Early Intervention and Language Development in Children Who Are Deaf and Hard of Hearing

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Pediatrics 2000;106;43-
DOI: 10.1542/peds.106.3.e43

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ABSTRACT. *Objective.* **The primary purpose of this study was to examine the relationship between age of enrollment in intervention and language outcomes at 5 years of age in a group of deaf and hard-of-hearing children.**

Method. **Vocabulary skills at 5 years of age were examined in a group of 112 children with hearing loss who were enrolled at various ages in a comprehensive intervention program. Verbal reasoning skills were explored in a subgroup of 80 of these children. Participants were evaluated using the Peabody Picture Vocabulary Test and a criterion-referenced measure, the Preschool Language Assessment Instrument, administered individually by professionals skilled in assessing children with hearing loss. A rating scale was developed to characterize the level of family involvement in the intervention program for children in the study.**

Results. **A statistically significant negative correlation was found between age of enrollment and language outcomes at 5 years of age. Children who were enrolled earliest (eg, by 11 months of age) demonstrated significantly better vocabulary and verbal reasoning skills at 5 years of age than did later-enrolled children. Regardless of degree of hearing loss, early-enrolled children achieved scores on these measures that approximated those of their hearing peers. In an attempt to understand the relationships among performance and factors, such as age of enrollment, family involvement, degree of hearing loss, and nonverbal intelligence, multiple regression models were applied to the data. The analyses revealed that only 2 of these factors explained a significant amount of the variance in language scores obtained at 5 years of age: family involvement and age of enrollment. Surprisingly, family involvement explained the most variance after controlling for the influence of the other factors ($r = .615$; F change = 58.70), underscoring the importance of this variable. Age of enrollment also contributed significantly to explained variance after accounting for the other variables in the regression ($r = -.452$; F change = 19.24). Importantly, there were interactions between the factors of family involvement and age of enrollment that influenced outcomes. Early enrollment was of benefit to children across all levels of family involvement. However, the most successful children in this study were those with high levels of family involvement who were enrolled early in intervention services. Late-identified children whose families were described as limited or average in involvement scored >2 standard deviations below their hearing peers at 5 years of age. Even in the best of circumstances (eg, early enrollment paired with high levels of family involvement), the children in this study scored within the low average range in abstract verbal reasoning compared with hearing peers, reflecting qualitative language differences in these groups of children.**

Conclusions. **Consistent with the findings of Yoshinaga-Itano et al,[1] significantly better language scores were associated with early enrollment in intervention. High levels of family involvement correlated with positive language outcomes, and, conversely, limited family involvement was associated with significant child language delays at 5 years of age, especially when enrollment in intervention was late. The results suggest that success is achieved when early identification is paired with early interventions that actively involve families.** *Pediatrics* **2000;106(3). URL: http://www.pediatrics.org/cgi/content/full/106/3/e43;** *hearing loss, deaf, hard-of-hearing, early identification, early intervention, language, newborn hearing screening.*

ABBREVIATIONS. deaf/hh, deaf and hard-of-hearing; SD, standard deviation; PTA, pure tone average; DEIP, Diagnostic Early Intervention Program; FM, frequency modulated; TC, total communication; PPVT, Peabody Picture Vocabulary Test; EOWPVT, Expressive One-Word Picture Vocabulary Test; SE, standard error; PLAI, Preschool Language Assessment Instrument.

Recent evidence indicates that many children with sensorineural hearing loss achieve language abilities similar to hearing peers if comprehensive intervention services are provided by 6 months of age.[1,2] Advocates of early intervention emphasize the importance of maximizing sensitive periods of development to prevent the communication, language, and literacy delays frequently observed in children with mild to moderate/severe losses[3–7] and those with severe to profound losses.[8–13] Early detection and intervention are believed to be critical steps toward proactive management of these children. Recent technological advances allow for identification of hearing loss soon after birth,[14–17] and the concept of universal newborn hearing screening has been endorsed by the National Institutes of Health,[18] the Joint Committee on Infant Hearing,[19] and the American Academy of Pediatrics.[20]

Despite widespread theoretical and practical support for universal hearing screening, concerns about the costs versus the potential benefit to society continue to be raised.[21] Recently, Bess and Paradise[22] characterized the advocacy for universal screening as

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Received for publication Feb 18, 2000; accepted May 10, 2000.
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premature and ill-advised. Among their objections was concern for the lack of empirical evidence documenting the effectiveness of early intervention.[23] This statement, and related criticisms of early intervention research, prompted further investigation of intervention outcomes in relation to age of identification. Researchers have worked to address at least 2 primary questions: 1) Does early intervention contribute to lasting differences in language outcomes for children with hearing loss?; and 2) What variables, in addition to early intervention, influence outcomes?

Three recent studies address the first question. Robinshaw[24] described outcomes for 5 early-identified children with severe to profound sensorineural hearing loss in comparison with hearing, age-matched controls and a group of 12 late-identified children with hearing loss. Results showed a clear advantage for the early-identified subjects, who achieved developmental milestones in vocalization and language at similar ages to their hearing peers and in advance of their later-identified hard-of-hearing peers. This study has limited generalizability, however, because of the small number of subjects, variability in the interventions implemented, and lack of use of standardized measures.

