quality of the memory-processes, it has to be said, remains unclear."

In order to find out whether there is a connection between the length of iconic memory and dyslexia, Høien conducted (1979) an investigation using 58 subjects who had special reading difficulties and a control group (N = 54) who did not have reading difficulties, but
who were matched against the experimental group for age, intelligence and educational milieu. The length of iconic persistence was measured with a specially-made tachistoscope that could transit light-signals in the form of various patterns or alphabetic letters. The signals could be exposed singly or successively with varying inter-stimuli intervals. Reading-performance in both groups was also measured, using diagnostic reading tests.

The results showed that there were far more cases of deviant iconic persistence (over + 2 sigma or under - 2 sigma) among the experimental group than in the control group. Among the 58 subjects of the experimental group, 23 had long iconic persistence, 29 had moderate persistence (+/- 2 sigma) and 6 subjects had short iconic persistence. The difference in the variance between the experimental group and the control group was significant at the 0.01 level. In the control group the persistence values were concentrated around a mid-point, but the experimental group showed a wide distribution of the results. The results showed too that pupils with short or long persistence scored significantly worse in reading tests than pupils with moderate persistence. Pupils with long iconic persistence, relatively speaking, had the greatest difficulties in the reading of new word-images, while pupils with short iconic persistence had difficulties in reading longer words on account of the short available coding-period, and they must consequently often rely on guesses. The difference in the variance between the experimental and the control groups "could suggest that deviant iconic persistence stands in a certain causal-relation to special reading difficulties" (Høien 1979 p. 93). A closer analysis of the results showed also that "there is a clear and significant connection between length of persistence and the grouping of dyslectics." (Høien 1979 p. 93) Parallel with, and independent of Høien's investigation, Riding and Pugh with a comparable experimental design arrived at the same interesting results, concerning both the connection between deviant persistence and reading difficulties, and the point that pupils with long or short persistence scored significant worse in reading tests than pupils with moderate persistence.

Høien (1979 p. 186-189) asserts that the research results may lead to practical / educational consequences:

"The relation between length of iconic persistence and the reading process may have practical consequences for the proper organization of reading instruction. If these research findings are interpreted correctly, the knowledge of persistence-length may have consequences for the choice of method in reading instruction, for the placing of the pupil in the classroom and for the structuring of the reading material itself."

Concerning the choice of method for reading training it is usual to distinguish between an analytical method (word-image method) and a synthetic method (vocalization method). In practical reading instruction, Høien (1979 p.187) asserts that;

"Newer reading methods can hardly be characterized as purely analytic or synthetic, but should be seen rather as combined methods."

From his own research findings Høien (1979, p. 187) concludes that pupils with long iconic persistence may encounter difficulties if the reading instruction is based on synthetic methods. These methods demand fast identification of single letters which must thereafter be put together to form a sound-package. On the other hand, he says, there are grounds for believing that the analytical methods may be more appropriate for pupils with long iconic persistence. The long persistence may, in fact, be an advantage since it offers the pupil a longer identification period.

For pupils with short iconic persistence the synthetic methods will probably be
appropriate during learning to read. The short persistence prevents masking during the putting together of sounds, but it may lead to guessing and recognition-errors when at a later stage the pupil progresses to whole-word reading.

The consequences, in other words, are that iconic memory that is too short in comparison with moderate iconic memory offers too little time for identifying the whole-word image ("m" in the word "mother" may be forgotten when the pupil has finished identifying the final letter of the word), but iconic memory that is too long makes for interference (the letters are mixed up, such that e.g. the word "stop" becomes "post"). Omissions and reversals are also common symptoms of dyslexia. But Høien (1979 p. 189) cautions that these conclusions are hypothetical and have to be considered as provisional.

In presenting so amply the research of Høien (1979) and others (Riding and Pugh 1977; 1979; Treisman 1975) it is because the results provide premises for a possible interpretation of the training-effect arising from the use of the Braillemaster/Magnimaster.

