The Effects of Early Middle Ear Disease on the Auditory Abilities of Third Grade Children

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ABSTRACT

Twenty-nine third grade children with functionally normal hearing who presented a history of symptoms consistent with middle ear disease before age three were tested with nine published measures of auditory abilities. As a group they performed less well than a control group of nineteen third grade children who had not presented such symptomatology. Intercorrelations among the measures revealed a profile of performance for the children with the positive histories that differed from that of the control subjects. When compared to the total third grade population, the group with a history of middle ear symptomatology demonstrated lower average scores on achievement tests and contributed in greater than expected proportion to the number of third grade children who were enrolled in supportive educational services.

The adverse effects of auditory deprivation resulting from sensorineural hearing loss in infancy and early childhood have been well documented (Myklebust, 1960; Luke, 1965; Johnson, 1962; Hine, 1970; Wollman, 1975). The literature clearly demonstrates that sustained and extensive restriction on auditory stimulation during critical developmental periods severely limits the acquisition of auditory and verbal skills. Katz (1978) recently reviewed some of the effects of conductive hearing loss on auditory function. He surveyed the evidence obtained from physiological and behavioral study of animals and humans presented with short and long term deprivation of visual or auditory stimuli. He concluded that monaural as well as binaural

reduction in sensory input, even that of relatively mild degree, can affect the structure and function of the auditory nervous system in such ways as to produce auditory perceptual and language development and learning problems in children. There have been a few investigations on the effects of early conductive hearing loss which can produce mild and episodic restrictions of auditory input. These studies indicate that children who have histories of significant conductive hearing loss may display speech and language delay (Holm and Kunze, 1969; Downs, 1976; Dalzell and Owrid, 1976), inferior auditory abilities (Lewis, 1976), reading retardation (Bond, 1935; Barton, 1967; Ling, 1972), learning disabilities (Jaffe, 1971; Katz and Illmer, 1972), emotional problems (Eisen, 1962) and intellectual retardation (Kaplan et al., 1973).

These reports of the serious consequences of early middle ear disease are especially significant in view of the numbers of children affected. Prevalence studies of early conductive hearing loss (Kessner et al., 1973; Downs, 1975) indicate that thirty percent of all children between the ages of six months and three years of age present evidence of middle ear disease, and at least half of this group sustain significant hearing loss secondary to the disease. Thus approximately fifteen percent of an elementary school population may have been subject to temporary or sustained auditory deprivation which could result in one or more of the broadly identified deficits mentioned above.

Most investigations of the effects of chronic conductive hearing loss in children have focused on language and academic skills as dependent variables. The interest in the language and academic skills of children with mild conductive hearing loss seems to have been based on the assumption that the observed deficiencies are not so much the result of impaired auditory functioning, but rather a reflection of the reduced or limited auditory information. Ling (1972) points out, however, that the educational retardation observed in many children with histories of conductive hearing loss may reflect subtle language difficulties as much as the simple inability to hear in the classroom. Unlike the child with a permanent sensorineural hearing loss whose academic functioning is adversely affected by both the cumulative effects of auditory deprivation and the limitations of the peripheral auditory system, the older child with an earlier history of fluctuating hearing sensitivity due to chronic conductive impairment may function with an effectively normal peripheral mechanism but with an impaired ability to appropriately or optimally utilize the received auditory information.

The results of recent studies clearly illustrate that children with histories of chronic middle ear disease and hearing impairment differ from their peers in verbal language and verbally related academic skills. However, most of the investigators selected subject samples from depressed or deprived environments. For example, Kaplan et al. (1973), studied the effects of middle ear disease on Eskimo children. Lewis (1976) worked with Austrailian aboriginal children who had histories of chronic otitis media. Other investigators selected subjects from clinic population. Most of the studies of the effects of middle ear disease in children reported results obtained from children who had documented hearing losses at the time of testing (Kaplan, 1973; Dalzell and Owrid, 1976; Lewis, 1976). Holm and Kunze (1969) reported that the hearing of their subjects "was not sufficiently depressed to affect the child's performance." Needleman (1977) did not report on the hearing status of her subjects. There has been little published research on the related but somewhat different questions of the effects of early middle ear disease on the auditory abilities of children in whom the disease (and threshold loss) has been resolved. While it is of interest to study the auditory functioning of children who have sustained mild hearing loss, in order to support the contention that the results of the research demonstrated the effects of early auditory deprivation it seems reasonable to suggest that the subjects must have had functionally normal hearing at the time of data collection.