Further evidence of the benefits of intervention before 6 months of age was provided by Apuzzo and Yoshinaga-Itano,[2] based on a retrospective analysis of outcomes in 69 children, grouped by ages of identification. Infants identified between birth and 2 months of age performed significantly better at 40 months of age than did later-identified infants on measures of general development and expressive language. Because of concerns about sample distribution, including a limited pool of subjects in the early identification group, the study was replicated on a larger, more representative sample.[1]

Receptive and expressive language skills were examined in 150 deaf and hard-of-hearing children (deaf/hh): 72 identified before 6 months of age; 78 identified after 6 months of age.[1] The majority of children (96%) were enrolled in the Colorado Home Intervention Program.[25] Several child and family background variables were controlled in the analysis. Children were evaluated between the ages of 13 and 36 months. Children enrolled in services before 6 months of age performed significantly better than later-identified peers in receptive and expressive language, with an effect size of nearly 1 standard deviation (SD). The early identification advantage was observed in children with normal cognitive abilities, regardless of communication mode, degree of hearing loss, socioeconomic status, gender, minority status, or presence of additional disabilities. Children identified before 6 months of age performed comparably to hearing peers on language measures administered.

It is not yet known if the advantages observed through the latest tested age (36 months) in the study by Yoshinaga-Itano et al[1] will be maintained at later ages. Some have suggested that children may simply catch up once intervention has begun. It is important to examine outcomes beyond the third year of life and to control for developmental differences of children tested at varying ages by evaluating all subjects at the same chronological age point (eg, 5 years of age).

Early intervention researchers have also examined the influence of background variables, such as family factors, on outcomes. Previous research documents that families vary widely in their adjustment to the child's hearing loss,[26,27] motivation,[28] affective state,[29] responsiveness to the child,[30,31] and social support,[29,32–34] all of which can influence long-term outcomes. Parents who become involved in intervention have been found to communicate better with their children and to contribute more to the child's progress than parents who do not participate in such programs.[35,36] Calderon et al[37] retrospectively analyzed characteristics of 28 families who participated in the same early intervention program. Among their findings was the conclusion that late identification results in families spending limited time in early intervention programs. As a consequence, parents of later-identified children did not demonstrate high levels of confidence or independent knowledge related to their children's language needs.[37] Multiple variables may influence intervention outcomes. Better understanding of these relationships is needed.

The primary purpose of the present study was to explore the relationship between age of enrollment in early intervention services and specific language development outcomes measured at 5 years of age in a group of children with sensorineural hearing loss. Because vocabulary and verbal reasoning skills are known to contribute to reading comprehension,[38] the status of these specific language behaviors in children enrolled in intervention at various ages was of interest. It is hypothesized that age of enrollment will be correlated with language performance at 5 years of age, and that the earliest-identified children will attain standard scores that approximate those of hearing peers. A secondary goal of this investigation was to examine the relationship between family involvement in intervention and child language outcomes.

METHODS

Participants

Participants in this study were 112 children (58 males; 54 females) with prelingual-onset hearing losses ranging from mild to profound (mean better ear pure tone average [PTA] = 77.8; range = 25–120 dB; SD = 24.2). All children were graduates of the Diagnostic Early Intervention Program (DEIP), a parent/infant program operated in a metropolitan community. Children were included in this retrospective study if they had: 1) confirmed bilateral, sensorineural hearing loss; 2) participated in the DEIP program between 1981 and 1994; 3) received formal language evaluations through 5 years of age; 4) lived in a home where English was spoken; 5) hearing parent(s); and 6) no evidence of major secondary disabilities, including nonverbal intelligence scores <70. Table 1 summarizes the demographic characteristics of the sample.

Age of Identification/Enrollment

The children in this study represent a group whose hearing losses were identified before the implementation of universal screening of hearing in newborns in the local community. They were identified through such procedures as high-risk registries, neonatal intensive care unit screening, child find programs, and

TABLE 1. Demographic Characteristics of Study Sample

Characteristic	No.	Mean	SD	Range
Age of identification*	112	1.55	1.10	.00–4.53
Age at entry*	112	1.83	1.13	.03–4.53
Degree of hearing loss (in dB)	112	77.75	24.20	25–120
Mild (21–40 dB)	9	30.84	5.43	25–40
Mild to moderate (41–55 dB)	17	48.80	4.33	41–55
Moderate (56–70 dB)	19	63.61	3.83	56–70
Severe (71–90 dB)	20	80.51	5.09	71–88
Profound (91 dB +)	47	101.90	5.56	91–120
Nonverbal IQ	84	102.27	14.16	70–147
Ages of enrollment* by category				
0–11 mo (.0–.92 y)	24	.45	.27	.03–0.91
11.1–23 mo (.93–1.92 y)	42	1.39	.29	.93–1.90
23.1–35 mo (1.93–2.92 y)	24	2.37	.31	1.95–2.90
35.1+ mo (2.93+ y)	22	3.61	.48	3.00–4.53

* Ages of identification and enrollment are expressed in years/portions of years.

parental self-referral. They ranged in age of identification from the second day of life to 54 months of age, with a mean of 1.55 years (18 months). Age at amplification and enrollment in intervention services ranged from .03 year (<1 month) to 4.53 years (54 months), with a mean of 1.83 years (22 months). The average time that elapsed between age of identification and initiation of services across the group of children was 3 months.

