# Long- term language abilities of subjects with hearing impairment trained by the written-oral language method

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**Original Article**

# Long- term language abilities of subjects with hearing impairment trained by the written-oral language method

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## Abstract

**Purpose:** Communication skills of children with hearing impairment commonly fall below that of normal- hearing children. This study examines the long-term effectiveness of training these subjects from infancy until entering primary school by the use of the written- oral language method (the Kanazawa method).
**Methods:** Language abilities of 30 subjects with hearing impairment who received language training with the written-oral language method were assessed after a varying number of years. Reading comprehension was measured just before subjects entered elementary school at age 6. Verbal intelligence quotient (VIQ) and performance intelligence quotient (PIQ) scores were determined using the Wechsler intelligence scales for the same subjects when their ages were between 9 and 39 years. Influence of PIQ scores, training initiation age, degree of hearing loss, and reading comprehension on VIQ was examined using multiple regression analysis.
**Results:** The correlation between three factors (PIQ scores, training initiation age, degree of hearing loss), and VIQ scores of subjects was not significant, whereas that between reading comprehension and VIQ scores was significant within the statistical analysis. Reading comprehension influenced subjects' language ability.
**Conclusion:** These findings suggest that training initiation age, degree of hearing loss, and high PIQ scores do not predict VIQ scores after the language training program and that developing reading comprehension by learning written language during infancy improves verbal language ability in people with hearing impairment trained by the written- oral language method.

## Key Words

Hearing Impairment, Language Abilities, Reading Comprehension, Long-Term, Follow up

## Introduction

Communication skills of children with hearing impairment lie along a continuum between children with hearing sensitivity within normal limits and children who have hearing impairment and are unable to communicate by oral language [1-3]. Even when the extent of hearing impairment is mild, speech and language scores may fall below that of normal-hearing children. In addition to having limited vocabulary knowledge, children with hearing impairment also lack knowledge of syntax [4].

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[5]. Generally, the acquisition of function words and interrogatives is especially difficult for people with hearing impairment [6・7・8]. Studies around the world have reported retardation of oral language ability by several years in children with hearing impairment [9・10・11]. Blank [12] and Furth [13] suggested that the delay in language development is closely associated with the loss of hearing. In addition, Hiskey [14・15] administered the Hiskey- Nebraska Test of learning aptitude, a nonverbal test, on both normal-hearing children and children with hearing impairment and found that the latter had worse scores. Thus, low language ability has been reported to be a characteristic of children with hearing loss [16]. In addition, children with hearing impairment have poor language ability not only in oral communication, but in reading comprehension and writing ability as well.

In Japan the term "stagnation of development at age 9" often has been used for children with hearing loss [17]. This term refers to the inability to understand abstract expressions, which is a necessary step in the language development process that occurs around age 9. The difficulty that children with hearing impairment face in learning to read and write appears to lie in the auditory nature of reading. Pre-reading children with normal hearing readily symbolize and internalize the experiences of infancy and early childhood in auditory form through aural-oral communication with their parents. Consequently, the early stages of training for children with hearing impairment must be reconsidered. The training method tested in the present study is a written-oral language method called the Kanazawa method [18]. This training method has been used for more than 30 years with children with hearing loss. The written-oral language method adds on to the conventional auditory- oral method in that it includes visual aspects such as written language early in training. Many people with hearing impairment have been reported to achieve equivalent language ability as normal-hearing people using the written-oral language method [19-25].