A feature shared by Høien's method and the author's is that the tachistoscope was used as experimental measuring instrument. But there is a difference that is crucial, for among other things the assessment of alternative methods of treatment, in how this measuring-instrument was used in the two research designs. Høien used the tachistoscope only diagnostically, in that the interstimuli interval (pause between two stimuli) was used to measure the length of iconic memory of the subjects. In the present author's investigations the measuring-instrument was used both diagnostically and for training purposes, since the exposure-time for the stimulus was first used to measure the subjects's identification speed, and later was used to attain greater identification speed for various stimuli (high-frequency words). In Høien's investigation, in other words, a treatment aspect for changing (improving) deviant perceptual function is not present, while the present author's method involves as a primary goal the purpose of changing (improving/increasing) the subjects' ability for perceptual comprehension. In this lies no favouritism for the present author's own method, since each of the two methods measure dissimilar aspects of the processing of an interaction in which the length of the iconic memory and the identification speed of stimuli are probably mutually dependent on each other, if e.g. functional reading is to be attained. This form of mutual dependency between two different levels of information-processing, theoretically may lead to a hampering (slowness) in e.g. iconic persistence or in identification speed, can lead to dysfunction or a blocking of the whole (or in parts of) the information-processing. Why and how this hampering may possibly occur among the experimental subjects, for the time, can only be answered speculatively, but the consequence(s) in the form of reading-retardation may be discussed theoretically and measured as a break of function (symptoms) among those retarded in reading.

Let us see if it is possible to find a hypothetical clarification of what kind of perceptual/cognitive processing occurs when high-frequency words are established in the lexical memory through tachistoscope-training. (Gjessing «MDRV» et al.«MDNM» 1988. p. 193; Leegard 1987, p. 176-194).

We take visual perception as our point of departure and suppose that through training the individual attains normal, good reading with proper phonological, orthographical, syntactical and semantic representation in the lexicon. We further suppose the existence of the iconic memory level with a duration of less than 1 second, but at least 120 milliseconds (Høien 1979).

In Høien's investigation it was possible for the subjects to identify the least perceptual unit (grapheme/phoneme) represented by a letter, in an exposure-interval for S1 and S2 of 20 milliseconds (1/50 sec.) and with an interstimulation-interval that began with 100 milliseconds and was regulated upwards until the subject managed to read both letters
After this it is possible to identify an item of graphical information (single letter) in 1/50 second. This agrees at one level with the fact that 9 of the subjects in the present author’s own investigation, and in the interpolated test, identified 6-letter words in 1/40 second.

The difference, however, is in the amount of information, since the subjects in the present author’s investigation identified 6 letters (the word) almost as fast as Høien’s subjects identified one letter. If the author’s subjects grasped 6-letter words sequentially, should they then have required a longer exposure-time than 1/40 second per word? The results can be interpreted in only two ways:

1. **Either Høien’s subjects could have managed to grasp single letters 4-5 times as fast, or;**

2. **The present author’s subjects, on a perceptual/cognitive basis, converted whole words (instead of single letters) into a new perceptual least-unit (simultaneous comprehension of whole words).**

Alternative 1 meanwhile appears the most likely, in that Sperling (1969) regards exposure-times down to 4-5 milliseconds (1/250 -1/200 second) as possible for visual stimuli. Even exposure-times of 1/200 second provides ample possibility for sequential analysis of 6-letter words.

This explains, though, only what possibly happens when iconic persistence is too short and not what happens when it is too long. With alternative 2 one may ask instead whether the ways of coding in the two cases of different persistence lengths are unalike?

It could be that the ways of coding are different in the cases of too short and too long persistence as well as being different as compared to moderate persistence length, in that any stimuli that are faultily registered or processed at the iconic memory-level in turn lead to cognitive faulty-interpretation, that again in turn generates different kinds of reading errors (symptoms).

The explanation of how the ways of coding are different, may, in the case of those with iconic persistence that is too short, be found in the postulate that whole words (instead of the letter) are converted, through training and over-learning of identification speed, into a new least perceptual unit (simultaneous comprehension of whole words). Among those with iconic persistence that is too long, on the other hand, the same converting as a result of the same kind of speed-training, could lead to the state of affairs that a text would contain fewer perceptual least units that could cause interference in the amount of information.

