This article documented spoken language outcomes for preschool children with hearing loss and examined the relationships between language abilities and characteristics of children such as degree of hearing loss, cognitive abilities, age at entry to early intervention, and parent involvement in children's intervention programs. Participants were evaluated using a combination of the Child Development Inventory, the Peabody Picture Vocabulary Test, and the Preschool Clinical Evaluation of Language Fundamentals depending on their age at the time of assessment. Maternal education, cognitive ability, and family involvement were also measured. Over half of the children who participated in this study had poor language outcomes overall. No significant differences were found in language outcomes on any of the measures for children who were diagnosed early and those diagnosed later. Multiple regression analyses showed that family participation, degree of hearing loss, and cognitive ability significantly predicted language outcomes and together accounted for almost 60% of the variance in scores.

This article highlights the importance of family participation in intervention programs to enable children to achieve optimal language outcomes. Further work may clarify the effects of early diagnosis on language outcomes for preschool children.

As concluded by the United States Preventative Services Task Force (USPSTF) in 2001, there is a need for prospective, longitudinal studies that report on the speech, language, and educational development of children with permanent childhood deafness over time. Despite advances in hearing aid and cochlear implant technology, the provision of intervention services, and a greater awareness of the effects of deafness among educators, language delay remains an enormous problem for children with hearing loss. Research over the last 15 years has shown that, on average, these children learn language at only 50%–60% of the rate of children with normal hearing. Many children will have a language delay of at least 1 year by the time they are of school age, and around half have a severe language delay (greater than 2 standard deviations [SDs] below the mean) (Blamey et al., 2001b; Davis & Hind, 1999; Geers, 2002; Helfand et al., 2001; Ramkalawan & Davis, 1992; Wake, Hughes, Poulakis, Collins, & Rickards, 2004). Accordingly, academic achievement results for children with hearing loss have generally been poor, and a significant proportion never achieve functional literacy (Helfand et al., 2001; Moeller, Tomblin, Yoshinaga-Itano, McDonald Connor, & Jerger, 2007; Moores, 2001; Traxler, 2000; Vermeulen, van Bon, Schreuder, Knoors, & Snik, 2007; Walker, Munro, & Rickards, 1998). A greater understanding of factors affecting language development, and the most effective methods...
of improving language outcomes, is required to enhance the educational and career prospects and therefore the quality of life of children with hearing loss. There is also a need for evidence regarding whether earlier diagnosis leads to significantly better language and educational outcomes for children with hearing loss, as the existing body of evidence has been described by the USPSTF as only “fair to poor” (Thompson et al., 2001).

Prospective research on language development in children with hearing loss is difficult to conduct. Many variables potentially affect spoken language development, including age at diagnosis, degree of hearing loss, parental involvement, cognitive ability, quality of early intervention services, consistency of hearing device use, mode of communication, and additional disabilities. When examining outcomes that may be predicted by a large number of variables, large numbers of participants must be included in order to draw valid conclusions. However, this is difficult to accomplish in the case of children with hearing loss because hearing loss is a relatively rare condition (approximately 1–2/1000 babies are diagnosed each year), and many research centers do not have the resources to conduct large population studies. Due to this shortage of participants, many studies of more than a few children have been retrospective (Moeller, 2000) or have been based on convenience samples, where children are recruited due to availability and accessibility, and therefore may not be representative of the larger population (Blamey et al., 2001b; Wake, Poulakis, Hughes, Carey, & Rickards, 2002; Wake, Poulakis, Hughes, Carey-Sargeant, & Rickards, 2005; Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998). A further weakness of some studies is that they have relied on language data from only one measure (Calderon, 2000; Yoshinaga-Itano et al., 1998). In many studies, important variables such as uniform provision and management of hearing aids, mode of communication, and consistency of educational program were not controlled. Criticisms of previous research have also been made regarding blinding of assessors and lack of information on attrition rates and on criteria for inclusion and exclusion of subjects (Janjua, 2005; Thompson et al., 2001). It is difficult to compare the results of these studies directly in order to obtain a more global view of outcomes, as different age groups were assessed (Moeller, Yoshinaga-Itano, et al. [2000] assessed preschool children, whereas Blamey et al. [2001a] and Wake et al. [2002, 2004, 2005] assessed primary school-aged children), evaluation tools differed, and all studies except Blamey et al. (2001b) used sign language in their evaluation procedures. A more recent study in the United Kingdom examined the speech and oral language abilities of 120 7-year-olds using norm-referenced assessment tools (Kennedy et al., 2006). The strengths of this article were that it addressed several criticisms of previous work regarding clear criteria for inclusion and exclusion of subjects, convenience sampling, uniform protocols for the diagnosis of hearing loss, blinding of assessors, and the use of parent questionnaires. However, the issues of device management, mode of communication, and consistency of intervention were not addressed.