There have been many studies on the linguistic competence of children with hearing impairment [11・26・27]. For example, Myklebust [27] clarified differences in verbal and intellectual tasks between normal-hearing children and children with hearing impairment using the Wechsler Intelligence Scale for Children (WISC). Bragman also reported that normal Performance Intelligence Quotient (PIQ) can be achieved in children with hearing impairment, but there was no mention of a normal Verbal Intelligence Quotient (VIQ) [28] when the WISC-Revised (WISC-R) was used. Goetzinger and Rousey [26] reported normal PIQ scores (mean PIQ, 103.5) in adults with hearing loss, as measured by the Wechsler Adult Intelligence Scale (WAIS), although, again, VIQ scores were not mentioned. On the other hand, on the basis of the association between the PIQ score of the WISC- R and Wechsler Preschool and Primary Scale of Intelligence (WPPSI) and language tests, Watson et al [29] and Sarant et al [30] showed that children with hearing loss frequently show a normal PIQ and that there are strong relationships between PIQ score and language outcomes and between language skills and speech perception ability. Hashemi and Monshizadeh [2] showed that the VIQ score, as assessed via the WISC, was low in children with cochlear implants, which served to compensate for the loss of hearing, compared to children with hearing sensitivity within normal limits.

In Japan, Hasegawa [31] showed that children with mild and moderate sensory neural hearing loss had VIQ scores that were neither correlated with the PIQ score nor influenced by the level of hearing loss. However, VIQ scores were frequently below par when the mean hearing loss of was over 40dB. Sugiuchi et al. [32] reported that 41% of children with mild and moderate sensory neural hearing loss acquire a normal VIQ score (> 80).

Hirota [33] and Uchiyama et al. [34] evaluated the effectiveness of an early intervention program that used an auditory oral method on children with hearing impairment when they entered primary school. Using the WISC and WPPSI, Hirota [33] showed that 67% of subjects showed a higher VIQ score in comparison to the PIQ score. Similarly, Uchiyama et al. [34] reported that 69% of children with congenital hearing loss could acquire a VIQ score comparable to that in children with normal hearing and that, for children with hearing impairment to acquire a normal VIQ score, it is necessary to have a high PIQ score. They also reported that the development of language in children with hearing impairment is affected by various factors, including degree of hearing loss, intelligence (PIQ score), the age when training was initiated, and parents' education level and participation. In a retrospective study of 391 preschoolers with hearing impairment, Mori [35] reported that acquiring speech ability

(including VIQ score) beyond the chronological age level at 6 is critical to overcoming "stagnation of development at age 9." On the other hand, Kobayashi et al.[36], who used The New Diagnostic Reading Ability Test[37] on 30 children with hearing impairment who achieved high reading comprehension scores at school entry, found that these children maintained their high scores in higher grades. Hence, it is necessary to sufficiently develop the language abilities of these children during the preschool period to acquire long-term progress in language abilities.

While the Wechsler intelligence scales are generally used for assessing the linguistic competence of children with hearing impairment, long-term studies using the Wechsler intelligence scales have not been conducted.

This study aims to explore the relationship between VIQ score, PIQ score, age at which training commenced, degree of hearing loss, and reading comprehension before starting school in subjects with congenital hearing loss who have been trained by the written-oral language method from infancy, and who have reached the age of mother tongue acquisition. Further, this study aims to examine the influence of reading comprehension in infancy on the acquisition of verbal language (comprehension and expression) in people with hearing impairment.

## Methods

### 1. Subjects

Subjects included 30 subjects who were diagnosed with congenital hearing loss at the age of 0 to 4 years in the Department of Otorhinolaryngology of Kanazawa University. Selection criteria included being born with hearing impairment with no additional disability and having parents who agreed with our training method, parents with normal hearing. Subject's IQ and socioeconomic status were not part of selection considerations. Regarding prostheses, cochlear implants were used in four subjects and hearing aids in 26. There was no evidence of aggravation of hearing loss in any participant during the preschool period.

### 2. Study design

In infantile stage, children were given language training using the written-oral language method, which involved the presentation of auditory, written, and sign language at the institution while mothers continued the training at home. One of the authors taught the children's mothers sign and fingerspelling, which are based on spoken Japanese. Fingerspelling was used to teach function words. The program of written-oral language training consisted of teaching the children to understand sign,written, oral words and sentences and to express their needs by gesture, by selecting cards on which a words was written in Japanese characters〔Kanji (Chinese character) and/or Kana〕, and by speech. For almost infants, sign communication is the easiest communication mode. We transferred sign language to other communication modalities (written and oral language).[38]

Techniques for developing written and sign language and listening skills were demonstrated for the children's mothers once every 2 weeks. There was also a 2- hour group session for the mothers once every 2 weeks to go over what was being done at home. All children had been taught using the written- oral language method before enrollment in the mainstream education system at age 6. Later they visited our institution once or twice a year, and we checked their hearing level and evaluated their language abilities.

