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ABSTRACT

Sophisticated neurological research shows that early problems with auditory perception can result in long-range negative effects for the linguistic processes in general, and such long-range effects must be assumed to be correlated with induced degenerative changes in the auditory system and perhaps in the brain's linguistic sector. This research also shows that the reading disabled (RDs) have a significantly different perception of auditory stimuli than normal readers and that dichotic listening reveals these differences. Normal readers can be differentiated from RDs by using binaural audiometry to measure ear advantage. The 62 references assist in documenting that ear advantage is a poor indicator of hemisphere dominance for language, but that it may be a neglected factor in the diagnosis of dyslexia. (RS)

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FOREWORD

Children with auditory difficulties constitute a great problem for both psychologists and teachers.

This article is an attempt to direct attention towards the fact that hearing impairments - or merely "imbalanced hearing" - have far wider consequences than heretofore assumed.

Kjeld Johansen

SUMMARY

Sophisticated neurological research (brain mapping, regional blood flow, EEG, magnetic resonance, etc.) shows that reading disabled (RDs) have a significantly different perception of auditory stimuli. In addition, dichotic listening reveals the differences between normal readers and RDs in regard to auditory perception.

This article documents how binaural audiometry can help to differentiate normal readers from RDs by measuring ear advantage.

References assist in documenting that ear advantage is a poor indicator of hemisphere dominance for language, yet how it may be a neglected factor in the diagnosis of dyslexia.

Remedial therapy through specific auditory stimulation is recommended.

Various studies (EEG, SQUID, dichotic listening, binaural audiometry) seem to demonstrate that various sub-groups of poor readers primarily differ from normal readers over a range of functional characteristics related to auditory perception (latent period and the volume level for auditorily aroused potentials, ear advantage for verbal and various non-verbal auditory stimuli, varying threshold norms during monaural audiometry and characteristic advantages during binaural audiometry).
Furthermore, the majority of articulate children who later have literacy difficulties have been proven to have had distinctive hearing difficulties during their childhood.

The work of researchers occupied with the process of literacy acquisition most often reflects to a great degree the model they're searching for, be it cognitive, auditory, visual or other.
I, too, am liable to fall into the same trap and am well aware that others can perceive me as being rather one-eyed (one-eared would perhaps be better). However, if I fall, I will have done so deliberately (with my eyes wide open) since I feel that school psychologists and reading teachers do not sufficiently weigh the importance of hearing for the acquisition of literacy.

In the Danish educational discussion, the problems concerning the eventual implications of brain research for practical education are given little attention. Naturally, many good reasons for this attitude exist. One of them could be that the results of brain research are so apparently contradictory that drawing direct educational conclusions from them can seem difficult, if not impossible.

This article is an attempt to interest psychologists and others in close contact with the school system's remedial instruction for the question: to what extent is normal (optimal) hearing for a small child a necessary condition for the school child's acquisition of reading and spelling skills at a normal speed and at normal proportions?

ADVANTAGES AND LANGUAGE

Ever since R.W. Sperry (1970) during the mid 60's began publishing his observations and theories pertaining to cerebral asymmetry, laterality research has made great strides.
In the following, various aspects of this research, with special focus on relationships concerning hearing and language development, especially the acquisition of literacy, will be juxtaposed.

Through a range of studies, an attempt has been made to chart possible correlations for handedness, leg advantage, eye dominance, visual field advantage, ear advantage, ar special learning strategies which are thought to correlate with the cerebral dominance for language.

A common perception previously has been that the linguistic cerebral dominance relationships could be determined according to the research subject's ear advantage measured by various forms of dichotic listening. A primary right-ear advantage was (and is still by a number of scientists) considered to indicate a linguistic dominance of the left cerebral hemisphere.
This is, however, a simplification which is also responsible for blurring the picture of how the brain works with linguistic perception and production. (See also Teng, 1981).

The working of the human brain is divided into two parts. The two cerebral hemispheres process the incoming stimuli according to different principles, and structural relationships can be observed (at least in some areas) which seem to correlate with operational ones (Scheibel, 1984).

For the great majority of us, the sequential aspects of language are processed in the left cerebral hemisphere while other cues are processed in the right cerebral hemisphere. (Bradshaw & Nettleton, 1983).