*This explanation involves that speed-training does not have to change the deviant persistence-lengths among the subjects. Instead, the explanation suggests, rather, a supposition that speed-training gives increased accessibility for, and therefore better utilization of sensory input and mediates information to the brain (see below).*

Should we once again take as our point of departure Høien’s hypothetical consequence-analysis of iconic persistence that is either too short or too long in regard to reading methods (see pp. 164-165 above), we would now, on a theoretical basis, be able to sketch a symptom analysis:

- faster identification of whole words will better utilize the capacity in iconic persistence that is too short,
- faster identification of whole words, in the case of iconic persistence that is too long,
This latter postulate requires exemplification:
In contrast to letters that in isolation are seen as not being meaning-bearing, whole words can be understood as meaning-bearing (see p above). In this connection it makes less difference for the comprehension of the contents of continuous text to get interference among whole words than among letters, e.g. when the word:

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1234567 7345126
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"Between" suffers interference and becomes e.g. "Netweeb".

It is then more difficult to understand the meaning of the word than e.g. in the sentence:

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1 2 3 4 5 6 7 8
Shall we take a walk in the forest?
8 4 5 1 3 6 2
Forest a walk shall take in we?
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In this connection it is better (more functional) to have changed syntax than to have meaningless words. Here it is relevant to compare this matter with the sign-language of the deaf, in which the mutual relations of the signs are often very different from the mutual relations in spoken language, without this giving the deaf a worse comprehension of content than those with hearing (Tellevik 1981 p.99).

For persons with iconic persistence that is too long, it seems, therefore, of no consequence whether the word-comprehension is simultaneous or sequential. If they have learned both to recognize and to recall the word in the lexicon faster within the scope of their own iconic persistence-length, the increased identification speed (comprehension of whole words) will provide increased reading speed without interference between the words having any crucial influence on the understanding. The comprehension of the content of the text may then be established.

But theorizing such as this requires to be verified, e.g. in research designed to investigate whether pupils with iconic persistence that is too long actually avoid interference between letters, and simultaneously attain faster identification speed of e.g. high-frequency words. Ideally, the research design should include a general comparative study of the connection between the length of iconic persistence and identification speed of high-frequency words. As far as is known, such investigations have not been conducted.

Whether it be sequential or simultaneous comprehension of whole words, the results of Table 1 and Figure 1 for the dyslectic group (interpolated test) and the results from the control group (see p. 125 and 128) show that these subjects had a latent perceptual capacity at the level of iconic memory for comprehending up to 6-letter words in 1/40 second in any case. This is a considerably faster identification speed than the one shown in the pretest by both the same dyslectic group and the subjects of the other experimental groups (see Table 1 and Figure 1). Thus, the training showed that it was possible to increase this identification speed (see Table 1 and Figure 1) to become closer to the (previously mentioned) latent perception-speed. For the dyslectic group, meanwhile, the difference in the identification speed between the pretest and the interpolated test was not as great (3/40 - 1/40 second). This is possibly because these Junior School pupils, through the whole of their primary schooling right to the time of the experiment, despite
everthing had been given traditional dyslexia treatment and that much general reading training that identification speed, and therefore also reading speed (see Table 2 and figure 2) had reached a more or less acceptable level. The analysis above is in agreement with Høien’s premises for the diagnosis of reading difficulties in the frame of a process-analytic view, and shows too that it is important to arrive at a more effective identification technique (a training programme) for pupils with reading difficulties.

"The identification of unknown words on the basis of an analysis and synthesis of single sounds is extremely demanding. It is especially difficult to use such a technique in the reading of longer words. Here, the short-term memory enters into play, and establishes clear limits for how many elements one may memorize during the sound-linking phase. It is therefore important that the pupils arrive at a more effective identification technique. The majority acquire a technique more or less unconsciously, perhaps without the school providing training in this area. Some pupils though require a special learning-programme for the drilling of this identification technique." (Høien 1982a p.83)

In harmony with Høien’s (1982, p. 83) and the present author’s own analysis above, it should now be possible to draw three conclusions:

1. Reading instruction along the lines of traditional theories of learning with emphasis on simultaneous influence on the senses, will offer the majority of school-pupils (approx. 90%) enough stimulation, and with the passage of time also the best stimulation and the best learning conditions, for the achievement of good reading speed and thus good reading-performance.

2. For pupils with sensory loss (the blind and the partially sighted) and for pupils with specific learning difficulties (dyslectics) there is a requirement for temporary specific modality-training (tactile or visual) in which stimulation of the cognitive memory functions and the influence of the other senses is reduced to a minimum during training. The "touch-tachistoscope training and tachistoscope-training (special drilling over-learning/specific sense training) with high-frequency words, in this connection, and thus far, seems to be the best (supplementary) method for the attainment of good reading-performance.