Degree of Hearing Loss

All of the children had congenital, bilateral sensorineural hearing loss. Table 1 includes the number of participants within each hearing loss category. Unlike the typical population of children with hearing loss,[39] this distribution has a larger than expected number of children in the profound category and relatively few children in the mild hearing loss category. All children in the study used binaural personal amplification at home and frequency modulated (FM) amplification when involved in preschool services (3–5 years of age), according to school and audiological records.

Intervention Program

All children in this study were enrolled in DEIP[40,41] for 6 months after identification of hearing loss. This multidisciplinary, family-centered program is designed to support families of recently diagnosed children in identifying needs and making decisions related to intervention options. Once a family completes the initial intervention in DEIP, they are referred to the early intervention program determined to be the most appropriate to meet the needs of the child and family. In the population of children in this study, 110/112 (98%) went on from DEIP to 1 of 2 local early intervention programs that provided services from birth to 5 years of age. Of this group, 59 attended an auditory/oral program and 51 attended a total communication (TC) program. Both programs were specifically designed for deaf/hh children and implemented similar curricular approaches for language intervention. The remaining 2 children lived in rural communities and were served by the auditory/oral program on an outreach basis.

During early intervention, families received 1 to 2 home visits weekly in addition to involvement in a parent support group. Families learning to sign also had weekly family sign classes available. The average duration of the family's enrollment in the birth to 3 years of age intervention program was 15 months. The minimum participation in the birth to 3 years of age program was 0 (in cases of late identification after 36 months of age) and the maximum participation was 35 months. After birth to 3 years of age services, all children attended preschool programs that met daily (3–5 years of age) in 1 of the 2 previously described intervention programs. Attendance records were used to quantify each family's participation in these services.

Procedures

Audiological Measures

Comprehensive audiological evaluations were completed on the children in this study at a minimum of 6-month intervals during their time in the intervention program. Pure tone thresholds were obtained with TDH-49 earphones (Telephonics Corp, Huntington, NY) or ER-3A insert phones (Etymotic Research, Indianapolis, IN) for the frequencies 250 through 8000 Hz bilaterally. The children also received regular listening checks of their amplification by trained teachers and electroacoustic monitoring of personal amplification and FM systems during audiologic evaluations. Better ear PTAs were calculated for the thresholds of 500 Hz, 1 kHz, and 2 kHz, regardless of configuration, with 115 dB used as the calculation for no response thresholds. Audiograms obtained after the child's third birthday were used in all subsequent analyses.

Measures of Nonverbal Intelligence

All children in the study were seen for psychological evaluations during their preschool years. Certified clinical psychologists with expertise in working with deaf children administered nonverbal intellectual measures or developmental assessments to the study participants. The psychologist selected the test instrument deemed to be most appropriate for the child, depending on his/her age at the time of testing. Measurement tools included the Weschler Preschool and Primary Scale of Intelligence,[42] the Weschler Intelligence Scale for Children-III,[43] or the Hiskey-Nebraska Test of Learning Aptitude.[44] Nonverbal IQ scores were derived in 84 of 112 cases. In the remaining 28 cases, the psychologist did not provide a formal test score, because of the child's young age at the time of testing. In these cases, the psychologist used infant developmental measures, such as the Bayley Scales of Infant Development[45] or the Hawaii Early Learning Profile[46] to assess the developmental status of the child. In all of these cases, the psychologist reported that the child had at least average intelligence.

Language Measures

Children in this study were involved in regular, longitudinal monitoring of developmental status as part of their comprehensive early intervention programs. It is beyond the scope of the present study to examine all of the measures that were completed during the child's enrollment in the intervention program. Instead, measures of vocabulary and verbal reasoning skills collected at or near 5 years of age are the focus of the present investigation. Each child was tested individually by a speech language pathologist with additional training and experience in working with children who are deaf/hh. Signing children included in this study used a manual code of English (signing exact English). Adults who tested these children were fluent in the communication mode of the children, as determined through objective evaluation of staff sign language skills. All child language scores were entered into the children's archival records, which were reviewed for the purposes of this retrospective analysis.

Vocabulary Skills

Participants' vocabulary skills were assessed with the Peabody Picture Vocabulary Test (PPVT),[47,48] an instrument commonly used to measure receptive vocabulary for standard American English. This test was standardized on children with normal hearing and was not specifically designed for children who are deaf/hh. However, these materials have been applied to different populations of children including children with hearing loss as a measure of English vocabulary.[9,49–51] It was also relevant to the goals of this study to compare early- and late-identified participants with normal hearing peers, which further motivated the selection of this measure.