Input entering by way of the right ear gives a stronger response in the left hemisphere and arrives before input entering by way of the left ear (Elberling, 1986). In the studies of the type I am familiar with, the subjects tested were exclusively normal, right-handed men whose language dominance has without a doubt been in the left hemisphere, the case for nearly 100% of all right-handed individuals and 70% of left-handed.

It must be presumed, therefore, that the function of the right ear is of particular importance for individual linguistic perception and production. This supposition will be substantiated in the following. If the supposition is correct, it is probable that specific and measurable "defects" in the hearing of the right ear can have a corresponding, negative effect on one's ability to acquire and process language.

NEURO-PSYCHOLOGICAL STUDIES CONCERNING ADVANTAGES

From the age of four, a normal, right-handed child demonstrates a linguistic right-ear advantage (Witelson, 1977; Woods, 1980).
Halperin, Nachshon and Carmon (1973) found that the right ear is best suited for the perception of complex melodies in which the number of tempo changes is important.
Robinson and Solomon (1974) had the same results when they

studied the perception of dichotic pairs of clear, rhythmic tones.
Natale (1977) found right-ear advantage during the perception of non-verbal, rhythmic sequences, especially for sequences of increased complexity, and especially for right-handed individuals.

As is intimated, the normally functioning, right-handed individual already possesses at a very early age an advantage for perception of language through the right ear. It has furthermore been demonstrated that this advantage is closely related to special auditory cues such as frequential complexity and tempo change, characteristics typical for consonants.

The individual's ear advantage is, however, partially a functional phenomenon which can be disturbed by the intensity of the sound, for example. Berlin (1977) found during experiments with verbal stimuli that at a general sound level of 80db, an increase of 15dB for the left ear meant the shift of the advantage to this ear. At 50 decibels, the level for the left ear only needed to be increased by 5 decibels in order to attain left ear advantage for synchronous signals.

Various studies show that the very acoustically complex consonants are primarily decoded in the left cerebral hemisphere. Vowels are longer in duration and acoustically simpler meaning that consonants are more vulnerable to disturbances and loss than vowels are, especially if the consonants are initially perceived in the wrong cerebral hemisphere (Bradshaw & Nettleton, 1983).

The frequently experienced linguistic dominance by the left cerebral hemisphere is probably not dependent on linguistic symbols or on the prevailing phonemic characteristics of language, but rather on the need for analytical, time-dependent and sequential decoding both in the receptive and especially the expressive side since the left cerebral hemisphere is characterized by precisely these methods of operation (Bradshaw & Nettleton, 1983).

Psychologists have often demonstrated that persons with seriously retarded reading ability obtain especially low scores on the WISC test in the code test, the number span test and the picture series test.
According to Bannatyne's dyslexia index for the WISC-test, these three sub-tests are called sequential in relation to the other two groups, the spatial and the conceptual. There are many school psychologists who, happening upon low sequential scores coupled together with normal conceptual and spatial scores, will as a rule make a note of "specific learning disabilities" and refer the student to remedial instruction according to the established educational guidelines.

SUPPRESSION

A great number of researchers have concerned themselves with the phenomenon whereby stimuli entering one ear (most often the right one) appears to simultaneously suppress stimuli entering the other ear, and that this phenomenon is the cause of a demonstrated ear advantage.
The studies are many and their conclusions are often contradictory. (Connolly, 1985; Geffen & Quinn, 1984; McKeever, Nolan, Diehl & Seitz, 1984).
A contributory cause of the widely varying results can naturally be different examination methods, but could also be due to the fact that each phoneme's concrete, physical components such as frequency, volume and length are given little consideration by the researchers.

These qualities are precisely the ones decoded by way of the auditory system's physiological construction (Pribram, 1979/-1987).
Therefore, advantage or dominance can, at first, very well be correlated to precisely these purely physical aspects. (Deutsch, 1983; Deutsch, 1986).

Nonetheless, each individual's level of attention also plays a role in auditory advantage. The purely cognitive qualities of experience and memory enter in as well. (Bever & Chiarello, 1974).

READING DISABLED (RDs)

What now differentiates RD students from the norm described previously?

For a long time now, dyslexia research has focused on lateral discrepancies as far as leg advantage, handedness, field of vision dominance and eye dominance are concerned. Quite a few studies have found that lateral differences seem to have some, but not definitive, importance in connection with reading and spelling difficulties.