3. Temporary, specific sense training may lead all pupils more quickly ahead to good reading-performance. This is perhaps especially the case for the learning of foreign languages.

Automation.

Earlier (p. 152 - 153 above; Hunstad 1985a, p. 40; Hunstad 1988, pp. 55-57) we have pointed out that fast identification of whole words seems to be a critical variable for the attainment of general good reading-performance. We have also shown that it is possible to increase the identification speed for high-frequency words with a transfer effect to continuous text (see Results Chapter pp. 114-128). Among theoreticians and teachers in special education this demand for perception-speed seems generally accepted. e.g. when Lundberg (1983, pp. 297-300) describes the need for automation in the reading process:
"In order to become a good reader it is necessary that the word-decoding takes place with high speed and good precision without one having the attention drawn to the decoding. The process, in fact, has to proceed automatically. The decoding aspect of reading is a skill that has strong resemblance with many other skills such as e.g. playing the piano, tennis, slalom skiing, telegraphy, handicrafts, circus acts, driving a car. Common to all such skills is that they have become automatic through a lot of wide training, often large portions of special over-learning. The point of automation is that no mental resources are spent in order to carry out the maneuvers. Instead one may direct the attention to superior questions as e.g. comprehension while reading and telegraphing, choice of road in car driving, tactics in tennis, aesthetic judgement in music.

No matter which of the ways into the lexicon is blocked, the majority of those who are weak in reading have a faulty automatized decoding. Quite simply, they have had too little training".

Despite the demand for automation through training, neither normal training methods nor special-educational methods of treatment in reading (as e.g. the functional-analytic and the process-analytic methods), so far as the present author is aware, has incorporated a systematic training procedure designed to increase identification speed and reading speed.

It is true that a number of textbooks, both national and international, have incorporated measurement of speed as a part of the study-technique procedure for silent reading. Clearly, such procedures are worthwhile in their own right, quite generally.

For pupils who are weak in reading, study-technique reading training is clearly not enough:

"But it is not enough for a pupil weak in reading just to begin to read. He/she also has to have more systematic assistance with the text from the teacher, learn how to understand the word's orthographic structure and give up "rough and ready" reading".  
(Lundberg 1983 p. 298)

The Magnimaster-method seems to be precisely a special-educational facility and a supplementary procedure that meets the need for special over-learning among pupils who are weak in reading.

If we define retardation in reading as a perceptual failure, it seems that pupils weak in training require specific perception-training (special over-learning), in which expenditure of concentration and cognitive-energy resources e.g. for syntactic and semantic functions, are reduced to a minimum while the identification speed and reading speed become automated.

Since the method requires fast identification of single words, the syntactic and semantic functions become reduced to possible associative thoughts the pupil might have in connection with one word at a time. When for example the word "pound" is exposed in the tachistoscope the pupil may associate with it the money he needs for the evening's cinema outing. Such association and formulation of sentences based on high-frequency
words is, indeed, a part of the methodical procedure during the initial phase of the tachistoscope training. In many ways therefore, special over-learning may be compared with the drill and rote learning of home-work reading of earlier times. The demand on the pupil for reading again and again the texts to be read so as to be able to repeat the contents as word-perfect as possible, in all likelihood led to the pupil trying to read as quickly as possible (for, if nothing else, to be as quickly finished with the homework as possible). The demand of word-perfect repetition of the study-material thus gave the pupil the required over-learning both for being able quickly to recognize the word-image while doing the reading and for being able to recall the word-image/text-image when he is called to speak in school. Even if the drill and rote learning of "the old days" gave this good perceptual effect, there are still two reasons, at least, for not re-introducing them as a method of schooling now: In the first place, also in the old days we had pupils with reading and writing difficulties, something that suggests that the pupils who were most strongly disposed towards reading difficulties did not manage to satisfy the demand for being able to remember their texts by heart (they were the losers and were known to be so). Secondly we have the long educational experience that in general drill and rote learning do not motivate enough, and nor do they give the insight and involvement in the reading material that is necessary for a good internalization of knowledge.

In contrast to this, it seems that the Magnimaster-method can replace the drill of former times, with the pupil being given a rational, appropriate and motivating way of getting the special over-learning that is required in order to make full use of their potential for perceptual speed.