The literature and research on the effects of temporary restrictions of sensory input on infrahuman organisms supports the hypothesis that children who have experienced fluctuations in auditory sensitivity may fail to develop normal auditory abilities. The studies which have investigated the effects of early conductive hearing loss in children are in essential agreement that children who have suffered recurrent episodes of auditory restriction differ in several dimensions from normal children. These studies, however, have been confined mainly to clinic and/or disadvantaged populations. The majority of the subjects in studies on effects of every middle ear disease have had active ear pathology at the time of data collection. The sensory deprivation literature and the literature on the development of auditory abilities strongly suggest that early auditory deprivation can result in the inferior use of the auditory channel which in turn may impede the acquisition of language and language related skills.

METHOD

The research was undertaken on the premise that chronic fluctuating conductive hearing loss in the early life of a child can

interfere with the optimal development of his auditory skills into later life. The study was designed to assess the auditory abilities of normally hearing elementary school age children who presented symptoms of chronic middle ear disease before age three and to determine the relationships of their auditory skills to their educational achievement and need for special services. In an effort to control for some of the potentially confounding variables, both experimental and control subjects were drawn from the third grade population of a representative suburban school system. At the time of data collection no child was known to evidence middle ear disease or other than functionally normal hearing sensitivity. Third grade children were selected as subjects for the study for three practical reasons. By age eight the incidence of active otitis media in the childhood population is lower than it is in the younger child. Third graders have been in the educational setting sufficiently long to accumulate a record of academic and test performance and for the needs for special services to have been determined. And, the performance ceiling for some of the test materials would be potentially reached with other children.

Subjects

The subjects in this study were selected on the basis of responses to a questionnaire which had been designed to identify children who had symptoms of middle ear disease before age three. The questionnaire had been validated with a group of parents of children who had confirmed middle ear disease before age three and with a group of parents of children who had not had symptoms of middle ear disease (Kessler, 1978). Questionnaires were mailed to the parents of 265 third grade children enrolled in the four elementary schools of a suburban community. The questionnaire data based on 140 returns were assessed via a computerized discriminant analysis procedure (Van de Geer, 1971) which yielded the two groups of subjects for the study.

The normal CONTROL group consisted of nineteen third grade children (eight females and eleven males) who had no reported history of middle ear disease. The age range was from eight years three months to nine years two months, with a mean age of eight years seven months. All of these children attended regular third grade classes and were of normal intelligence. On the basis of responses to a questionnaire item on parental occupation, socio-economic status was assigned a numerical ranking according to the **Socio-economic Index for Occupations in the Detailed Classification of the Bureau of Census**: 1950 (Oppenheim, 1966). The socio-economic range for this group was eight to ninety-three and yielded a mean of 55.68.

The EXPERIMENTAL group, that with a history of early middle ear disease, consisted of twenty-nine subjects whose questionnaire data indicated that they had presented observable symptoms of middle ear disease before age three. The age range was eight years two months to nine yars six months with a mean age of eight years nine months. All of this group of children attended regular classes and were of normal intelligence. The parental occupation socio-economic rankings ranged from eight to ninety-six with a mean of 60.65. The control and experimental groups of children were shown to be statistically equivalent in terms of age and average parental occupation status.

Each child in both the control and experimental groups were audiometrically screened immediately prior to testing to confirm the functional normality of peripheral hearing. The screening criterion was 20 dB HTL (ANSI-1969) for the octave frequencies 500 through 4000 Hz.

Test Materials and Administration Procedures

Auditory memory, selective auditory attention, auditory closure and sound blending were the specific auditory abilities of interest in this study. These test instruments were chosen according to the following criteria:

A. The test must have been standardized on a group of children which included a sample of children of the ages of the subjects in this study.
B. There must have been published normative, validity and reliability data.
C. The test must have offered a standard method of administration which was compatible with tape recorded presentation.
D. There must have been a standard scoring procedure.
E. The test must have been amenable to presentation in the school setting.