Since ear advantage has been used to determine the supposed cerebral dominance for language (right-ear advantage corresponding to left-side language dominance), the picture has not been clear.
Not until the realization appears that ear advantage does not provide a stable picture of linguistic cerebral dominance does the situation begin to come into focus. (Teng, 1981).
Field-of-vision and ear advantages can actually change for an individual as functions of a forced or self-established work method (Bradshaw & Nettleton, 1983).

Zenhausern (1987) writes that for 85% of RD children, the auditory system in the left cerebral hemisphere is poorly functioning, and that these children have difficulty transforming words into sounds - grapheme to phoneme conversion. The remaining 15% have no difficulties with this conversion, but the sound of a word does not lead to its meaning.

My experiences demonstrate that a sizeable number of RD children have developed an ear advantage which is the opposite from their advantage for hand, foot and eye.

From a small pilot study carried out in April, 1988, I have found the following correlations between ear advantage and hand dominance for a group of RDs (28 boys and 12 girls between the ages of 9 and 23 years) and 40 students in two normal classes (aged 14):

Fig. 1:

	N=40 RDs	N=40 controls
LEA	15 (1, 13, 1)	3 (0, 3, 0)
XLEA	6 (1, 4, 1)	5 (1, 4, 0)
XEA	8 (2, 6, 0)	10 (0, 10, 0)
XREA	10 (2, 8, 0)	6 (1, 5, 0)
REA	1 (1, 0, 0)	16 (2, 12, 2)

LEA: Left ear advantage; XLEA: unsure, but primarily LEA; XEA: unsure ear advantage; XREA: unsure, but primarily REA; REA: right ear advantage. The figures in parentheses show handedness (L, R, A). See also Fig. 2.

NEUROLOGICAL STUDIES OF INDIVIDUALS WITH RETARDED READING ABILITY

Shucard, Cummins, Gay, Lairsmith & Welanko (1985) have, in a study of a homogenous group of dyslexic students (N=30), found the most significant divergence from a corresponding group of normal readers through measurement of the amplitude of auditorily aroused potential (EEG).
Duffy, too, (see Hughes, 1985) has had great success diagnosing dyslexia by measuring auditorily aroused potential. Dykman, Ackerman & Holcomb (1985) write, regarding corresponding EEG studies, that their greatest surprise was discovering that young individuals with retarded reading ability displayed much slower auditory latency than other youths.

These studies referred to here do indeed demonstrate that literacy difficulties can be revealed through measuring how the auditory stimuli is processed, and that measurable divergences in auditory perception are reliable indicators of reading and spelling problems. (Duffy says 95% reliable).

STUDIES OF EAR ADVANTAGE

Studies using different forms of dichotic listening seem to elucidate the point that some RDs, in contrast to normal readers, display wavering or predominant left ear advantage.
Hugdahl (1986) is of the opinion that what is involved is primarily a phenomenon of attentiveness: RDs are, to a lesser degree than normal readers, able to maintain their attention towards a specific ear.

The problem we are describing could well be, as Hugdahl maintains, an attentiveness problem, but other explanations also exist. Hugdahl gives no explanation of why the RD has a different "level of attention" toward binaural (dichotic) stimulation.

OWN STUDIES

A simple hearing examination, which can be carried out using a common audiometer, gives results which show RDs diverging from "the norm" in a way corresponding to the studies described above.

First, a careful, monaural audiometry is performed whereby hearing thresholds are meticulously determined at 5 dB intervals between 10 and 90 dB. The method used is the usual one.