The vocabulary scores of children in the oral and TC programs were compared using analysis of variance. This revealed no significant differences for communication mode ($F[1,110] = .326$; $P = .569$), which justified combining the 2 intervention groups for analysis. There are extensive data supporting the concurrent and predictive validity of the PPVT with young children.[47] Concurrent validity of the PPVT for the children in this study was examined by correlating the PPVT scores with a measure of expressive vocabulary (Expressive One-Word Picture Vocabulary Test [EOWPVT]).[52] The 2 vocabulary measures were significantly correlated ($r = .81$; $P < .01$). Correlations between these 2 vocabulary tests were intentionally included to determine whether receptive vocabulary measures were inflated by signed administration (eg,

Did clues available in signs bias responses on this multiple choice test?). In 92% of the cases, subjects' scores were lower on the PPVT than on the EOWPVT, making the PPVT a more conservative estimate of performance overall. In addition, the PPVT was correlated with global measures of receptive and expressive language, using the Preschool Language Scale-III[53] or the Reynell Developmental Language Scale[54] scores. Significant positive correlations were obtained between the PPVT and receptive language ($r = .80$; $P < .01$) and expressive language ($r = .74$; $P < .01$) measures. The test authors note that for hearing children, the PPVT correlates most highly with other measures of vocabulary and moderately well with tests of verbal intelligence.[47]

Verbal Reasoning Skills

Verbal reasoning skills were examined with the Preschool Language Assessment Instrument (PLAI).[55] This instrument was designed to assess children's ability to answer questions and to respond to demands that range from simple (eg, What is this?) to abstract (eg, Why can't the boy fit this piece into the puzzle?). This test had been administered to a representative subgroup of 80 of the study participants. Children in this subgroup of 80 had mean scores on all independent variables that closely approximated the total subject group. Children's responses were scored for accuracy and quality according to test guidelines. Scores from participants in this study were compared with performance data provided by the test developers on 120 normal hearing preschoolers, who ranged in age from 3 to 5 years.

Family Involvement Rating

A rating scale was developed to characterize the quality of family participation in the intervention program. Family involvement was rated retrospectively by early interventionists who had extensive contact (eg, twice weekly home visits, weekly parent meetings over a period of at least 2 years, and often over 4 years) with the families in the study. Each family received a global rating from 1 to 5 to reflect their participation in the intervention program. Raters were given specific descriptions of characteristics representing each category, before assigning their ratings (see "Appendix") and were asked to consider issues such as familial adjustment, session participation, effectiveness of communication with the child, and advocacy efforts in assigning their ratings. Scores were assigned as follows: 1 = limited participation; 2 = below average participation; 3 = average participation; 4 = good participation; and 5 = ideal participation. At least 2 interventionists who worked directly with the family were asked to independently rate the levels of participation they had experienced with the family.

Judgments were compared for interrater reliability. Complete agreement was found when both raters assigned the same point score. Categorical agreement was found when raters accurately placed families into 1 of 3 categories (eg, 1–2 = below average; 3 = average; 4–5 = above average). That is, raters agreed on the category of assignment (and did not deviate by 2 or more points). Judges were also asked to indicate their confidence in their ratings (eg, by circling on the form questionable, okay, or good). Any ratings judged as questionable were eliminated, leaving 100 ratings for analysis. Cohen's κ was calculated to examine interrater reliability for interventionists working in the auditory/oral and TC programs. Coefficients for exact agreement were $\kappa = .802$ for the oral program and $\kappa = .896$ for the TC program; categorical agreements were $\kappa = .882$ for the oral program and $\kappa = .94$ for the TC program. In the entire dataset, only 2 sets of judgments deviated by 2 points on the scale. For the regression analysis, rater disagreements were handled by assigning the average of the scores of the 2 judges (eg, judgments of 1 and 2 resulted in a rating of 1.5).

Statistical Analyses

Multiple regression models[56] were used in this study to explore the collective and separate effects of the various factors on children's language outcomes at 5 years of age.

RESULTS

Vocabulary Skills

A statistically significant negative correlation of $r = -.46$ ($P < .01$) was found between the variable of age of enrollment and vocabulary skills measured at 5 years of age. Thus, earlier enrollment in intervention services was associated with significantly stronger language outcomes at 5 years of age. Fig 1 illustrates the means and SDs for children entering at various stages along the age of enrollment continuum. On the PPVT, a standard score of 100 is considered average with an SD of ± 15 (eg, standard scores ranging from 85 to 115 are considered to be within the limits of the average range).

Notably, there is a systematic decline in the mean vocabulary standard score with increasing ages of enrollment. Effect sizes were calculated to represent the magnitude of this finding.[57] The results indicated an effect size difference of .69 between children enrolled before 11 months of age and those enrolled between 11.1 and 23 months of age. The effect sizes increased as the earliest-enrolled children are compared with later enrollees, with differences of .99 and 1.6, respectively. Furthermore, the earliest-enrolled children performed in the average range on the vocabulary measure, compared with normally hearing 5 year olds, regardless of degree of hearing loss (mean PPVT score = 94; standard error = 3.1).

However, it is also obvious from Fig 1 that there is considerable variability in individual performances along the age of enrollment continuum. It was of interest to determine what factors may account for such wide variability. As a first step in understanding the relationships among the variables, correlations between vocabulary and a variety of other measures were examined.