Nine standardized tests or subjects were chosen to assess the four specific auditory abilities:

Auditory Memory

DS: **Wechsler Preschool and Primary Scale of Intelligence** (Wechsler, 1967) Digit Span subtest.
SM: **Goldman-Fristoe-Woodcock Auditory Skills Test Battery** (Goldman, Fristoe, Woodcock, 1976) Memory of Sequence subtest.
RS: **Detroit Tests of Learning Aptitude** (Baker and Leland) Auditory Span for Related Syllables.
OD: Oral Directions subtest.

Selective Auditory Attention

FN: **Goldman-Ristoe-Woodcock Auditory Skills Test Battery** (Goldman, Fristoe and Woodcock, 1976) Selective auditory attention in Fan-like Noise subtest.

CN: Selective auditory attention in Cafeteria Noise subtest.

LN: Selective auditory attention in Linguistic Noise subtest.

Auditory Closure

AC: **Illinois Test of Psycholinguistic Abilities** (Kirk, McCarthy and Kirk, 1960) Auditory Closure subtest.

Sound Blending

SB: **Illinois Test of Psycholinguistic Abilities** (Kirk, McCarthy and Kirk, 1960) Sound Blending subtest.

The subtests of the **Goldman-Fristoe-Woodcock Auditory Skills Test Battery** were commercially available on cassette. To insure uniformity and to control test administration, the stimulus items for the remaining tests were recorded on cassette tape by a clear, general American female speaker. Through a loudness matching procedure using experienced adult listeners, the volume control on the playback recorder was set and marked to yield a uniform presentation level of 60dB HL through earphones for the speech stimulus materials.

Data Collection

The nine auditory tests were administered to the subjects on an individual basis. The stimuli were presented diotically to each child at the preselected level through circumaural earphones in a suitably quiet room. The presentation order of the tests was randomized to reduce possible effects of fatigue and practice. Instructions were given orally or as prescribed by the respective manuals. The subjects were socially reinforced at suitable intervals during the test sessions. Test responses were recorded during the test sessions and later scored in accordance with the instructions in the respective test manuals. The subjects were tested in one hour test sessions which included two short rest intervals.

Supplementing the test data collected in the auditory abilities assessment were the scores provided by the school on all third grade children on the Word Study Skills and Word Comprehension subtests of the **Stanford Achievement Tests**, primary level (Karlsen and Merwin, 1973). Data on the number of third graders who were receiving supportive services were supplied by the educational specialists in each of the four schools. These

specialists also indicated which subjects in the two research groups were enrolled in specific supportive services.

RESULTS

Auditory Abilities

The average scores and standard deviations for the control and experimental groups on each of the nine tests of the auditory abilities are shown in Table 1. The mean performance of the experimental group was inferior to that of the control group on eight of the nine measures of auditory performance. The results of t-tests derived by computer using the **Statistical Package for Social Sciences** (Nie et al., 1975) revealed, however, that for only four of these tests, were the means sufficiently different and the variances sufficiently restricted to yield significance at the preselected 95 percent confidence level. Significant differences in the performance between groups were observed on the digit span subtest of the **Wechsler Preschool and Primary Scale of Intelligence** (PS), the auditory memory for related syllables subtest of the **Detroit Tests of Learning Aptitude** (RS), the fan-like noise subtest of the **Goldman-Fistoe-Woodcock Auditory Skills Test Battery** (FN), and the sound blending subtest of the **Illinois Test of**

TABLE 1

T-TESTS ON TESTS OF AUDITORY ABILITIES

TEST	CONTROL MEAN	CONTROL S.D.	EXPERIMENTAL MEAN	EXPERIMENTAL S.D.	T-VALUE	PROB.
Auditory Memory						
DS	11.73	3.05	9.89	2.87	2.12	0.020*
SM	32.21	20.18	34.69	27.66	-0.34	0.396
RS	19.74	5.24	6.93	3.06	2.09	0.021*
OD	23.16	12.96	12.48	7.19	1.64	0.054
Selective Attention						
FN	65.52	27.63	50.96	29.86	1.70	0.048*
CN	62.26	26.95	47.48	34.41	1.58	0.060
LN	70.11	26.89	62.21	31.87	0.89	0.188
Auditory Closure						
AC	39.47	4.36	37.86	6.16	0.99	0.164
Sound Blending						
SB	39.89	3.99	36.55	3.37	3.12	0.001*

* $\alpha<0.05$

Psycholinguistic Abilities (SB). Of the four auditory abilities which these tests were to have sampled; namely, auditory memory, selective auditory attention, auditory closure, and sound blending; significant test results were distributed among three. Facility for auditory memory was sampled by four subtests, out of which two were significant and one other approached significance. Selective auditory attention was sampled by the three noise subtests of the GFW, out of which one produced a significant result and a second approached a significant outcome. Auditory Closure and Sound Blending were sampled by only one subtest respectively, those identified by like name from the ITPA. A significant difference in average performance between the control and experimental subjects was shown in their abilities for sound blending, while no difference was shown in their average abilities for auditory closure.