Such specific learning that the tachistoscope provides may seem boring and thus also harmful for children. But the method is arranged in short training-sequences, and the pupil competes with him/herself ("yesterday I recognized 5-letter words in 1/20 second, today I shall be able to do them in 1/10 second). Both from the experiments and from practical experience in schools the present author has seen that the method can be extremely motivating for the pupil, also over a longer period, as long as the experimenter/teacher loyally keeps to the short training sequences. When the basic perceptual speed is trained according to the Magnimaster-method the pupil is perhaps ready for the previously mentioned study-technical reading methods. With the great variety and enormous etiological/symptomatological complexity that reading problems involve, and with the, it must be said, quite limited research findings that are available, it is right to express the reservation that the Magnimaster-method probably does not cover all types and cases of reading problems. Even if increase of reading speed should be a general possibility for humans, there would all the same be a range of deviant perceptual, cognitive and socio-emotional variables that may block (Gjessing et al. 1988, pp.91-92; Høien 1982, pp. 80-81) the increase of this specific identification speed that the Magnimaster-method is designed for.

The connection between identification speed and automation seems, all the same though, to be obvious. If the relevant automation is defined as unconscious, reflex-conditioned and appropriate steering of behaviour (cf the example of car-driving p. 136-137 above), it is possible that an individual's conscious desires for attaining rational, situation-defined control may be fulfilled. Here it is a question of appropriate coordination of cognitive and sensoric processes. In order to attain functional and appropriate reading, the automation therefore has to be a kind of catalyst which releases and coordinates sensoric functions with cognitive functions, as in e.g. the comprehension of form and spatial orientation in a syntactic and semantic setting. Good reading becomes, in other words, also a question of an automatized ability for orienting oneself in time and space.

How well this automatized orientation-ability has been developed will be decisive
for that which is the main point of reading, namely the comprehension of the substance of the text.

But reading and the comprehension of the matter of a text is not enough. A prerequisite for the individual being able to continue to read and understand new material is that the reading takes place with a minimum expenditure of time, if the loss of motivation for reading is to be avoided. Reading speed thus has to be automatized too.

Thus, from a theoretical perspective, the causation of reading difficulties might be a failure or a slowness (see pp 165-166 above) in the coordination between conscious and unconscious cognitive and sensoric processes. The symptoms of reading difficulties seem to agree with such an hypothesis, either as a failure in the comprehension of the form of word-images (e.g. taking one thing to be another thing, omissions, simplifications, complete and incomplete reversals and assimilations in the phonetic and graphic synthesis), as failure in spatial orientation of the text-image (e.g. lack of comprehension/understanding of the words’s placing and connection in sentences and paragraphs) or as failure in the memory function. e.g. at the iconic level (p. 165 above, p. 176-177 below). Resulting conditions such as difficulties of concentration, inferiority feelings and sometimes anxiety, may further magnify and conserve reading difficulties (Hunstad 1985a, p. 9; Hattvet and Hunstad 1987, pp. 9-10; Andersen and Hunstad 1988, p. 146).

**Accessibility and Cross-modal Transfer of Learning**

In addition to the results presented in the Results Chapter, some reference might be made to another comparable empirical study: In the discussion of cross-modal transfer of learning (Hunstad 1895c, pp. 55-57), it was supposed on a theoretical basis that the precondition of a coordination between specific modality-factors of lower order and independent modality-factors of higher order, also covered reading:

"In this learning, both lower order and higher order modality variables enter. Perhaps it is a necessary precondition for the cross-modal transfer of learning that all biological functions are normally developed. Any retardation in one or more of the specific modality factors of lower order must thus be compensated for by reinforcement" (Hunstad 1985c, p. 55).

"If sensing is classified, according to Gibson’s (1966) distinction, as a specific modality factor, the subject’s light projection must be classified as energy processing and thus must be counted as a predis-position of lower order" (Hunstad 1985c, p. 53).