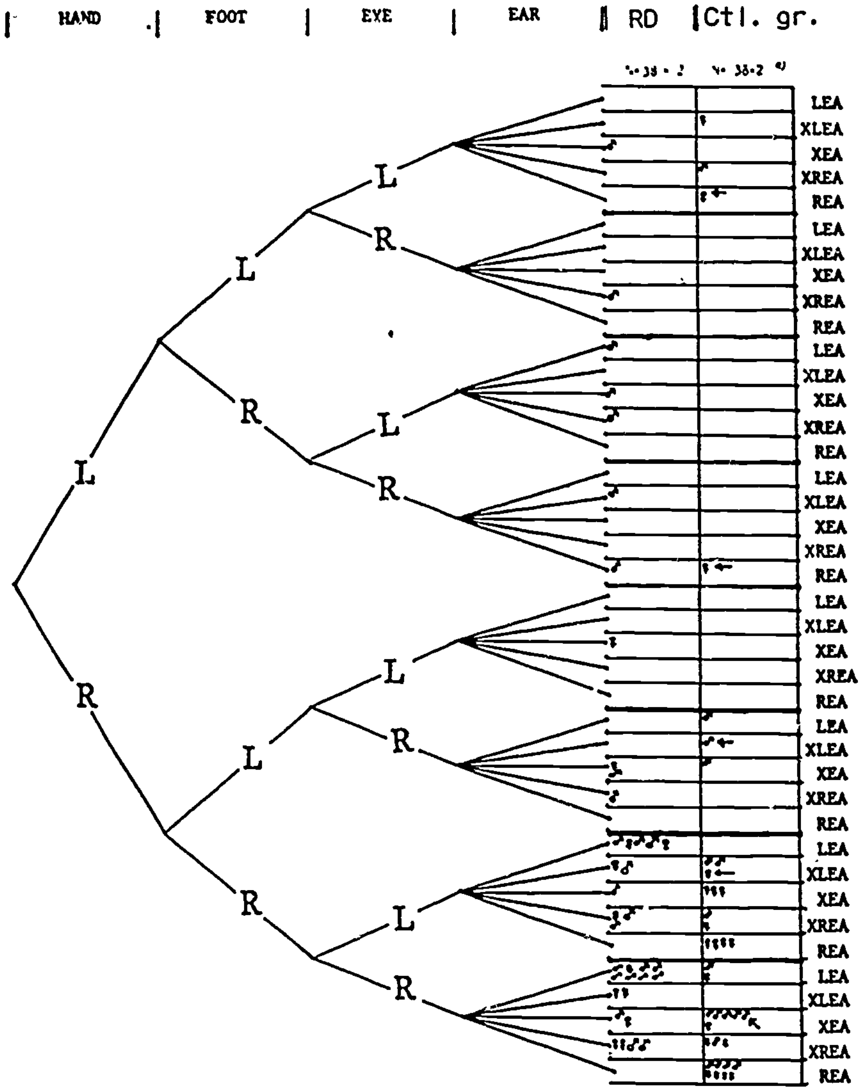
Next, two rounds of binaural audiometry are carried out. The first round, at 20 dB, registers only with which ear the subject thinks the sound is being heard (left, right or both).
In the second round, the binaural thresholds are found and once again the ear with which the subject thinks the sound is being heard is registered (left, right or both) (Johansen, 1987).

What is both interesting and important is that one finds various characteristic divergences from the "good" readers in the retarded reading ability group. For example, a very definite left ear advantage is evidenced whereas the "good" reader has a just as definite right ear advantage. Furthermore, RDs often have highly changeable thresholds and/or advantage shifts depending on the sound frequency and/or volume, a characteristic very rarely exhibited by good readers.

Studies of this kind reveal some exciting deviations for some left-handed subjects whose linguistic dominance appears to be right sided. A small group of left-handed dyslexic students show reactions during binaural audiometry which are laterally reversed in relation to right-handed dyslexic students.

At the same time, the deviations support rather than compromise the hypothesis concerning the importance of ear advantage for the ability to process language (Johansen, 1986).

PREFERENCES:



EAR-ADVANTAGE MEASURED BY BINAURAL AUDIOMETRY. Computations of scores. The binaural audiometry consists of 22 items: 11 different frequencies (125-8000 Hz) and 2 different volumes (20 dB and hearing threshold).

Percent indications to LEFT ear: 100 LEA 80 XLEA 60 XEA 40 XREA 20 REA 0

Two ambidextrals in the control gropu had clear REA and two ambidextrals in the RD group had LEA and XLEA. These four are not in the above table.

This form of "dichotic audiometry" supplements the information available from other forms of dichotic listening such as the SSW test, for example.

During monaural audiometry, it is most often the RD who has highly variable thresholds or whose left ear over a wide frequency range is 5 to 10 dB more sensitive than the right ear, which generally, but not always, turns out to be correlated to left ear advantage (during binaural audiometry) for the frequency range mentioned (cf. also Berlin, 1977).

It is not a case of an actual hearing impairment (thresholds of under 20 dB for both ears), but of what might be called "un-balanced stereophonic hearing".