Participants were tested a number of years following their training (Table 1). All the tests they were able to answer by oral language.

Table 1. Number of years following the training program that participants were tested for our study

| Number of years | Number of participants |
|---|---|
| 3-5 years later | 9 |
| 6-10 years later | 11 |
| 11-15 years later | 6 |
| 16-20 years later | 2 |
| > 21 years | 2 |

### 3. Materials

We assessed subjects' language abilities via the WISC-III[39] or WAIS-III[40] depending on the age of subjects at the time of testing. The items were presented in a manner similar to that for people with normal hearing, which necessitates the use of spoken language and lip reading. A routine procedure was followed for each test. In cases when the subjects were unable to hear the questions, the examiner showed cards with the questions written on them while reading the questions aloud to prevent hearing mistakes. Cards with written questions were shown only during the reading of questions, and the duration of exposure was matched to the oral presentation of the question. However, for the test on digit span, participants

received information only through auditory stimulation and lip reading; the written form was not presented. Subjects were asked to answer orally, and all answers were recorded. If speech could not be understood due to poor articulation, subjects were asked to write down the unclear parts of their responses.

Progress in the reading comprehensions of the subjects was evaluated with The New Diagnostic Reading Ability Test [37], which is based on norms for hearing children. Reading comprehension was measured just before subjects entered elementary school at age 6, and the results (reading comprehension scores) was read from the subjects' medical records at that time. The New Diagnostic Reading Ability Test consists of four parts. In part 1, subjects read short paragraphs followed by a multiple-choice question. In part 2, subjects select the correct reading of Japanese kanji and kana characters from the options provided. Part 3 consists of two sections: section 1 measures reading comprehension of long paragraphs and section 2 requires subjects to identify the theme of those paragraphs. In part 4, the subjects' ability to identify the correct meaning of words is assessed. Reading comprehension scores were grouped according to the ranges recommended for the test (extremely low, <34; low, 35 to 44; normal, 45 to 54; high, 55 to 64; and extremely high, >65). The scores within the extremely high group were regarded to be in the first group and high scores as the second group. The third group corresponded to the reading comprehension of Year 1 primary school pupils and above.

**4. Ethical considerations**

Before conducting this study, approval from the Medical Ethical Committee of Kanazawa University was obtained (Approval number: 241). An explanation of the objectives and methods of this study was given to subjects if they were adults and to parents of subjects if they were children. Written and verbal consent was obtained from all participants. Written and verbal consent was obtained from all participants or their next of kin, caretakers, or guardians on their behalf.

**5. Statistical Analysis**

Pearson's correlation analysis was used to explore the relationship between VIQ score, PIQ score, and reading comprehension score. A multiple linear regression model was created with PIQ score, age at training initiation, degree of hearing loss, and reading comprehension score as independent variables and VIQ score as the dependent variable. The details were further examined in a stepwise method. JMP 6.3. (SAS Institute Inc., Cary, NC, USA) was used for statistical analysis. In all analyses, the statistical threshold was set at $p < .05$.

## Results

The age of subjects at the time of this study ranged from 9 to 39 years (median, 13.5 years). At the time of assessment, there were 12 primary school children, 7 junior high school student, 1 high school student, and 10 university students/graduates. The age at training initiation was< 1 year for 6 subjects (2 male and 4 female), 1 year to 1 year 11 months for 12 (7 male and 5 female), 2 years to 2 years 11 months for 9 (3 male and 6 female), 3 years to 3 years 11 months for 2 (both female), and 4 years to 4 years 11 months for 1 (female). The median age at training initiation was 21.0 months. The median age at training initiation according to the mean hearing level was 27 months for those with a hearing level < 90 dB and 14 months for those with a hearing level ≥ 90 dB. The median corrected hearing level for all subjects was 40 dB; the corrected hearing level was < 40 dB for 14 subjects, 40 to 70 dB for 14 subjects, and ≥ 70 dB for 2 subjects (Table 2).