Compensating through reinforcement, here, became focussed on the optimization of sight conditions among subjects with slight residual vision (light projection) , but the experiment itself (Hunstad 1885c) and earlier experiments (Hunstad, Selnes & Krekling 1979: Hunstad and Selnes 1980), showed too that speed in braille-reading did not produce transfer of learning to ordinary print, nor vice-versa. In contrast to the other variables in reading-performance (comprehension of form, spatial orientation, syntax and semantics) which did give cross-modal transfer of learning (Hunstad 1985c; 1988), neither identification speed not reading speed gave cross-modal transfer of previously learned speed in reading. The same experiment (Hunstad 1985c) and later experiments
showed, however, that the basic (or latent) reading speed that was acquired either through cross-modal transfer of learning or directly through learning in one modality could be increased by making use of special over-learning (tachistoscope training). Also in these experiments the conclusion that speed, as an amodal modality factor of lower order, is a critical variable that requires special over-learning through the relevant modality-specific information that is given in the tactile way or visually, if increased identification speed and reading speed is to be attained among subjects in the visual acuity-area 2 metre to finger-telling 1 metre (Hunstad 1988, p. 84-85).

All of the present author’s experiments (N = 96 *) using braille readers as subjects (N= 42), with subjects who achieved sight function in the visual acuity-range light-projection 2 metre to finger-telling 6 metres (N = 54), and with sighted dyslectics (N = 11), thus show that speed is a critical variable in reading.

Whether braille or normal script was used as reading medium, the subjects who were given reading training (N = 42) attained a significant increase in identification speed of high-frequency words and reading speed in continuous text. The additional numbers of subjects that are here included thus reinforce the conclusion of page 158 that:

The critical speed-variable seems in principle to be independent of what kind of reading problems and sensoric dysfunction the subjects have.

For subjects with strongly reduced vision though, it is a pre-condition that the sight conditions can be optimized (see footnote p 175 above). The reinforcement (optimization of sight condition) seems, then, to be a precondition for being able to compensate retardation in one or more of the specific modality factors of lower order in cross-modal transfer of learning (Hunstad 1985c p. 55). In the same way it seem that automation of processes that by and large must be conditioned by the sensoric system (identification speed and reading speed), could also take place through reinforcement or special over-learning (see p. 173 above), through the remedying of a failure or slowness in the processes of the sensory function (see p.p 173-174 above). The questions concerning how the failure occurs and how the habilitation takes place in the perceptual system, though, have to stand unanswered.

But the significant results concerning increased perceptual speed (and achieved sight function among the majority of the subjects) seem to suggest that through tachistoscope training the sensory apparatus (visual or tactile) becomes more accessible for receiving information and mediating it to the brain (see the supposition above).

But the experiment on cross-modal transfer of learning (Hunstad 1985c) showed that in special cases the achieved accessibility in the sensory system was not good enough. There may also occur failure in the coordination between conscious cognitive processes and unconscious automatized sensory processes (see p. 173 above). In the experiments on cross-modal transfer of learning (Hunstad 1985c; 1988) the present author for almost a year failed to manage to verify that the 3 subjects who took part in the preliminary test of the experiment, really could see (the des- * 10 subjects with light perception and 4 subjects with light projection did not manage sight function and therefore reading function neither Hunstad 1988 p. 83.)) cription of the preliminary test has not been published previously):

These 3 subjects with visual acuity = light projection 6 metres previously had not been able to comprehend form visually, but had the ability for reliable and quick tactile identification of form-
matching of geometrical figures and normal script capital letters produced in relief. When subsequently the same geometrical figures and capital letters were presented to them under optimized sight conditions (e.g. strongly magnified) on the CCTV monitor, they showed through their body-language that they understood the forms of the figures and the letters. This could be observed by the fact that they made head movements that followed the form of the figures and letters. Despite the large number of times when they were asked what they saw, or were asked: "do you see anything then?" (not a leading question), it was not possible for them to say (verbalize) what it was that though their body-language they so clearly expressed that they saw. Just before the present author was ready to give up the whole experiment (in that he could not accept the body-language answers as verification that they could see) a colleague asked what was the kind of learning that was best internalized among the blind. This question made it clear that in this connection the author "had not seen the wood for the trees". If there is anything that is well-internalized (practiced) among the adult blind, it has to be their own written language (braille) that they read every day.

Consequently the subjects in the preliminary test were presented with visual (enlarged) braille on the monitor. To the same question as before (What do you see now?) they replied verbally and spontaneously, visually identifying one letter after the other the whole of the braille alphabet correctly. Without the subjects being prepared for it, suddenly the same geometrical figures and letters in normal script that they previously could not verbalize that they saw, were now presented between the visual braille characters. Now they could suddenly verbally (and spontaneously) both discriminate and match the geometrical figures and capital letters of normal script, visually.