The phenomenon can also be described as more of a qualitative than quantitative deviation from optimal hearing levels. This indicates that what is described is a sensorineural phenomenon (which entails a reduced ability to discriminate) and not a conductive hearing impairment. (See Greisen and Jepsen, 1986).

Consider the fact that a consonant has a frequency spectrum ranging from 250 to 4000 Hz, and remember that it is possible to measure how the ear advantage for a poor or fair reader shifts many times inside of this spectrum while the good reader exhibits a constant right ear advantage. Therefore, a larger study of this phenomenon, possibly using the SQUID technique (see Eberling), could presumably provide useful knowledge concerning possible causes for the linguistic difficulties of some children.

It seems essential to me for the evaluation of a child's linguistic (and literacy) development whether the left-sided ear advantage has arisen as a result of hearing impairment in the right ear during childhood or if it has been caused by injury or congenital predisposition. More about this in the following.

HEARING IMPAIRMENTS, LINGUISTIC DEVELOPMENT AND LITERACY

M.A. Dalby (1986) states that approximately 95% of articulate children (N=30) who later become dyslexic have had hearing problems during childhood while less than 15% of a comparable group of children (N=30 non-dyslexic) have had hearing problems. Unfortunately, a statement of handedness and . which ear had a hearing impairment is missing.

In my opinion, some answers must be sought in the interplay (or the lack thereof) between the various advantages used to process stimuli.

C.G. Watson (1975) has documented how double-sided, sensorineural

hearing impairment influences linguistic development, including vocabulary and literacy.
Children with hearing impairment, whether it applies to high frequencies or the entire range of frequencies, have retarded literacy development. Eleven-year olds with lesser hearing impairments for the entire frequency range are a whole three years behind.

In his article "Perceptual and Academic Deficits Related to Early Otitis Media" (Kavanagh, 1986) Peter W. Zinkus states that frequent disturbances in central auditory processing influence the development of reading, spelling and mathematical skills in spite of an average or more than average intelligence.

Webster and Webster (1977) emphasize that conductive hearing loss during growth periods which are important for brain development causes morphologic changes in certain neurons in the medulla oblongata's auditory system of laboratory rodents.
In other words, a long-range effect of conductive hearing impairment is neural degeneration.

Lewis (1976) came to the conclusion based on studies of children with chronic otitis media that both the ability for auditory discrimination and as well as for reading were poorly developed.

Sak and Ruben (1982) compared siblings with and without repeated bouts of otitis media occurring before their fourth year. The study showed that early otitis media means poorer verbal abilities, poorer auditory decoding and spelling problems.

Both Godfrey et al.(1981) and Sloan (1980) make the case that special difficulties with auditory processing early on results in reading difficulties later on.

Stillman (1980) is of the opinion that especially problems with the binaural hearing have this long-range effect.

Studies of the possible linguistic long-range effects of early hearing impairment occasionally demonstrate that such long-range effects apparently cannot be documented.
Leviton and Bellinger (1986) have made a critical review of a series of new studies (including a Danish one). Their conclusion is that only two out of five studies reviewed have been carried out in such a way as to allow a hypothesis correlating early hearing impairment with later language problems to be either supported or rejected.
The two studies fulfilling these requirements convincingly demonstrate the correlation of early and continual otitis media to impaired linguistic functioning later on.

In summing up, it can be ascertained that hearing impairments from the ages of 0 to 3 (such as those resulting from prolonged

or frequently repeated hearing impairment in connection with otitis media) have disabling effects for both auditory processing of language as well as reading and spelling.
However ear illnesses contracted at a later period do not seem to cause linguistic difficulties to the same degree.
Traditional monaural screening at 20 dB by the school nurse or doctor seems quite inadequate for an assessment of the extent to which the child's auditory functioning is of decisive influence for established reading difficulties.
I am specifically referring to the information provided by the Danish school health authorities on the recommendation forms for educational and psychological examination and counseling.

ATTEMPTS AT A NEUROLOGICAL EXPLANATION

In an unfinished manuscript, Norman Geschwind (1985) states:

> "As is well known, lesions of Wernicke's area in the posterior superior temporal region produce a disturbance of all modalities of language. Hence, it also appears rational to consider the possibility that this region might be at fault. One might ask why a congenital lesion in this region would lead to so much greater an impairment of written than spoken language. This is an interesting problem that I hope to address at another time, but will not deal with here."