Table 3 shows the results of reading ability tests done when subjects were 6 years old, before the start of formal schooling. The mean reading comprehension scores of the 30 subjects when they were 6 years old and had not started schooling was 53.86 (SD = 13.01), with a range

Table 2. Age and number of hearing- impaired children at training initiation

| | Hearing level | | Corrected hearing level | | | |
|---|---|---|---|---|---|---|
| Age at training initiation | < 90 dB | ≥ 90 dB | < 40 dB | 40 ≤ 70 < dB | ≥ 70 dB | Total |
| < 1 year | 1 | 5 | 2 | 3 | 1 | 6 |
| 1 year-1 year 11 months | 6 | 6 | 5 | 6 | 1 | 12 |
| 2 year-2 year 11 months | 7 | 2 | 4 | 5 | 0 | 9 |
| 3 year-3 year 11 months | 2 | 0 | 2 | 0 | 0 | 2 |
| 4 year-4 year 11 months | 1 | 0 | 1 | 0 | 0 | 1 |

Table 3. Reading comprehension level before the start of formal schooling classified by hearing levels

| | Reading comprehension level (deviation value range) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 (extremely low, below 34) | 2 (low, 35-44) | 3 (normal, 45-54) | 4 (high, 55-64) | 5 (extremely high, above 65) | | | | |
| hearing levels | | | | | | Total | Mean | Range | Std.deviation |
| 40-69 dB | 0 | 2 | 1 | 0 | 1 | 4 | 50.50 | 36-79 | 19.43 |
| 70-89 dB | 0 | 0 | 4 | 8 | 1 | 13 | 55.76 | 45-70 | 7.05 |
| ≥ 90 dB | 3 | 1 | 3 | 3 | 3 | 13 | 53.00 | 28-80 | 16.03 |
| Total | 3 | 3 | 8 | 11 | 5 | 30 | 53.86 | 28-80 | 13.01 |

from 28 to 80. The scores of 24 of 30 subjects (80.0%) fell in the third group and above, which meant that these subjects had a reading comprehension more advanced than their age (subjects were evaluated as being in Year 1 in primary schools because the test was carried out before the commencement of schooling).

Table 4. Results of VIQ, PIQ, FIQ (WISC- III or WAIS- III)

| IQ | VIQ | PIQ | FIQ |
|---|---|---|---|
| 120-129 | 2 | 6 | 2 |
| 110-119 | 4 | 10 | 7 |
| 90-109 | 12 | 12 | 16 |
| 80-89 | 6 | 2 | 3 |
| < 80 | 6 | 0 | 2 |
| Mean | 93.1 | 108.6 | 100.7 |
| Range | 54-124 | 87-129 | 71-122 |
| Std.deviation | 18.3 | 12.2 | 14.2 |

VIQ, verbal intelligence quotient; PIQ, performance intelligence quotient; FIQ, full scale intelligence quotient
IQ score: normal low: 80-89, normal medium: 90-109, normal high: 110-119

Table 4 shows the WISC-III or WAIS-III scores of subjects, which are split into VIQ, PIQ, and Full scale Intelligence Quotient (FIQ) components. Twenty- four of 30 subjects (80.0%) achieved a VIQ score ≥ 80. The mean PIQ score of these subjects was 108.6, and there was no difference between this and the PIQ score of all 30 subjects. There was no significant correlation between PIQ and VIQ scores ($r = 0.21$, $p = .259$, DF=29) (Figure 1). The correlation between reading comprehension score and PIQ score was not significant ($r = 0.12$, $p = .496$) (Figure 2). On the other hand, there was a significant correlation between reading comprehension score and VIQ score ($r = 0.73$) (Figure 3).