Relationships Between Vocabulary and Other Measures

Table 2 shows the Pearson product moment zero-order correlations between the child and family background variables and the children's vocabulary scores on the PPVT. Of the variables examined, the strongest significant correlation was found between family involvement and vocabulary ($r = .646$; $P < .01$). This suggests that the more involved the family with the child's intervention program, the higher the child's vocabulary scores were at 5 years of age.

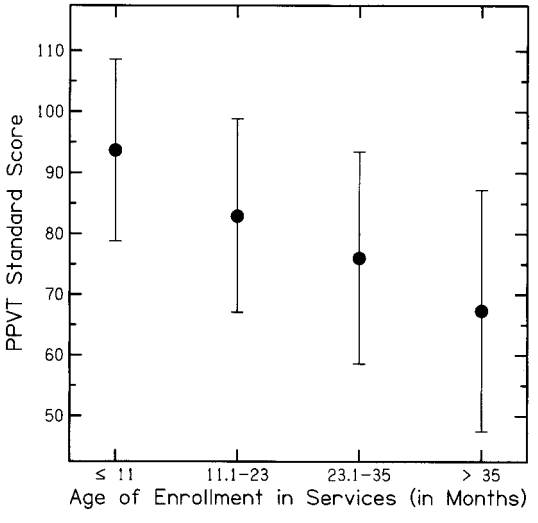

Fig 1. Means and SDs of PPVT scores for subjects as a function of age of enrollment in intervention.

TABLE 2. Zero-Order Correlations Between Background Variables and Vocabulary

	n	PPVT	PTA	Nonverbal IQ	Family Involvement	Age of Enrollment
PPVT	112		−.033	.289*	.646*	−.464*
PTA	112			.018	−.012	−.111
Nonverbal IQ	84				.223	−.092
Family involvement	100					−.204
Age of enrollment	112					

* $P < .01$.

There was also a significant correlation between nonverbal intelligence and vocabulary ($r = .289$; $P < .01$), and as noted above, a statistically significant negative correlation was found between age of enrollment and vocabulary scores ($r = -.464$; $P < .01$). Degree of hearing loss was not significantly related to vocabulary performance ($r = -.033$).

Regression Analyses

To explore further the relationships between family involvement, age of enrollment, nonverbal intelligence, and vocabulary skills, a series of linear hierarchical multiple regressions were conducted. Before formal analysis, the relationships were tested for evidence of nonlinear components (cubic, quadratic relationships) and were found to be linear. In the regression analysis, the variable of interest is intentionally excluded at step 1, and is then entered at step 2 to examine the unique variance it contributes, while controlling for the other factors. Based on the correlational results, family involvement, nonverbal intelligence, and better ear PTA were entered into the multiple regression as 1 step, with vocabulary as the dependent variable. These factors together accounted for 44.0% of the variance in children's vocabulary scores ($R^2 = .440$; F[3,79] = 19.93; $P < .01$). Once age of enrollment was entered, all 4 variables accounted for a total of 55.5% of the variance in children's vocabulary scores ($R^2 = .555$; F[4,75] = 23.346; $P < .01$). R^2 change (.114) was significant (F change = 19.237; $P < .01$) at step 2, indicating a significant contribution of unique variance (11.4%) by the age of enrollment factor over and above the other factors.

In further regressions, the variables of family involvement, nonverbal intelligence, and better ear PTA were systematically separated out to determine the unique variance each contributed to vocabulary scores. Of all the variables, family involvement contributed the most unique variance (35.2%; R^2 change = .352; F change = 58.70; $P < .01$). A small amount of unique variance was accounted for by nonverbal intelligence (R^2 change = .025; F change = 4.211; $P = .044$). Better ear PTA did not contribute independent of the other factors included in the regressions (R^2 change = .002; F change = .37; $P = .548$). Table 3 summarizes the results of the regression models, showing the unique contributions of the independent variables.

Analysis of Combined Effects on Vocabulary

For the children in this study, there seems to be an important interaction between the factors of age of enrollment and family involvement. Figure 2 illustrates vocabulary scores as a function of both of the contributing variables. The impact of latest identifications is particularly dramatic for children who have average to low average family involvement ratings. The mean vocabulary scores for children in this situation ranged from 56.5 to 62.5, or >2 SD below age expectations. Fig 2 also illustrates that early enrollment in services was of benefit to language learning, even with limitations in family involvement. The mean scores for early-identified children with various family involvement ratings ranged

TABLE 3. Summary of Regression Models for Age of Enrollment, Family Involvement, Nonverbal Intelligence, and Better Ear PTA With Vocabulary as the Dependent Variable

Independent Variables	Vocabulary			
	R^2 Change	F Change	Significance of F Change	Partial Correlations
Age of enrollment	.114	19.24	.000	−.452
Family involvement	.352	58.70	.000	.615
Nonverbal intelligence	.025	4.21	.044	.196
Better ear PTA	.002	.37	.548	−.100