But when they were presented with the lower case letters of normal script (which they had not learned through the tactile modality), they did not know what they saw, and they gave verbal expression of that fact.

Besides the points that this preliminary test: 1. gave the first indications of cross-modal transfer of learning from the tactile to the visual modality, and 2. verified that persons with light projection can see and comprehend form visually, the pattern of developments within the experiment showed too that;

The subjects did not understand, at once, that the sense of sight could mediate information.

Only when a visual stimulus was presented (braille letters) that could be associated with previously practiced and automatized tactile comprehension of form, was the visual information both accessible to, and made conscious by, the subjects. The experiment thereby seems further to confirm the hypothesis that:

A failure or slowness in the coordination between unconscious, sensoric processes of modality-factors of lower order and conscious cognitive processes of modality-factors of higher order, can be habilitated through special over-learn-
As an introductory way of getting the subjects to understand that the sense of sight can mediate information, the method using visualized braille was later used in experiments with congenitally blind subjects with light-projection (Hunstad 1985c, pp. 34-35: Hunstad 1988, pp. 83-84).

The consequences seem to be that

Through tachistoscope training accessibility and thus increased automatized identification speed and reading speed can be established. But a precondition, however, is that the relevant stimuli and language symbols are meaningfully internalized (practiced) at the cognitive level.

Let us then, finally, consider what are the educational consequences that conclusion nr. 2 (pp. 169-170 above) may lead to for groups having reading difficulties that we have not previously discussed.

Concerning lengths of tactile persistence we know of no investigations in which they have been measured. Even if internal difference between iconic and tactile persistence (e.g. different lengths) should become manifest, it is reasonable to suppose that in reading occurs an approximately synonymous perception-processing from the registration of stimuli to the coding in the lexicon for the two modalities.

Since now with the help of data-steered reading lists in braille it is possible to give braille readers the same training as the sighted receive with high-frequency words, the method for the sighted can, in principle, be used for the blind (“touch”-tachistoscope training).

In the present authors own investigations (Hunstad 1985c; Hunstad 1988, pp. 55-58) cross-modal transfer of learning from tactile to visual modality was shown. A similar cross-modal transfer of learning has been shown subsequently through a larger-scale investigation (N = 254), but here with three-dimensional figures as stimuli and with fully sighted children (3-8 years of age) as subjects:

"Bidirectional cross-modal transfer of learning was found, supporting the suggestion that such transfer occurs when training and transfer oddity tasks share a common dimension" (Krekling, Tellevik and Nordvik 1989).

A characteristic feature of cross-modal transfer in the present author's own investigations was that the visual modality gave low identification speed and reading speed at the start. Speed, here defined as the expenditure of time in the intake and mediation of information from the visual sensory modality to the cognitive registering and processing, showed itself to be a critical variable. Even if the experiment of Krekling, Tellevik and Nordvik (1989) is not directly comparable with the present author's experiments on cross-modal transfer of learning, because in that experiment demands were not made upon speed nor was reading-performance included, the demonstration of bidirectional transfer of learning leads to the questions whether there are different abilities and/or dissimilar kinds of development in the two different modalities (see problem 3 p. 112). The answers to these two questions may be decisive for the choice of methods for reading-learning for persons with reading difficulties and/or persons with handicaps of sensoric function. That the dissimilar modalities to a certain extent give rise to different abilities seems to be documented in the theoretical basis for the deployment of psycholinguistic tests, e.g. the Illinois Test of Psycholinguistic Abilities.
(Gjessing and Nygaard «MDRV» et al. «MDNM» 1975). In the function-profile for the ITPA test, in one and the same person it is precisely functional differences between the different modalities at the automatic and the representative level that often appear. On the other hand the experiment of Krekling, Tellevik and Nordvik (1989) showed a qualitative, equal and bidirectional cross-modal transfer of learning for the variables; form, texture and weight. This is in partial agreement with the present author’s findings in which form, spatial orientation, syntax and semantics gave cross-modal transfer of learning from the tactile to the visual modality, while speed did not give cross-modal transfer (see pp. 170-171 above). Additionally the results of Krekling, Tellevik and Nordvik (1989) showed that "The growth in visual performance, however, began earlier than tactile" (p. 95). In their discussion this was interpreted thus:

"This could mean that visual processing is more effective for encoding relational stimulus properties. Thus, vision might be superior in perceptual tasks requiring the subject to attend to relational or amodal stimulus properties compared to the somatosensory system" (Krekling, Tellevik and Nordvik 1989, p. 95).