(This was written during the weeks leading up to the fourth of November, 1984, the date on which Geschwind died, 58 years old.)

The Handbook of Clinical Audiology (J. Katz, ed., 1985) and other sources conclude that Geschwind was approaching the opinion that decoding of both auditory as well as visual linguistic stimuli takes place in the terminal area's marginal zone in Wermicke's area. Decoding of the sequential side of written language in the left hemisphere is in compliance with this hemisphere's special work method.
A (congenital) injury to this auditory perception area would thereby have consequences for the processing of sequential, visual linguistic stimuli as well.

Perhaps injuries acquired at an early age have the same consequences, too (my comment). In this light, it would be reasonable to assume that possible auditory problems in early phases of linguistic development have other and more significant consequences for the decoding of the phonetic than of the non-phonetic written language.
Or to put it another way: a European runs perhaps a greater risk of developing dyslexia caused by auditory problems than his/her Chinese or Japanese counterpart. Dyslexia is actually quite unknown in Japan and China.

This phenomenon could be made the object of research which could also include a charting of the respective differences between how the congenitally deaf acquire their written language in China and how they acquire it where the written language is phonetically based like ours is.

VARIOUS STUDIES AND THE INFLUENCES OF LITERACY STRATEGIES

Through various methods of examination, an attempt can be made to establish an individual's cerebral dominance for linguistic decoding, and, on this basis, either attempt to encourage a literacy strategy which builds upon the individual's strong sides or influence the student towards a changed (more appropriate) literacy strategy.

Two examples of examination methods meeting these requirements are Jack Katz's (1985) SSW test (published in Danish under the name SSO test) and Torben Møller-Sørensen's VISUAL HSP (Hemisphere Specific) test (1987).

Choosing a literacy strategy on the basis of the SSW test has been shown possible (Rasmussen, 1987). Hemisphere-specific training of reading in which an attempt is made to stimulate towards an appropriate literacy strategy has also shown itself useful (Møller-Sørensen, 1988).

Hemisphere-specific auditory stimulation in which the hearing of the right ear is intensively stimulated in the frequency range ascertained through binaural audiometry to have left ear advantage is perhaps a possibility also.

Lane (1981) describes, based on personal attempts with the ARROW material (Aural-Read-Respond-Oral-Written) involving auditory stimulation with the subject's own voice (feedback via a tape recorder), how such training increases the student's auditory attentiveness whereupon appreciable improvements in consonant discrimination and sentence understanding can be ascertained. (See also Lane, 1985).
A similar effect of feedback with one's own voice is described by Tomatis (Madaule, 1976; Manassi, 1982) who in apposition to Lane primarily stimulates the right ear in similar manner, but otherwise, to a great extent, uses sound stimulation corresponding to Joudry's (i.e. classical music frequency-filtered to fit the objective)(Joudry, 1984).
Torben Møller-Sørensen describes how visual stimulation (HSP literacy training) also shifts the auditory advantage.

Guy Berard (1982), Patricia Joudry (1984) describe how intensive auditory stimulation simultaneously shifts both the auditory and the visual advantage.

In addition, deaf persons have a much less stable right-sided visual advantage than is the case for the hearing population (Springer & Deutsch, 1981, pp.143-144). An account of a study is given made by Walter McKeever, et al. (1976) in which, by means of a tachistoscopic presentation of words and letters, field-of-vision advantage among congenitally deaf persons compared with normally hearing persons was studied. They found primarily right field-of-vision advantage in both groups, but by far clearest in the group that could hear.
They concluded that auditory experience is a primary factor in the lateralization of human visual linguistic processing.

All of these observations harmonically intertwine towards a statement concerning the integration of our senses and the possibilities for transverse stimulation.
There is good reason to seriously study these possibilities.

LITERACY THEORIES AND CEREBRAL DOMINANCE

Our knowledge about the function of hearing as a decisive factor in a child's development of literacy skills must have an influence on the choice of literacy theory.

Schreiber (1987) is of the opinion, based on a series of personal studies of children and adults, that children who are in the process of learning their mother tongue rely on their language's prosodic cues (rhythm, accentuation, and melody) when decoding syntactic elements. Therefore, correct decoding of this part of the spoken language plays a part in the later acquisition of the written language.