To examine which factors influenced the VIQ score, a multiple linear regression analysis was done using the forced entry approach with PIQ score, age at training initiation, degree of hearing loss, and reading comprehension score as independent variables (Tables

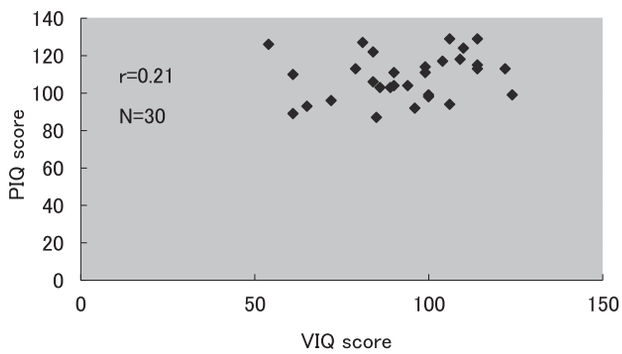


Figure 1. Relationship between verbal intelligence quotient (VIQ) score and performance intelligence quotient (PIQ) score

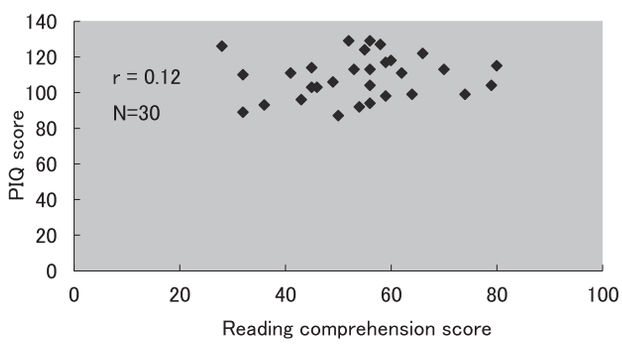


Figure 2. Relationship between reading comprehension scores and performance intelligence quotient (PIQ) scores

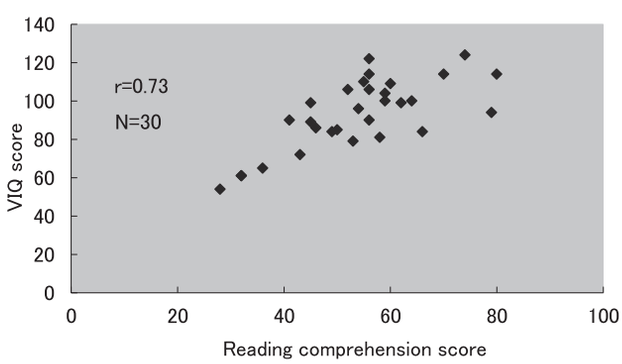


Figure 3. Relationship between reading comprehension scores and verbal intelligence quotient (VIQ) scores

Table 5. Relationship between VIQ score and PIQ score, age at training initiation, degree of hearing loss and reading comprehension score

| | β | Standard Error | t-value | p-value | VIF |
|---|---|---|---|---|---|
| PIQ score | 0.170 | 0.199 | 0.86 | 0.400 | 1.02 |
| Age at training initiation | - 0.168 | 0.221 | - 0.76 | 0.455 | 1.34 |
| Degree of hearing loss | - 0.0783 | 0.131 | - 0.60 | 0.555 | 1.31 |
| Reading comprehension score | 0.987 | 0.190 | 5.18 | < 0.0001 | 1.06 |

PIQ, performance intelligence quotient $R^2$ =0.570

Table 6. Result of Stepwise Multiple Regression for VIQ

| | β | Standard Error | t-value | p-value |
|---|---|---|---|---|
| Reading comprehension score | 1.04 | 0.18 | 5.79 | < 0.0001 |

$R^2$ =0.545

5 and 6) . Only reading comprehension score was significant, explaining 57% of the variance in VIQ score. There was no multicollinearity among independent variables according to the variance inflation factors. A second analysis using a stepwise approach was used to examine factors that would influence VIQ score, where the threshold of significance for variable addition or removal was set at $p<0.15$. Results showed that only reading comprehension was significant ($p<0.01$) and explained 54.5% of the variance in VIQ score, which was close to findings using the forced entry method. Thus, reading comrprehension score was the only factor that had a significant influence ($p <0.01$) on VIQ score.

