Using Computers in the diagnosis and remediation of developmental dyslexia

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ABSTRACT
The paper tries to answer the following questions:  
- Is it possible to use the computer both in dyslexia diagnosis and remediation?  
- What are the potentialities and peculiarities of computers in this field when compared with other tools?  
- Which are presently the best strategies and methods for computer-aided diagnosis and remediation of dyslexia?  
The paper also illustrates a joint research project of the Institute for Educational Technology (ITD CNR) and the Public Health Service Unit no.12 of Genoa (USL 12) focusing the attention on the computer programs produced by the research team.

THE RESEARCH PROJECT: AN OVERVIEW
The Institute for Educational Technology (ITD) of the Italian National Research Council (CNR) is presently involved in a research project concerning the computer-aided diagnosis and treatment of developmental dyslexia. It is a joint project of CNR and USL (Public Health Service Unit) no.12 of Genoa.

Aims
The main aims of the project are as follows:  
- to verify whether and how the computer can be used both in dyslexia diagnosis and remediation;  
- to study and evaluate the potentialities and peculiarities of computers in this field when compared with other tools;  
- to develop strategies and methods for computer-aided diagnosis and remediation and to set up dedicated computer tools; and  
- to create a database of all the available information on software products concerning developmental dyslexia.

Theoretical models
The reading process is characterized by two main aspects:  
1) encoding and  
2) comprehension;  
The research focuses on encoding problems and impairments.  
The research team adopted the theoretical model that Sartori defined as standard (1984). This model (shown in Figure 1) is based on the distinction between the visual lexical route and the phonological route of reading words.
According to this model there are two different approaches to word reading: 1) the visual lexical decoding and 2) the phonological recoding.

Using the lexical modality based on the recognition of the words as a whole orthographic structure, it is possible to process correctly known words only (i.e. both regular and irregular words whose visual "logogen" is stored in the input orthographic lexicon). This route, instead, prevents the correct reading of unknown words. The phonological route is based on the phoneme-to-grapheme conversion; the reader can process both unknown words and non-words but they cannot read successfully irregular words whose incorrect pronunciation is based on a whole lexical access to the stimulus.

As the specific objective of the research is the treatment of developmental dyslexia, the mentioned theoretical model was integrated with the three-stages model of spelling proposed by Frith (1985) in order to interpret the acquisition of reading and writing abilities in the developmental stage. The model is based on the functional distinction between three stages in the spelling process: logographic, alphabetic and orthographic.

Logographic skills refer to knowledge and the use of individual phonemes and graphemes and their correspondences, orthographic skills refer to the instant analysis of words as orthographic units without phonological conversion.

On the basis of these models the group designed the diagnostic tests and the remedial exercises; for the latter ones the aim was to improve the deficient function.
Population and work phases
The research involved a group of about 300 primary and secondary pupils (8-13 years old).
The research work consisted of two phases:

- a diagnostic phase concerning the building and administration of diagnostic tests consistent with the theoretical interpretive models, their correction and evaluation;
- a remedial phase concerning the building of exercises (directed to each deficient function), the definition and the organization of remedial activities and the analysis and evaluation of results.

The role of computers
To date, computers have not been used in the diagnostic phase. They have been mainly a tool for the analysis and evaluation of test results; diagnosis has been made with paper and pencil tests. A test is now being designed which will take advantage of the potentialities of computers regarding the organizational pattern, presentation form, statistical analysis and processing of data.

On the other hand, the remedial phase was completely computer-aided. After making a diagnosis for each subject and for each functional impairment, remedial training was completely put over to the computers; the computers managed the repetitive training phases which are of major importance in the treatment of this kind of handicap. As to recovery, both special purpose interactive educational software and common editing or graphic programs have been used.

In short, we can assert that in our experience the use of computers for diagnostic purposes needs further study while their use in remediation has proved successful.

HOW SHOULD COMPUTERS BE USED?
Computer programs cannot be considered as a magic tool either for diagnostic purposes or for remedial purposes, but they can play an important role in such fields when they are well structured and properly used.

Appropriate tools for specific impairments
In order to make the use of computers really fruitful, suitable computer tools should be selected in order to identify and treat specific impairments. Reading and writing problems often have different symptoms and causes, therefore both diagnostic and remedial tools must be oriented towards identifying the specificity of phenomena. Diagnostic tools should not generically enhance reading and writing problems; on the contrary, they should point out the particular kind of impairment involved (for instance impairment in the use of the visual route or of the phonological route, or unexpected stops at one of the stages of acquisition of spelling abilities, etc.). Remedial tools too should not be oriented to generalized impairments in spelling but should aim at treating specific deficiencies and impairments.

A complete panorama of the available material is useful:
to make a good choice among existing products; and
• to create new suitable tools, when they are not available, on the basis of the theoretical interpretative models and of the hardware potentialities.

The Software Library (BSD) at the ITD is presently collecting, storing and evaluating the best Italian and foreign software devoted to reading and writing disabilities that is available on the market.