It is usually assumed that decoding of the prosody takes place primarily in the right hemisphere which, according to the aforementioned material, could appear to mean left ear advantage for this portion of the auditory linguistic stimuli. (See also Bever & Chiarello, 1974; Deutsch, 1983; Deutsch, 1986)

My own studies show that ear advantage during binaural audiometry for children at ages 8 and 9 is not significantly different from that of children at age 14.
A study of two normal classes in 1985 (N=35, average age: 8 years and 8 months) found 15 students with right ear advantage (REA), 6 with left ear advantage (LEA) and 14 without stable ear advantage (XEA). (Cf. earlier described study). Divided up into boys/-girls the figures looked like this: REA 10/5, LEA 3/3, XEA 6/8. Of the 3 left-handed boys among the students, only 1 had left ear advantage. None of the girls were left-handed.

According to Stanovich (1986), beginning readers rely primarily on phonological characteristics when single words need to be decoded.

Later, a shift is made to visual processes when frequently occurring words are recognized while decoding of infrequently occurring words continues to happen primarily on the basis of their phonological information.

Bruck (1988) concludes, after a comprehensive study of 17 dyslexics with an average age of 11 years and a control group of 17 normal students with an average age of 8 (the students in the two groups were matched according to their literacy levels), that the spelling errors of the students in the control group were spelled more phonologically correct than were the errors made by the dyslexic students.
She furthermore concludes that when dyslexic students read, they attempt to rely on the phonological characteristics to a great degree just as normal readers do, but are unable to do so to the same extent.

Many studies of children's reading development suggest agreement concerning three developmental phases, where the first phase includes general idea, global reading, analogous processing, right hemisphere strategy.

The second phase is alleged to be oriented towards sequential processing, digital analysis, left hemisphere strategy.

The third phase (the experienced reader) uses both strategies depending on the nature of the assignment. The reader skims with the right field of vision and decodes unknown or difficult letter combinations sequentially (left hemisphere strategy), simultaneously decoding these "strings of letters" in the left field of vision as whole gestalts or word pictures (right hemisphere strategy). Consequently, a collaboration of the unique work methods of both hemispheres occurs.

A fourth reading phase can also be imagined, "the super reader", in which the reading technique corresponds to a great degree to the technique from the first level. Entire word pictures or perhaps even entire pages are decoded as pictures. Quite clearly it is an example of a right-hemisphere technique first and foremost adapted to decode written language which does not to the same degree as Danish, for example, necessitate sequential processing.
Documented examples of Japanese children reading at very high speeds (70,000 to 100,000 Japanese characters a minute) have been reported. (Lacroix, 1987).
Normal reading development has a progression through the first three phases. This means that training in letter reading and focusing on the details of written language, for example, can perhaps be initiated too early in relation to the child's physiological development.
Perhaps this could also mean that a child who at the age of six primarily uses a sequential reading strategy has jumped over the

first phase and risks never being able to master the third phase satisfactorily.

My experience has shown that many RDs have temporarily come to a halt in the first phase and are unable to cope with the sequential processing of the second stage. Many of these children possess the very same previously mentioned audiograms. A hypothesis concerning a possible correlation could be established on this foundation.

If an 8-year old child of normal talents still uses a reading strategy in which the "gestalts" are most important and in which the sequential processing (spelling) cannot be achieved, then sequential processing must be trained since this technique must be mastered before the third phase can be reached.
In my opinion, using the literacy strategy chosen by the child as a starting point is not enough.
Naturally, the child will, in general, improve his or her reading level as a result of literacy training - but not to a sufficient degree.
If there aren't any congenital or acquired neural injuries (in the left hemisphere's temporal l .e, cf. Geschwind) then improvement through training can occur. Perhaps an improvement can even be reached in spite of neural deficiencies (Diamond, 1984).

In the meantime, traditional educational initiatives are inadequate. The stimulation needed to be utilized must be specifically aimed at the difficulties of the individual child, wherefore these difficulties must be precisely defined with one or more supplemental examinations or test methods. Whereupon the teaching must be supplemented with specific perception training.

The reading of alphabetic writing is a sequential decoding process which at the time of early literacy development designates a break with the childs natural and developmentally conditional image decoding. Consequently, sequential decoding becomes the new element in the literacy training and is therefore what should be trained. If one decides to build reading training upon the child's decoding of gestalts (word pictures), then perhaps one risks securing the child to a decoding strategy which could result in problems later on.