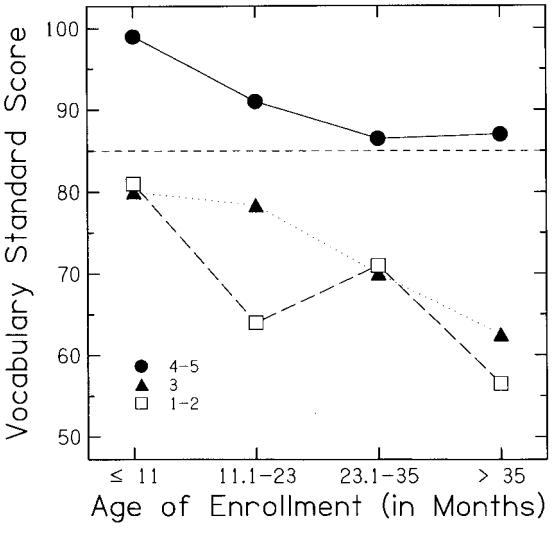

Fig 2. Mean vocabulary scores plotted as a function of the two key variables, age of enrollment and family involvement ratings. The area above the horizontal dashed line represents the lower end of the average range for normal hearing students (average range is 100 ± 15). The rating 4 to 5 (filled circle) represents the highest levels of family involvement; 3 (filled triangle) represents average family involvement; 1 to 2 (open square) represents below average family involvement.

from 80 to 99. Visual inspection of the results for children in the category of high levels of family involvement shows the strong contribution of this variable to outcome. These children's mean scores did not fall below the average range. Children who have the combined benefits of early enrollment and strong family involvement ratings were consistently the strongest performers (mean score = 99).

Verbal Reasoning

Verbal reasoning skills were assessed at 5 years of age in a representative subgroup of 80 of the study participants. Figure 3 illustrates the descriptive results for the participants. For purposes of data reduction, they are grouped by age of enrollment, in the same manner as Fig 1. Their performance on the abstract level of questions from the PLAI is compared with 25th and 50th percentile scores (low average and average) for hearing children of kindergarten age (5 years, 0 months to 5 years, and 11 months of age). Test items were classified as abstract based on guidelines from the test developer and represent the most stringent criteria for comparison. Only the earliest-enrolled children performed within the low average range (mean = 1.43) or at the 25 percentile compared with hearing peers. Children who were latest enrolled obtained scores on average that reflected considerable difficulty responding to any of the reasoning-based questions, and well below the hearing students' scores.

Correlations Between Verbal Reasoning and Other Background Variables

Table 4 includes correlations between background variables and verbal reasoning performance. A significant positive correlation was found between family involvement and verbal reasoning ($r = .610$; $P < .01$) and a significant negative correlation was found between age of enrollment and verbal reasoning scores ($r = -.310$; $P < .01$).

Children from families rated as above average in involvement obtained a mean score of 1.5 on abstract reasoning. Conversely, children from families rated below average received a mean score of .31 on this measure. These findings are comparable to the results for vocabulary, again suggesting the importance of the contributions of family involvement in intervention. The findings also suggest that even in the best circumstances (eg, early enrollment and above average or ideal family involvement) the children achieved abstract reasoning scores considered low average compared with their hearing peers. This result reflects important qualitative differences between these 2 groups of children.

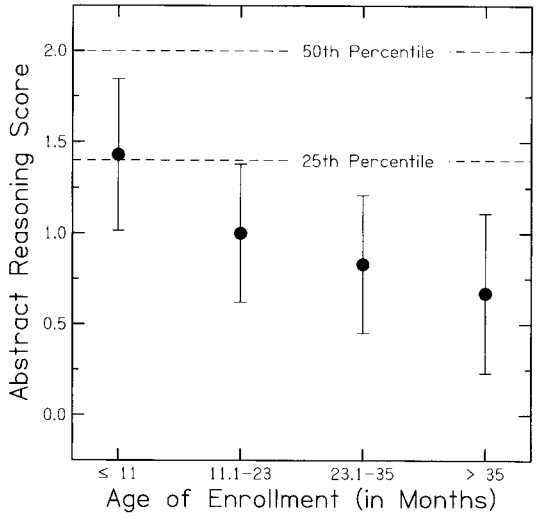

Fig 3. Means and 95% confidence intervals of verbal reasoning results for the most abstract level of questioning, grouped by age of enrollment. The dashed lines signify the scores representing the 25th and 50th percentile scores for normal hearing children.

DISCUSSION

In general the findings of this study are similar to those of Yoshinaga-Itano et al,[1] suggesting that early enrollment in intervention contributes to positive outcomes in language development. Children enrolled before 11 months of age had stronger vocabulary and verbal reasoning skills at 5 years of age than did later-enrolled children. These early-enrolled children obtained mean scores in vocabulary at 5 years of age that were within the average range compared with hearing age-matched peers. In contrast, average vocabulary scores for later-enrolled children (eg, >24 months old) were 1.0 to 1.5 SD below their hearing peers. These effect sizes are similar to those reported by Yoshinaga-Itano et al.[1] Such delays can be expected to interfere with academic development and understanding in the classroom.

In the present study, early enrollment in services was also associated with better verbal reasoning skills at 5 years of age. Children who were enrolled by 11 months of age scored within the low average range (25th percentile) in comparison to hearing peers when asked to respond to the most abstract reasoning questions on the PLAI (eg, "Why, what will happen if. . . ?"). Given the importance of both vocabulary and verbal reasoning skills for literacy development, these findings support the value of identifying and enrolling children early in life.