## Discussion

This study examined the relationship between VIQ scores in 30 subjects with congenital hearing loss and results of PIQ scores, age at which training commenced, degree of hearing loss, and reading ability tests done at age 6 (before starting school) . Results showed a correlation between VIQ score and reading comprehension score but no significant correlation between VIQ score and other factors within the statistical analysis.

The age at which training commenced, degree of hearing loss, and PIQ score have been reported to influence the acquisition of language, and hence VIQ score, in children with hearing impairment [30・34・41-44] . Previous studies have also reported that the earlier the training starts, the higher the VIQ score of children with congenital hearing loss, that is, the longer the training period, the higher the score [34・41・42] . A recent hearing screening of newborn babies found that the probability of improving communication ability roughly triples [41] when training is commenced early (within 6 months of birth) . These findings suggest that the age at which training commences is an important factor that influences language acquisition. On the other hand, it has been shown that even if hearing impairment is identified early, a high VIQ score cannot be attained if the degree of hearing loss is severe [43] . In cases where the level of hearing impairment is mild or moderate, VIQ score and the duration of training were found to correlate positively if at least 4 years of continuous training were completed before starting school [44] .

Some findings suggest that the VIQ score positively correlates with the PIQ score and that inborn intelligence influences language acquisition after birth [30・34] . In contrast, other reports indicate that the VIQ score of children with hearing impairment is extremely low despite having a PIQ score within the normal range [2・11・26・27] . However, as we found in a previous study, 77% of subjects achieved a VIQ score>85 even when the PIQ score was within the normal range [45] .

The findings of this study differ from previous research in that language acquisition, as represented by VIQ score, was not influenced by PIQ score, age at which training commenced, or degree of hearing loss. It is noteworthy that the median age at which training commenced in this study was 21 months and that 90% of subjects had started training by the age of 2 years and 11 months. Hence, it is probable that the VIQ scores in this study were not influenced by the age at which training by the written-oral language method was initiated because all participants commenced training relatively early.

It has been pointed out that issues with verbal-linguistic intelligence of subjects with hearing impairment [6-8] include

both comprehension and expression in spoken language, as captured by VIQ score, as well as problems with written language. Agatsuma [46] reported that reading comprehension of Year 6 pupils in an elementary school of children with hearing impairment educated by lip reading did not go beyond that of Year 3 pupils with normal hearing. King and Quigley [10] showed that the level of sentence structure comprehension shown by 18-year-old subjects with hearing impairment was lower than that of 8-year-old subjects with normal hearing. In other words, subjects with hearing impairment fared poorer compared to people with normal hearing in terms of speaking and writing abilities.

The written-oral language method training program used in this study introduced visual aspects for infants, taking into account how written language can be used for language acquisition regardless of the degree of hearing loss. The introduction of written language within the training modality aids word learning by clarifying language comprehension and expression when communication via auditory and verbal channels is unclear. This is in contrast to children with normal hearing, who could switch with ease from spoken language comprehension to spoken language expression [47]. As a result, children who have acquired sufficient vocabulary and knowledge of sentence structure via the aid of written language can then correctly understand auditory information and express themselves verbally.

It has been reported that children with hearing impairment can understand written language from the age of 12 months and that they are able to acquire vocabulary appropriate to their age [22]. Acquisition of particles is important in Japanese syntax. It has been reported that even children with severe hearing impairment (≥ 100dB) can acquire particles between 18 to 30 months [18・23] and that those with hearing impairment ≥ 90dB are better at acquiring and maintaining reading comprehension compared to those with hearing impairment < 90dB [19].