This interpretation of the effectiveness and development of the tactile modality agrees with ordinary observations from the first stages of teaching braille. Even if exceptions may be found, the great majority of beginners at the age of 7 show an almost incredibly low reading speed and an equally incredible low progression through the years in the development of reading speed (Hunstad 1985a, pp. 1-2). With speed defined as an amodal variable that does not give cross-modal transfer of learning from tactile to visual modality (see pp. 170-171 above), and notwithstanding that in development and effectiveness in the low-age range the visual modality is superior to the tactile modality (Krekling, Tellevik and Nordvik 1989), it nevertheless seems hardly reasonable to expect cross-modal transfer of learning from the visual to the tactile modality. This last postulate, in turn, agrees with the results of experience in teaching newly blind adults, where the teaching of speed proceeds at least as slowly as among the 7-year old beginners in braille, despite the fact that the adults had been very quick visual readers. It is also a common view that the tactile sense is not well-developed among sighted children, since the visual sense, with its superior effectiveness, is preferred. And touching goes against certain rules and conventions concerning what is allowed to touch ("just look, but do not touch"). Touching is considered, too, often as a breach of sexual norms. The educational consequences thus seem to be that:

The majority of newly-blind adults who are to learn braille, just as the congenitally blind, have the need for special over-learning and automation of identification speed and reading speed if they are to become accomplished readers of braille.

For the deaf-blind with residual vision (in any case with visual acuity down to fingertelling ad oculum), and with abilities good enough to acquire the deaf-blinds' sign-language, it should be possible to attain visual reading-performance through combining identification-training by datatachistoscope with ordinary reading-training under optimized sight-conditions using CCTV.

For the deaf-blind without residual vision it seems that now (with the reservation that they have the required abilities and can acquire the deaf-blinds' sign-language) it is possible to increase the effectiveness of braille reading by using the "touch"-tachistoscope method with data-steered reading lists.
Main conclusions.

If some of the present author's publications (Hunstad and Hagtvet 1989; Hunstad 1985a; 1985d; 1988; 1989b) are considered collectively as a whole, it is now possible to show that increased identification speed of high-frequency words, through the establishment of accessibility and of automation at the sensory and/or cognitive level, will lead to increased reading speed and thus also to improved reading-performance in continuous text.

The following main conclusions seem then to be relevant:

1. Through experimentally tested equalized reading-tests, reading speed can be measured more reliably than with previous methods.

2. With visual braille as the initializing medium, the congenitally practically blind with light projection => 2 metres can attain spontaneous sight function through the use of electronoptics. The sight function is interpreted as a consequence of cross-modal transfer of learning from the tactile to the visual modality. The sight function includes identification of geometrical figures and whole words, as well as slow but secure reading of continuous text in ordinary script. The identification speed and reading speed can be increased through training with the tachistoscope/"touch"-tachistoscope for visual ordinary script and for tactile braille.

3. Those with acquired practical blindness /light projection => 2 metres can attain sight-function through the use of electronoptics with slow but secure identification speed and reading speed. The sight function is attained spontaneously as a consequence of earlier visual learning, but the speed, most likely, has to be trained anew.

4. Those with visual acuity 1/400 - 1/60 (congenital or acquired blindness) can be taught to/attain secure reading of visual ordinary script by the use of electronoptics. Reading speed can be increased through training with the tachistoscope and seems to provide good ordinary usefulness in reading-performance.

5. Good identification speed of high-frequency words seems to be a general critical variable. Both for the visually handicapped and for dyslectics (with reservations concerning exceptions of special handicaps), this critical variable in principle seems to be independent of the different kinds of reading problems and sensory dysfunctions for the attainment of good reading speed in continuous text by the use of the tachistoscope/"touch"-tachistoscope-method.

Despite the obvious need for further research, it seems that, as they are formulated in this publication, the educational consequences and the main conclusions are mutually consistent.
* (Only in Norwegian, Swedish, Danish or German, otherwise in English).


Fraiberg, S. 1977. *Insights from the Blind.* Souvenir Press (E & A) LTD.


*Hunstad, E., Selnes, O.M. 1980. Visuell Contra taktile opplæring i lesning av