It was found that the factors of family involvement and age of enrollment explained significant amounts of variance in language scores. These findings point to the importance of both variables and to the strong contributions families make to outcomes for children. Some professionals have questioned whether late-identified children will simply catch-up after the initiation of intervention services. The results of this study suggest that strong levels of family involvement can buffer the effects of late enrollment to some degree. As shown in Fig 2, the impact of late enrollment on vocabulary skills is less in cases where family involvement was rated 4 to 5. Children in this study who showed a pattern of catching up were from the most involved families.

Figure 2 also shows that early enrollment makes a positive difference in vocabulary scores at age 5 years across all levels of family involvement. Earliest-enrolled children consistently performed better than later-enrolled children, regardless of the level of the family rating. However, the interaction of late enrollment and limited family support resulted in

TABLE 4. Zero-Order Correlations Between Background Variables and Verbal Reasoning

	n	Verbal Reasoning	PTA	Nonverbal IQ	Family Involvement	Age† Enrolled
Verbal reasoning	80		−.251	.161	.610*	−.310*
PTA	80			−.088	.046	.006
Nonverbal IQ	63				.227	−.067
Family involvement	80					−.276
Age enrolled	80					

* $P < .01$.
† Age enrolled was the age at which children began in the early intervention program. Children typically entered the program shortly after amplification was fit or were in the process of amplification fitting at the time of enrollment.

particularly poor language outcomes at 5 years of age. Children from at-risk families may be particularly susceptible to the consequences of later identification and enrollment.

The results underscore the point that the best outcomes are attained when families become involved and when intervention is initiated early. The early provision of intervention services may provide families the support they need to become actively involved in promoting the child's linguistic development. More in-depth understanding of the ways in which specific family factors interact with other background variables (such as age of enrollment) will inform early intervention practices. For example, the possible contribution of socioeconomic status to level of family involvement should be explored in future studies. Calderon[58] recently reported from a study of 28 deaf/hh children that socioeconomic status was a marginally significant predictor of maternal communication. She hypothesized that mothers from higher socioeconomic conditions may have access to more resources that support their development of communicative skills with the child.

In the present study, 47% of the families enrolled were rated as above average to ideal in their involvement in the intervention program. It is unclear how representative this population of families is of populations in other areas of the country. In some ways, this population may be atypical in that some families moved to the community to access services for their profoundly deaf children. This may have contributed to the greater number of profound children in the sample and some bias toward highly motivated families within the group.

It should be noted that children from families rated average or below in this sample obtained language scores at age 5 years that fell consistently below the average range. This suggests the need to involve families in intervention to foster optimal outcomes. This conclusion is supported by the findings of Calderon[58] cited above. She found that school-based parental involvement (eg, participation in individual educational plan meetings, parent meetings, etc) predicted early reading skills. However, maternal communicative skills were even more predictive of language and literacy. She emphasized that maternal communicative skill is a strong aspect of parental involvement, given that a parent must be highly involved to develop effective mutual communication with a deaf/hh child. In the present study, the family involvement rating scale incorporated both notions of participation in program-related meetings and quality of communicative interactions with the child. The present study supports the conclusion of Calderon[58] that professionals should actively involve parents with the goal of enhancing their communicative skills with the child.

Prospective research is needed to examine how interventions can be configured to result in active participation from the majority of enrolled families. It has also been pointed out that children who are identified late receive a limited duration of early intervention services in comparison to early-identified peers with hearing loss.[37] The results of the present study suggest that starting intervention late is not optimal for children or families.

A limitation of the present study is that language was examined only in relation to vocabulary and verbal reasoning skills. Language involves a host of skills in the areas of syntax, semantics, pragmatics, and phonology. Vocabulary and verbal reasoning skills were a highly specific focus of the 2 intervention programs studied. The results do not address qualitative differences that may exist between the participants and their hearing peers on these or other language measures. Cautious interpretation of performance comparable to hearing peers is warranted and prospective studies that include fine-grained analysis of language in matched comparison groups are needed. Prospective study of the family involvement variable with more refined tools, which include further construct specification, is also needed.

This study also found that degree of hearing loss was not a significant predictor of language outcome. This finding may have been influenced by the composition of the study population, which was skewed toward greater degrees of hearing loss. However, other authors have also reported the minimal contribution of this variable to child language scores.[1,4] It may be the case that with appropriate interventions, degree of hearing loss becomes a relatively minor predictor, at least for global measures of language performance. It is likely that speech production abilities may be influenced by degree of hearing, but such measures were not included in this analysis.

It should also be noted that a difficult-to-control confounding factor exists in studies that compare early- and late-identified children. Later-identified children and their families spend less time in intervention (eg, less time with amplification, shorter duration of service delivery) than their early-identified counterparts. Duration, intensity, and quality of ear-

ly-intervention services are variables that need to be considered when interpreting results.[59,60] Like earlier studies, this study has a confound in that later-enrolled groups received less intervention service than the earlier-enrolled children. However, the findings of this study suggest that late identification (resulting in late access to service) is associated with significant language delays that are difficult to resolve by age 5 years for most children with hearing loss. It may be argued that late identification simply leaves insufficient time to address the language needs of children so that they are linguistically prepared for school entry. Children who enter school with significant delays in language skills are at a distinct disadvantage and may encounter difficulties in academics, social–emotional development, and self-esteem.