Based on the results of the current study, it appears that if a high level of written language comprehension was demonstrated at the age of 6 before starting school, then the VIQ score, representing the ability to express oneself with spoken language, would also be high. In other words, written and spoken language share commonalities, and developing reading comprehension may lead to acquisition of spoken language comprehension and spoken language expression. For instance, adults with normal language abilities suffering from hemispheric damage that involve the linguistic components tend to have aphasia and show difficulties in both written and spoken language. This would affect all aspects of communication, including listening, speaking, reading, and writing. When focusing on the fact that written language and spoken language share the same linguistic components and that there is compatibility between them, developing comprehension by use of written language from infancy would also lead to acquisition of spoken language in the long term.

The findings reported here suggest that the reading comprehension score at age 6 was correlated with VIQ score after age 9. In addition, more than 80% of subjects performed better than the average population in both reading comprehension and VIQ score. Although it is conventionally reported that reading comprehension of children with hearing impairment is generally low, the current findings support our previous findings that children with hearing impairment can acquire written language comprehension [48・49]. Several studies have examined outcomes of training programs in which children with hearing impairment received aural-oral training. Kato [43] and Nakata [50] reported that 36.3% and 46.1% of children with hearing impairment, respectively, achieved VIQ scores ≥ 85, and Mori and Uchiyama et al. [34] reported that 38% and 69% of children with hearing impairment, respectively, achieved VIQ scores ≥ 80. In terms of long-term follow up of training methods for infants, Mori [35] found that the size of vocabulary acquired during infancy affected linguistic ability after schooling age, and Kato and Arao [51] reported that syntax comprehension and VIQ score at the start of schooling influenced the ability to construct sentences after children began schooling. These findings, however, were not conclusive.

Use of the auditory channel should be considered first in the language acquisition of children with hearing impairment. However, there are limitations in using the auditory channel alone that can be addressed with the use of sign and written language. For children with hearing impairment, written language conveys information more accurately than spoken language. The findings of this study support the introduction of written language at infancy to increase language acquisition in children with hearing impairment.

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# 文字 - 音声法による訓練を受けた聴覚障害者の言語能力の長期経過

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要　旨

聴覚障害児のコミュニケーション能力は、一般的に健聴児に比べ低いといわれている。本研究は、乳幼児期から文字言語を導入した文字 - 音声法（金沢方式）による言語訓練を就学まで受けた聴覚障害児・者の音声言語能力について、9 歳以降の言語成績を調査し、幼児期の文字言語理解力の長期的な音声言語理解力への影響について分析した。対象は幼児期に文字 - 音声法による訓練を受けた 9 歳から 39 歳の聴覚障害児・者 30 名である。対象の訓練開始年齢、平均聴力レベル、就学前 6 歳時点での読書力検査、及び就学以降のウェクスラー知能検査の言語性知能（VIQ）、動作性知能（PIQ）の成績を調査した。統計処理は、ピアソンの相関係数を用いウェクスラー知能検査で結果が得られた VIQ と PIQ、読書力検査で結果が得られた読書力偏差値との関係を調べた。VIQ 値に影響を与えると考える因子として訓練開始年齢、平均聴力レベル、PIQ、読書力偏差値を独立変数として選出し重回帰モデルを作成した。さらにステップワイズ法にて詳細を検討した。その結果、VIQ と読書力偏差値は高い正の相関を示し、訓練開始年齢、平均聴力レベル、PIQ については強い無相関性を示した。また、VIQ の獲得は訓練開始年齢、聴力レベル、PIQ に影響されないことがわかった。これまでに、幼児期から文字言語の早期導入により、小学校就学前に年齢以上の読書力レベルが獲得できることが報告されていることから、訓練開始年齢や平均聴力レベル、PIQ にかかわらず、聴覚障害児が音声言語を獲得する上で、幼児期から文字言語を導入することは有効であると考える。