Academic Achievement

Information on academic achievement as assessed by the Word Study Skills and Reading Comprehension subtests of the **Stanford Achievement Tests** was made available by the schools cooperating in the study. The t-test for the difference between a sample and population mean (Bruning and Kintz, 1968) revealed the differences between the experimental group and the total third grade population to be significant (a 0.05) on both measures.

Enrollment in Supportive Services

Information about third grade children in general and for the control and experimental groups in particular who were receiving supportive assistance in speech and language, remedial reading, and for learning disabilities were also provided by school personnel. Thirty-two percent of all third graders were receiving some kind of supportive service. For the control group of nineteen children, the percentage was 31 percent. Of the experimental group of twenty-nine children, 55 percent were receiving supportive services in one or more of these areas. This value was shown by the chi-square statistic (Snedecor and Cochran, 1973) to represent a significantly greater than average enrollment for these services among the group of children with the histories of early middle ear problems.

Other Results

For each group, Pearson product-moment correlation coefficients were obtained between each of the nine tests used to assess the four auditory abilities. These correlations as derived with the **Statistical Package for the Social Sciences** (Nie et al., 1975), are

shown in Table 2. The measures for control group data yielded four significant correlations more than for the date for the experimental group. Of the r_2 values accounting for at least 25 percent of the common variance, eight were demonstrated by the measures for the control group, while only two such values were demonstrated in the results for the experimental group.

TABLE 2

SUMMARY OF SIGNIFICANT CORRELATIONS AMONG TESTS OF AUDITORY ABILITIES

	DS		SM		RS		OD		FN		CN		LN		AC	
	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E
SM		.463														
RS	.536	.455		.382												
OD		.456		.453		.563										
FN																
CN					.501											
LN					.530						.532					
AC					.630		.494					.391	.490			
SB	.488				.815		.532				.481	.526				.627

Refer to text for test abbreviations. The r's for the control and experimental groups are designated by C and E, respectively. No entry indicates nonsignificant correlation. Underline denotes correlations for which r^2 accounted for at least 25 percent of the common variance.

The correlational relationships between the parental occupation socio-economic ranking and a child's performance on the nine measures of auditory ability were examined for the children in both subject groups. No significant relationships were shown for the control group data. Only one such correlation, that for auditory closure ($r = 0.367$), was significant in the data for the experimental group.

The data available for the children in the experimental group was subjected to additional t-tests to examine the significance of differences between those subjects who were and who were not enrolled in special educational services. The average parental occupation socio-economic ranking for those children enrolled in

supportive services was 47, while for those not receiving such extra assistance the average ranking of 70 was significantly higher ($a=0.009$). On the two measures of academic achievement, the performance of the non-special education group was superior to the group receiving supportive services. Only the difference in scores between these groups on the Word Study Skills subtest attained significance ($a=0.004$), however. On six of the nine measures of auditory skills administered to this group, the performance of those children receiving supportive services was inferior to that of those not in apparent need of such extra assistance.

The differences were statistically significant for the tests assessing selective auditory attention in cafeteria noise ($a=0.001$), auditory closure ($a=0.017$), and memory for oral directions ($a=0.046$).

DISCUSSION

The results of this study indicate that normal hearing third grade children who had a history of symptoms of middle ear disease beginning before age three obtained significantly inferior scores on four out of nine measures of auditory abilities, and were generally weaker on four more, when compared to an otherwise matched group of peers who did not present such a history. When compared to the total third grade population, the experimental group presenting the early history of middle ear disease had significantly poorer scores on tests of academic achievement and contributed in significantly greater than expected proportion to the enrollment in supportive education services.