Children in the best circumstances in this study attained only low average scores in verbal reasoning. This result may reflect consequences of limitations in early access to language models. Some have conjectured that the first 6 months of life may represent a particularly sensitive period of development.[1] The consequences of limited exposure to language during this time are not yet understood.

It is also important to consider that the majority of children in this study were not identified through newborn-hearing screening mechanisms. The average age of identification was 18 months and the average age of enrollment in services was a discouraging 22 months. Furthermore, only 24 of 112 subjects in this study were identified before 11 months of age and of those, only 20 were identified before 6 months of age. This study needs to be replicated with a population including a larger cohort of children identified through newborn-screening programs. It is possible that the influence of age of identification will be found to be even greater as more children gain access to early intervention through universal newborn-hearing screening programs. The findings of this study also support the argument that high-risk-screening approaches are ineffective in identifying the full population of children needing early intervention services. In summary, there is need for proactive management. Children will benefit from early identification that is paired with comprehensive interventions that actively involve family members.

APPENDIX

Early Intervention Efficacy Project: Family Participation Rating Scale

In an effort to understand variables that influence the progress of young deaf/hh children, I am attempting to characterize the quality/level of family participation that existed in individual children's programs in our community. I am asking that 2 educators who worked directly with the families involved assign a rating to describe the level of family involvement. To aid this process, I have provided a verbal case description that represents each rating of 1 to 5. On this continuum, a rating of 1 represents limited involvement (far below average). A rating of 5 represents ideal involvement. You will notice on the rating form there is a place to indicate how well you recall the family (eg, you are indicating how confident you feel in assigning a rating). You are asked to indicate if your recall is good, okay, or questionable. If you believe that you are not familiar enough with a particular family, then do not assign a rating at all.

Rating Scale Descriptors

Rating of 5 (Ideal Participation)

Family seems to have made a good adjustment to the child's deafness. The family is able to put the child's disability in perspective within the family. Family members actively engage in sessions. They attend sessions and meetings regularly and pursue information on their own. They serve as effective advocates for their child with professionals/school districts, etc. Family members become highly effective conversational partners with the child and serve as strong and constant language models. Family members become fluent/effective users of the child's mode of communication. They are capable of applying techniques of language expansion. Extended family members are involved and supportive.

Rating of 4 (Good Participation)

Family members make a better than average adjustment to the child's deafness. Family members regularly attend parent meetings and sessions. Parents take an active role (perhaps not the lead) in Individual Family Service Plans and Individual Education Plans. Family members serve as good language models for the child and make an effort to carry over techniques at home. Some family members have fairly good facility in the child's communication mode and/or in techniques for language stimulation. Efforts are made to involve extended family members.

Rating of 3 (Average Participation)

Family is making efforts to understand and cope with the child's diagnosis. Family members participate in most sessions/meetings. Busy schedules or family stresses may limit opportunities for carryover of what is learned. Family may find management of the child challenging. Family attends Individual Family Service Plan and Individual Education Plan meetings but may rely primarily on professional guidance. Family attempts to advocate but may be misdirected in some of their efforts. Selected family members (eg, mother) may carry more than their share of responsibility for the child's communicative needs. Family members develop at least basic facility in child's communication mode. Family members are willing to use language expansion techniques but need ongoing support and direction.

Rating of 2 (Below Average)

Family struggles in acceptance of the child's diagnosis. The family may be inconsistent in attendance. They may be inconsistent in maintaining the hearing aids and keeping them on the child outside of school. They may have some significant life stressors that interfere with consistent carryover at home. Management of the child presents daily challenges to the family. Communicative interactions with the child are basic. Family lacks fluency in the child's mode of communication.

Rating of 1 (Limited Participation)

Family faces significant life stresses that may take precedence over the child's needs (eg, domestic abuse, homelessness). Family has limited understanding of deafness and its consequences for the child. Participation may be sporadic or less than effective. Parent/child communication is limited to very basic needs.

ACKNOWLEDGEMENTS

This study was supported in part by National Institutes of Health (NIDCD) Grant P60 DC00982.

I gratefully acknowledge Drs Brenda Schick, Patricia Stelmachowicz, and Michael Gorga for their mentoring and for their critical review of the draft manuscript.

I thank Dr Russell W. Smith for his guidance and review of the statistical methods implemented in this study.

I am grateful to Kathryn Beauchaine for her assistance in gathering audiological records, Sharon Wood for editorial feedback, Beth O'Connor for assistance with figure preparation, and the parent/infant educators and clinicians at Boys Town National Research Hospital and the Omaha Hearing School for their assistance in data collection.

I also thank 3 anonymous reviewers for their helpful suggestions.

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Pediatrics 2000;106;43-
DOI: 10.1542/peds.106.3.e43