Neuropsychological factors in the rehabilitation of developmental dyslexia

Lorusso, Maria Luisa

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The present series of studies focused on a number of important functional characteristics of Developmental Dyslexia, analysing deficits and peculiarities described in perception, attention, memory, and hemispheric integration. Their contribution to the reading deficit is investigated, as well as their involvement in improvement after intervention. The starting point is a review of a model of the origin of reading abilities and disabilities, of their subtyping and of intervention: Bakker's “Balance Model” of Dyslexia. The observations concerning improvement in reading and non-reading functions after treatment following the Balance Model guide the construction of a series of studies aimed at investigating the role of each factor in reading improvement, its relationship with other factors involved, and the deriving implications for the various aetiological theories of Dyslexia.

The main results and conclusions from the various chapters can be summarized as follows:

- **Chapter 2** offers an overview of Bakker’s “Balance Model”, ranging from the neuropsychological model of reading acquisition, to the classification system for dyslexia subtyping, and the rehabilitation program based on these premises. Bakker’s model is compared to other developmental models and classification systems. Crucial differences concern the role of the two hemispheres in the reading process, and the role of phonological processes in reading, which in the Balance Model are associated with visual-spatial analysis and P-type (RH) reading. Evidence is reviewed from various intervention studies based on Bakker’s model of Hemisphere-Specific Stimulation, showing substantially positive results, in spite of the heterogeneity that characterizes subjects, procedures and methods.

- **Chapter 3** compares the effects of Visual hemisphere-specific stimulation (VHSS) according to Bakker’s model, to those of a commonly used, reading-focused training (RT). VHSS proved to be more effective, particularly for improvement of reading accuracy, but also spelling abilities and more general abilities, such as verbal memory and phonemic awareness, although not directly targeted in the program, showed consistent improvement.
• **Chapter 4** analyses the contributions of hemispheric, attentional and processing speed factors to the effects of neuropsychological treatment of developmental dyslexia, through manipulation of various characteristics of Bakker’s VHSS (constant vs random lateral presentation vs central presentation, and rate of word presentation). Since these manipulations did not produce any relevant differences in reading improvement among treatment groups, it is hypothesized that some of the most relevant factors for improvement are to be found among the common variables involved in treatment for all groups, i.e. memory, automatization and strategic factors. A speculative explanation is given for the greater improvement found in spelling measures after treatment with random laterally or centrally presented stimuli, in terms of the higher degree of interhemispheric coordination and integration involved in these two experimental conditions.

• **Chapter 5** describes the characteristics of the distribution of visual processing resources across the visual field, in different dyslexia subtypes according to Bakker’s and Boder’s classifications. This distribution is studied by means of the FRF (form-resolving field), representing the rate of recognition of letters presented in the centre and in the periphery of the visual field. The FRFs of dyslexic children and poor readers show higher visual recognition rates of letters in the periphery to the right of fixation, as compared to normal readers. The absence of significant differences in the FRFs of the various subtypes of dyslexia suggests that this characteristic is general to dyslexic readers, and that it has to do with the organization of visual perception preceding the processes of stimulus analysis that distinguish the various subgroups. It is suggested that a progressive “narrowing” of the FRF on the right side characterizes normal readers, while dyslexic children would fail to learn how to mask irrelevant information.

• **Chapter 6** shows how VHSS treatment, as compared to Reading-focused Training (RT), also produced a significant increase in the ability to inhibit information in unattended location outside the attentional focus. Crucially, VHSS increased dyslexic children’s reading performance, and also accuracy in phonemic awareness tests. It is hypothesized that lack of a normal supra-modal spatial map in the posterior parietal cortex (PPC) would cause the attentional filtering functions to be disturbed, thus producing both visual and phonological perceptual deficits observed in dyslexia. Since VHSS produced improvement of both reading and the inhibition mechanism, it is
suggested that the inhibition mechanism of selective spatial attention could be one of the factors responsible for reading improvement.

- Chapter 7 concerns the effects of intervention with VHSS on the distribution of visual processing resources across the visual field, as measured by the FRF. The changes in the FRF were compared in two groups, one receiving standard lateral presentation of words, the other receiving the same stimuli in random lateral position. The children in the second group had their FRF widened on the left side at 12.5 deg. of eccentricity, while the first group (standard VHSS) narrowed their FRF at the same eccentricity and side. These differential effects could be explained by the existence of two distinct attentional mechanisms, one related to a retinocentric reference frame, the other to a stimulus-centered system. The results thus further support the view of a direct effect of Bakker's treatment of developmental dyslexia on spatial-attentional functions and visual processing.

- Chapter 8 contributes to the validation of Bakker's classification of dyslexia into P, L and M-types, showing that they differ with respect to the efficiency of callosal functions. A test of callosal transfer of tactile information was administered to normal readers and to the three subtypes of dyslexic children. All dyslexic children showed impaired performances especially in the crossed-localization condition (requiring callosal transfer). In this condition, L-types and M-types made a significantly larger number of errors, while there was no significant difference in performance between P-types and controls. These findings are discussed in terms of defective callosal transfer or deficient somatosensory representation in children with L- and M-type dyslexia.

- Chapter 9 provides a discussion of the various findings which leads to the following conclusions:
  a) deficits of various neuropsychological functions have been documented in the present studies, including verbal memory, phonemic awareness, attentional functions, distribution of perceptual resources across the visual field, and callosal functions.
  b) visual hemisphere-specific stimulation (VHSS) is more effective than reading-focused training (RT), both in the improvement of reading and in the improvement of verbal memory, phonemic awareness, and attentional inhibition processes (also detectable in changes of the FRF).
  c) the correlations found between improvements in the various nonreading functions and reading and spelling measures suggest that the functions that were previously shown to be deficient in dyslexia also play a role in its remediation. Whether this should be seen as an
indication of their causal role in the aetiology of dyslexia, or whether they just take part in compensatory processes, is still not clear.

The implications of the results of the present studies with respect to some of the main aetiological theories of dyslexia (emphasizing the role of hemispheric, callosal, phonological, magnocellular, attentional, or cerebellar functions) are discussed. Considering the variety of functions involved, each of them lending support to one or more of the various aetiological theories of dyslexia, a multifactorial model appears to be the best explanation of developmental dyslexia.