This article provides prospective data that documents the spoken language outcomes of young children with hearing loss in Australia. Spoken language outcomes in Australian preschool children have not been documented previously. Given the likely differences in educational and audiological management between countries, it may not be appropriate to apply clinical and educational practices based on outcomes for children overseas. It is therefore important to evaluate Australian children in order to determine their needs. This study used language assessment measures that allow the direct comparison of Australian results with those from previous studies in the United States (Moeller, 2000; Yoshinaga-Itano et al., 1998) and with outcomes for older Australian children (Blamey et al., 2001a; Wake et al., 2005). These direct comparisons could not be made previously due to significant differences in methodology between studies.

The objectives of this study were to

1. evaluate the language abilities of children aged 1–6 years with hearing loss;
2. compare the language abilities of early- and later-diagnosed children; and
3. examine the relationships between language abilities and characteristics of children, such as age at entry to early intervention, cognitive abilities,
and parent involvement in children’s intervention programs.

Materials and Methods

Participants

The children who participated in this study were all attending the Taralye Oral Language Center for Deaf Children, the largest early intervention service provider for preschool children with hearing loss in the state of Victoria, Australia. At the commencement of the study, all children attending Taralye were invited to participate. Fifty-seven children (32 males and 25 females) were recruited into the study. The children

1. were aged 1–6 years old during the period of data collection;
2. had an assumed congenital hearing loss (loss was suspected or confirmed before 12 months of age);
3. used a cochlear implant or hearing aids or both;
4. used only oral communication;
5. had parents with normal hearing; and
6. lived in a home where English was spoken (and was the primary language in all but one family).

All but two participants had a permanent bilateral sensorineural deafness (two children had significant permanent conductive deafness). The severity of hearing loss at the time of assessment was mild (21–40 dB hearing level [HL]; \( n = 7 \)), moderate (41–55 dB HL; \( n = 17 \)), moderate–severe (56–70 dB HL; \( n = 11 \)), severe (71–90 dB HL; \( n = 6 \)), or profound (>90 dB HL; \( n = 16 \)). Hearing loss figures are for the better ear unaided pure-tone-average threshold (PTA) in dBHL (averaged over 500, 1,000, and 2,000 Hz). All children with a cochlear implant were assigned a PTA of 75 dB HL, given that a cochlear implant has been estimated to provide an auditory speech perception capacity similar to that found in children with unaided hearing thresholds in the severe range (Blamey et al., 2001b; Boothroyd & Eran, 1994; Dettman et al., 2003). Twenty-four children were identified due to parental concern, 21 were identified through the high-risk register screening program, and 12 were identified through referral from a specialist maternal and child health nurse. Eighteen children were diagnosed by 6 months of age, 15 were diagnosed between 7 and 12 months, 11 were diagnosed between 13 and 18 months of age, and 3 were diagnosed between 19 and 24 months. A further 10 children were diagnosed after 25 months of age. Causes of hearing loss were unknown \( (n = 28) \), genetic \( (n = 15) \), prematurity \( (n = 6) \), viral illness \( (n = 3) \), congenital malformation of the cochlea \( (n = 2) \), and auditory neuropathy \( (n = 3) \). The hearing devices of these children were managed by Australian Hearing, the responsible government body. Eighteen children with a severe-profound or profound hearing loss used the Nucleus CI24 cochlear implant with the SPRINT body-worn speech processor and the ACE speech-processing strategy (Psarros et al., 2002). These children were managed by the Cochlear Implant Clinic at the Royal Victorian Eye and Ear Hospital, and all had 20 active electrodes. Table 1 presents the demographic characteristics of the children.