The abovementioned attempts to harmonize some of the theories concerning literacy development correspond rather well to theories formulated by Taylor & Taylor (1983), who call the various decoding strategies of the hemispheres, "left pathway" and "right pathway" processes.
While left pathway process such as orthographic, phonological and syntactic processing are exclusively thought to take place in the left hemisphere, Taylor and Taylor imagine that the right pathway processes encompassing gestalt decoding (called iconic

reading by some) can also take place, to a certain degree, in the left hemisphere.

Can the brain be made to function so that the unique work strategies of each half are utilized during reading?

Hemisphere-specific training of reading is one possibility, but another one is the processing of sequential, auditory input primarily induced through the right ear, otherwise known as hemisphere-specific auditory stimulation. Only a few school psychologists have firsthand knowledge of this method. Fewer have any practical experience with it.

FINAL COMMENTS

In my opinion, when working with the possible causes of reading problems, we must assess both the primary perception as well as the respective linguistic processes based upon this perception. In this article, I have attempted to point out that early problems with auditory perception can result in long-range negative effects for the linguistic processes in general, and that such long-range effects must be assumed to be correlated with induced degenerative changes in the auditory system and perhaps in the brain's linguistic sector. (See also Geschwind & Galaburda, 1984; Katz, 1985).

A special and precise form of audiometry which involves binaural measurements, among other things, shows characteristic differences in the hearing of good and poor readers.
I perceive this as an indication that optimal hearing during one's entire childhood and especially during the earliest years is a necessary, though insufficient, prerequisite for the establishment of normal linguistic processes.

Fjordbo and Rasmussen (1987) have collated five well-known researchers' view of the concept "visual dyslexia" and related their theories to more recent theories of reading acquisition. Fjordbo and Rasmussen conclude that the widespread disagreement among researchers concerning the observable consequences of "visual dyslexia" makes it doubtful whether any visual aspect whatsoever exists in the present complex of dyslexic problems, and that interest for the linguistic background of children about to learn literacy skills should be heightened.
Fjordbo and Rasmussen mention that genetic or educational relationships can also be causes, but that these are only vague ideas lacking any clear evidence to back them up.
In my opinion, auditory decoding difficulties are connected with all forms of dyslexia. Some dyslexic individuals have, in addition to and in connection with dyslexia, visual and/or spatial difficulties also.

The circumstance that less than 25% of congenitally deaf individuals reach a reading level higher than one corresponding to the third or fourth grade collated with the fact that congenitally blind individuals, who decode Braille with several fingers on their right hand together with only one finger from their left, can reach an appreciable reading level should also be included in the formulation of a widely encompassing literacy theory.

A lesser Danish study (Kristiansen, 1984) suggests that there are fewer RDs among right-handed Braille readers than there are among left-handed Braille readers.
Furthermore, it is evidenced that a larger reading field in the right hand (utilization of several fingers) results in the greatest increase in the reading speed. A good Braille reader actually appears to carry out both sequential and gestalt decoding by way of the right hand. (Cf. the theory concerning the third reading level and Taylor and Taylor's theories concerning "left and right pathway processes" referred to above).

Naturally, a child can develop reading and spelling problems from causes including difficulties with the implementation of higher mental processes (of a lexical or comprehensive nature) than the elementary perception of sound and sight impressions. (See Leegaard, 1987).

I have not wanted to enter into a discussion of indirect (phonological) or direct (non-phonological) access to the linguistic lexicon. Nevertheless, it appears to me that there isn't necessarily any discrepancy between the viewpoints I have presented and such a double-route theory. (See Humphreys & Lindsay, 1985; Humphreys & Lindsay, 1987).

To compare the differences in literacy strategies between students with both normal hearing and normal vision and students who have hearing impairments, or are congenitally deaf or blind, can possibly provide researchers of literacy or causes of dyslexia inspiration to revisions in certain areas of their theories.

Additional research in, for example, differences between the phonetic connection of written language collated with children's auditory difficulties and literacy difficulties possibly arising later on will be able to provide valuable information and contribute to exposure of the implicit hypotheses from this article.

Finally, we must not forget, in connection with research concerning the importance of hearing for language development, that hearing impairment can have other causes that otitis media. Among such causes are poisoning from certain types of antibiotics, crookedness in the neck and skull pressures.

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