As to the differential diagnosis of reading and writing problems, very few computer tools so far exist; however, a lot of specific material is available for their treatment.

A few computer-tools as a proposal

In the early phases of our research, ready-to-use Italian and foreign interactive programs, adapted to our scopes and theoretical assumptions, were used. Later on, a few remedial programs were designed and produced to meet particular needs. First of all, exercises using common graphic and word-processing programs were designed. Such exercises are divided into different series according to the specificity of the impairment to be treated. In the case of special purpose interactive programs, the computer is fully used and its potentialities are fully enlightened: it can administer exercises, accept and evaluate the answers and supply immediate feedback as well as a global statistical analysis of results.

In the case of text editing and graphic programs, computer potentialities are not fully used; these programs do not allow any qualitative or quantitative data analysis and besides they provide no immediate feedback on the correctness of answers. Nevertheless, these programs can be profitably used since they require the student's involvement both in autonomous writing and in symbol decoding; moreover they are easy to use and run on most types of computers.

Within our research, two remedial programs have been designed and produced to meet particular needs. The first program is related to the visual word-recognizing ability (TACHISTOSCOPIO) and the second one to letter recognition (LETTERE). The two programs run on an IBM PC or compatibles and can be used for both diagnosis and remediation purposes.

LETTERE is a program for letter recognition. It can be used to verify and drill the visual and phonological competence in word recognition; it can also be used for 'shape recognition' exercises.

The base exercise consists of the identification of one target-letter (either lower case or upper case) among a list of options shown simultaneously. See Figure 2
The program contains a few ready-to-use exercises but can allow one's own exercises to be created within guidelines. Not only does the program take into account all the results but it also supplies a quantitative analysis, distinguishing between different kinds of errors (substitutions and omissions).

TACHISTOSCOPIO is a program for the diagnosis and training of reading problems. As to the diagnosis, the program allows one to establish which of the two routes is being used, the visual-lexical route or the phonological one, and performs a qualitative and quantitative analysis of results (number and kind of errors). The remediation can be defined as a tool for the methodical training of the visual route of reading and of short-term memory. The basic exercise consists of a timed presentation of a word-stimulus (a single word or a short sentence) which the student must read correctly.

The program itself contains a few basic lists of Italian words chosen on the basis of their frequency, their image impact and their grammatical category, but it is also possible to input any self-made list of words. During the execution of the exercises changes are possible. They can concern:

- the time of the stimulus presentation (from 100 msecs to one second);
- the position of stimulus presentation (right, left, center);
- the character dimension (small, medium, large);
- the way of presignalling the stimulus (window, pointer on the first letter, unpresignalled stimulus); and
- the response modality (oral or written).

Lastly, the results analysis is automatically undertaken and displayed.

CONCLUSIONS: WHY SHOULD COMPUTERS BE USED?

Our work is still in progress but, on the basis of preliminary results, we can draw a few conclusions on the use of computers in this particular field. On the whole the computer proved extremely reliable for remediation. Of course, we do not mean that we should replace the recovery operator, but we think it is a useful tool to help, improve and vary the various remedial activities.
Advantages in comparison with traditional tools
When compared with traditional remedial tools (generally based on the constant presence of the operator dose to the impaired child) the use of computers offers many advantages:
- **resource saving**: the whole recovery process can be completely computer-managed and one operator can look after many children at the same time;
- **flexibility**: it is possible for a person other than the recovery operator (e.g. a parent) to assist the child while they perform the exercises;
- **homogeneity**: a fixed series of exercises are administered for the same type of impairment, following constant patterns;
- **motivation**: a higher level of subjects' motivation was almost always registered, often leading to an increase in the benefit gained. 'Playing' with a computer is amusing and thus learning is easier; exercises, though repetitive, can present varied graphical patterns as well as suitable feedback that can attract and involve the student; and
- **concrete and plastic experience with language**: computers let the pupils deal with lexical stimuli in a totally new and particular way that enables them to experiment with the 'physical features' of languages.

Moreover the use of computers also provides a higher degree of individualization of the remedial routes (i.e. during the remedial activities individualized routes can be selected) and also makes possible a complete evaluation of performance and results through various statistical analyses of data.

The computer is an indispensable tool
As regards a few particular aspects of reading and writing impairments, the computer should be considered an indispensable tool and not a complementary one. For instance, from a diagnostic point of view it is difficult to verify the integrity of the lexical decoding strategy with pencil-and-paper tests, while where a computer is used, flash exposition to different stimuli can provide reliable data in a short time. In the same way, a lot of specific remediation activities can be profitably designed and carried out only via computer (e.g. computer-managed presentation of stimuli to promote the use of the visual-lexical decoding route).

In the future, computers based on new, sound technologies will become even more reliable for the diagnosis and treatment of reading and writing problems. At present, most computers used in schools are 'dumb' while dyslexics could gain a lot of help from interacting with a 'speaking' machine capable of harmonizing graphical and acoustic outputs and supporting the mutual integration of the two different codes in children's minds.

REFERENCES