The experimental group performed significantly poorer on tests which measured auditory sequential memory, selective auditory attention, sound blending (phonemic synthesis) and sequential auditory memory. In spite of the significant group differences on these measures, and the trend on some others towards lower levels of performance, the overall outcome for the group presenting a history of early middle ear disease did not suggest a general performance deficiency in all auditory abilities, but revealed a tendency towards poorer than average ability in some skills. Further analysis of the data suggests that the average performances overall do not yield a complete account of the differences between the groups in this study. Specifically, the correlation studies indicate stronger and more significant correlations between auditory abilities in the control group. These results suggest that while individual control group subjects tended to maintain a rather uniform level of performance across tests, the

early middle ear disease group of subjects displayed varied patterns and levels of performance. In fact, the data on individual subjects revealed several subjects in the experimental group who displayed marked deficits on only one or two measures.

While the control and experimental groups were clearly distinguished by their performance profiles, certain features of the auditory tests and their administration may have prevented further statistical deliniation of differences on these measures. The differences in performance may have been minimized by the selection for test purposes of reasonably isolated components of auditory function. For the most part, the auditory abilities tests selected used in the study measured individual auditory skills in isolation from the interactive influence of other adequate or inadequate abilities. The effects of a relatively severe deficit in one skill on overall auditory functioning may therefore not have been fully revealed. For example, a normal memory channel may be overloaded by the requirement to hold more than the normal informational capacity because of a limitation in the ability to attain auditory closure. The possibility is considered that the specific skills assessed in this study may not have been particularly sensitive to the complexity or subleties of auditory processing and therefore may have overestimated the auditory functioning of subjects who had specific processing deficits.

Secondly the data collection procedures were carried out in a manner which may have offered some advantage to the subjects who had auditory deficits. Children who have inferior auditory abilities seem to have the least difficulty in quiet one-to-one listening conditions, when auditory stimuli are simplified and instructions are clear. On the other hand, less than ideal listening conditions do not seem to as adversely effect the performance of children with normal auditory function as they do children having auditory problems. It is reasonable to speculate that the controlled conditions of the test environment, the one-to-one test administration and the structured instructions may have minimized the differences demonstrated in auditory functioning between the control and experimental groups in this study. As children with auditory processing deficiencies, like hearing-impaired children with peripheral deficits, acquire some facility with language they may develop strategies to compensate for their inefficient auditory abilities. These strategies may suffice when listening occurs under good environmental and otherwise favorable conditions, but they may be subject to breakdown when more difficult listening and communication demands are encountered.

Finally, the age range of the subjects selected for inclusion in the study may have influenced the results in such a way as to potentially obscure the disparity in auditory abilities between the groups. Research had demonstrated that the auditory abilities which were assessed in this study begin to plateau at about age eight. The plateau, of course, tends to restrict the scores at the high end of the scales and reduce the gaps between the higher and lower functioning subjects. In view of the fact that the control group outperformed the early middle ear disease group in all but one of the nine tests of auditory abilities, a ceiling effect may have accounted for the failure to demonstrate more statistical differences between the groups.

The literature on socio-economic background and the incidence of middle ear disease in children has pointed out an inverse relationship between these variables (Fay, et al., 1970; Kessner et al., 1973; Downs, 1975). In addition to the fact that there is apparently a greater prevalence of the disease among the lower socio-economic children, there is a view that the effects of the disease are more detrimental in children from impoverished backgrounds (Lewis, 1976). While the results of this study tend to support such a view, they are also consistent with the underlying assumption of research which asserts that the primary effects of early auditory deprivation would be relatively independent of other variables. With the exception of one small positive correlation, the results demonstrated no relationship between the auditory skills assessed in this study and socio-economic status. All children may be equally susceptible to the effects of auditory deprivation resulting from middle ear problems during the early important developmental and learning stages of their lives. On the other hand, the differences between the socio-economic status of the experimental subjects who were and who were not enrolled in special education services suggested that it is when such children have been reared in an impoverished environment that they are most likely to evidence the speech, language and academic incompetencies observed in school.

The effects of early auditory deprivation which were demonstrated in this study did not appear merely as a result of reduced perhipheral hearing sensitivity. The subjects were not selected from clinic populations but on the basis of parental recall of symptoms of middle earl disease which had occurred before age three. It should not be inferred on the basis of the results of this research that mild episodes of middle ear disease will necessarily have serious or prolonged detrimental consequences. It has been shown, however, that early middle ear disease can

result in auditory inefficiencies and that children who cannot for whatever reason effectively compensate for these inefficiencies may have difficulty in acquiring adequate language and academic skills.

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