Taralye early intervention staff are speech pathologists, teachers of the deaf, or audiologists. All children have access to the professional expertise of various staff as needed (including that of an educational psychologist), although each child is assigned a case manager upon entry to the program. The service delivery model is based on family attendance at the center for individual therapy sessions and focuses on parent education and facilitating children’s spoken language attainment in a developmentally appropriate manner. Intervention goals and session frequency are determined based on the needs of each family (ranging

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Median</th>
<th>SD</th>
<th>Range</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at identification (months)</td>
<td>10</td>
<td>12.0</td>
<td>1–51</td>
<td>57</td>
</tr>
<tr>
<td>Age at entry to intervention (months)</td>
<td>15</td>
<td>12.7</td>
<td>2–52</td>
<td>57</td>
</tr>
<tr>
<td>Age at hearing aid fitting (months)</td>
<td>15</td>
<td>13.3</td>
<td>2–52</td>
<td>39</td>
</tr>
<tr>
<td>Age at cochlear implant (months)</td>
<td>12</td>
<td>6.0</td>
<td>7–22</td>
<td>18</td>
</tr>
<tr>
<td>Primary caregiver education (years)</td>
<td>16</td>
<td>1.7</td>
<td>11–19</td>
<td>57</td>
</tr>
<tr>
<td>Degree of hearing loss (dBHL)</td>
<td>63</td>
<td>31.6</td>
<td>21–120</td>
<td>57</td>
</tr>
</tbody>
</table>
from weekly through to monthly sessions), but all programs focus on teaching spoken language through a partnership with parents, who are the primary facilitators of their children’s language development. The Taralye program uses an auditory–verbal communication approach and a play-based learning philosophy where carefully planned play experiences are used to promote learning and the development of spoken language, social, and other skills. From 18 months of age, group programs are offered, including an onsite 3- and 4-year-old kindergarten program. All children of appropriate age (regardless of degree of hearing loss) attend kindergarten with their hearing peers, where they are supported by Taralye staff. This occurs regardless of whether they attend kindergarten only at Taralye or also in their local community.

**Assessment Procedures.** Selection of language evaluation tools was based on the age of the child. For children aged less than 3 years, only a parent questionnaire was administered. For children aged 4–6 years, two standardized language tests were administered. For children aged 3 years, all three evaluation tools were administered. This means that results on one, two, or all three of the language evaluation tools may be presented for an individual child, depending on their age. Table 2 shows the numbers and ages of children assessed on each language evaluation tool.

**Language assessments.** Language abilities were assessed using three measures. All formal tests were administered face-to-face in the auditory–visual condition, at a distance of 1 m. All testing was conducted by an experienced clinician, and sessions were videotaped to facilitate checking of online scoring. Tests were administered and scored according to the procedures described in the test manuals.

**Children Aged 1–3 Years:** For children aged 1–3 years, language was assessed using the Child Development Inventory (CDI) (Ireton, 1992). This is a standardized screening and assessment tool, presented in a parent questionnaire format, for use with children aged 15 months to 6 years of age. The CDI measures children’s development in eight areas; however, only the expressive language and language comprehension scales were used in this article. The expressive language scale comprises 50 items covering expressive communication from simple gestural, vocal, and verbal behavior to complex language expression. The language comprehension scale comprises 50 items covering language understanding from simple comprehension to understanding of concepts. The CDI provides norms for children with normal hearing aged 1 year to 6 years and 3 months of age. Scores can be expressed in terms of “percent below age,” where the 30% below age cut-off (equal to 2 SDs below the mean) defines the normal range. A 25% below age cut-off is considered the lower end of children whose development is “mildly delayed.” As this test does not provide standard scores, expressive and receptive language quotients (LQs) were calculated for each child using the formula (age score/chronological age) × 100, where age score is the age at which the average score of normally hearing children is equal to the score of the child being evaluated. Therefore, a child whose language development was age appropriate, would have an LQ of 100. A total LQ was also calculated by averaging receptive and expressive LQ scores. The CDI was chosen to enable a direct comparison of results from this study with those of Yoshinago-Itano et al. (1998), who reported that children aged 12–36 months, who were diagnosed before 6 months of age, had significantly higher LQs on the CDI than children diagnosed after 6 months of age. Three-year-old children were also assessed using other norm-referenced assessment tools discussed below, in order to compare

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>CDI</th>
<th>PPVT</th>
<th>CELF-Preschool</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>33</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>42</td>
<td>42</td>
<td>42</td>
</tr>
</tbody>
</table>

*Note. Administration of language evaluation tools was based on the age of the child. For children aged less than 3 years, only the CDI was administered. For children aged 4–6 years, the PPVT and the CELF-Preschool were administered. For children aged 3 years, all three evaluation tools were administered. Therefore, dependent on their age, a child may have results on one, two, or all three of the language evaluation tools.*
the validity of the CDI results with those of norm-referenced tests.

Children Aged 3–6 Years: For children aged 3 years and over, receptive, expressive, grammatical, and semantic language skills were assessed using the Clinical Evaluation of Language Fundamentals-Preschool (CELF-Preschool; Semel, Wiig, & Secord, 1992). The CELF-Preschool consists of three receptive language subtests (Linguistic Concepts, Sentence Structure, and Basic Concepts) and three expressive language subtests (Recalling Sentences In Context, Formulating Labels, and Word Structure). The receptive language subtests involve closed-set tasks, in which children are required to point to a picture in response to a verbal prompt. The expressive subtests require a verbal response after a verbal and pictorial prompt. The CELF-Preschool has been standardized for ages 3 years through to 6 years and 11 months and provides norm-referenced scores for each 6-month interval within this age range. Children’s performance on this test is reported using standard scores.

Receptive vocabulary for children aged 3 years and older was assessed using the Peabody Picture Vocabulary Test (PPVT-III; Dunn & Dunn, 1997). It is a closed-set test in which the child is required to point to the one of four pictures that best represents the meaning of a verbally presented stimulus word. Alternative forms of this test (Forms A and B) were used in alternate years to avoid learning effects. As with the CELF-Preschool, children’s performance is reported using standard scores.

Use of the CELF-Preschool and the PPVT enabled a more direct comparison to be made between the results of this article and previous studies in which these tools were used to assess language outcomes for older children, which reported delayed language development, regardless of age at diagnosis, and conflicting results about the influence of degree of hearing loss on language outcomes (Blamey et al., 2001a; Wake et al., 2002).

Other assessments. Nonverbal Cognitive Status and Additional Disabilities: The Taralye psychologist assessed the nonverbal intelligence of children participating in the study. For children aged over 30 months, the Weschler Preschool and Primary Scale of Intelligence, Third Edition (Wechsler, 2002), was used. For younger children, a nonverbal performance scale score was obtained using the Griffiths–R scale, which measures cognitive and motor skill development in young children up to a 2-year-old level (Griffiths & Huntley, 1996). Children with scores below 80 (i.e., just over 1 SD below the mean) on either measure were classified as having cognitive abilities below the average range. This cut-off score was chosen in order to compare results with those of Yoshinago-Itano et al. (1998), who also used 80 as the cut-off. Two children who participated in the study did not receive a cognitive assessment. The presence of additional disabilities as well as hearing loss was diagnosed by medical practitioners, or the psychologist, or reported by parents. Thirteen of the children had additional disabilities. Six children with low cognitive ability were diagnosed with hearing loss before 6 months of age. Five children who were assessed using the CDI had below-average cognitive abilities, and 10 children who were assessed using the PPVT and CELF-Preschool had below-average cognitive abilities.

Family Participation: The Moeller’s Family Rating Scale (Moeller, 2000) was used to characterize the quality of family participation in children’s early intervention programs. Two early interventionists or other professionals who had worked closely with both the child and their family were asked to retrospectively rate family involvement in the child’s program over the course of the previous year. Each family was given a single global rating on a scale of one to five, and raters chose their ratings from specific descriptions of characteristics that represented each participation category. The descriptions included issues such as familial adjustment, session participation, effectiveness of communication with the child, and advocacy efforts of the parents on behalf of their child. Ratings were as follows: 1 = limited participation, 2 = below average participation, 3 = average participation, 4 = good participation, and 5 = ideal participation. Raters were also asked to indicate their confidence in their ratings as questionable, okay, or good. No ratings were reported as questionable. Ratings were compared for
inter-rater reliability. Complete agreement was found when both raters gave the same score, and categorical agreement was found when raters placed families in the same participation category, as defined above (i.e., ratings 1–2 = below average, 3 = average, 4–5 = above average. Where raters disagreed, an average of the two scores was used. If the raters had different confidence levels, a weighted average was calculated as follows:

\[
\text{Weighted average} = \frac{(\text{Rating 1} \times \text{Confidence 1}) + (\text{Rating 2} \times \text{Confidence 2})}{(\text{Confidence 1} + \text{Confidence 2})}
\]

Ratings were obtained for all families whose children participated in the study. No family was rated as below average in their participation level.

**Maternal Education:** Maternal education in each family was estimated using the education level (measured in years) of the primary caregiver, usually the mother. For one family, the primary caregiver was not the mother, and for two additional families, information about educational level was not available.

**Statistical Analyses**

Best subsets regression was used to evaluate all possible models of the regression equation for each measure and to identify the independent variables that best predicted language outcomes for use in multiple linear regression analyses of the factors affecting language outcomes in this sample. Best subsets regression is a technique for selecting variables in multiple linear regression by systematically searching through the different combinations of the independent variables and selecting the subsets of variables that best contribute to predicting the dependent variable. First, all models that have only one predictor variable included are checked, and the two models with the highest \( R^2 \) are selected. Then all models that have only two predictor variables included are checked, and the two models with the highest \( R^2 \) are chosen again. This process continues until all combinations of all predictor variables have been taken into account.

**Results**

Results for children with normal and low cognitive ability are often examined separately in the literature as nonverbal IQ is the strongest predictor of language outcomes for children with hearing loss up to the age of 5 years (Mayne, Yoshinaga-Itano, & Sedey, 2000). However, due to the relatively small number of participants in this study, although descriptive statistics are reported in the tables for these subsets of children, the results of all children who completed a particular language test were combined regardless of IQ status, with one regression analysis being conducted for each language test (three analyses in total).

Note that, for the regression analyses, all children with a cochlear implant were assigned a PTA of 75 dB HL. Given that a cochlear implant provides better access to speech information than a hearing aid in an ear with a profound hearing loss and has been estimated to provide an auditory speech perception capacity similar to that typically found in children with unaided thresholds in the severe range (Blamey et al., 2001a; Boothroyd & Eran, 1994; Dettman et al., 2003), this is a more representative measure of children’s current hearing ability than their most recent postoperative audiogram in their unimplanted ear. The alternative option, the use of a speech perception score, is a measure of an interaction between hearing and language ability, as no speech perception test assesses auditory ability independently of language. Given the ages of the children in this article and their delayed language skills, it is likely that a speech perception test would underestimate their auditory ability. It is acknowledged that this representation of hearing ability is less than ideal and that for any degree of hearing loss auditory ability can vary considerably (Boothroyd, 1991), particularly for profound hearing losses (Erber & Alencewicz, 1976).

Language Skills at 1–3 Years

Parents of 42 children aged 2–3 years completed the CDI. Table 3 presents CDI LQs, and Figure 1 shows the distribution of results with regard to severity of language delay for children with normal cognitive ability and children with low cognitive ability. Thirty-two children had normal cognitive ability, and 10 had low
cognitive ability. Overall, nine children (28%) with normal cognitive ability (three of whom were diagnosed with hearing loss before 6 months of age) had both age-appropriate receptive and expressive language skills. Of the children with low cognitive ability, one child (who was diagnosed with hearing loss before 6 months of age) demonstrated both age-appropriate receptive and expressive language skills on this measure.

Vocabulary Skills at 3–6 Years
Forty-two children aged 3–6 years completed the PPVT. Figure 2 shows the distribution of PPVT scores with regard to severity of language delay for all children. Thirty-seven children had normal cognitive ability, and five had low cognitive ability. The mean PPVT standard score for children with normal cognitive ability (aged 39–75 months) was 92.1 (SD = 13.7). Twenty-nine of these children (76%) had age-appropriate vocabulary, and eight (19%) were delayed in their vocabulary development. The mean PPVT standard score for five children with low cognitive ability (aged 46–66 months) was 78.4 (SD = 4.9). All five of these children had delayed vocabulary development.

Language Skills at 3–6 Years
The same group of 42 children who completed the PPVT also completed the CELF-Preschool. Table 4 shows standard scores for all children on the CELF-Preschool, and Figure 3 shows the distribution of results with regard to severity of language delay for children with normal cognitive ability and children with low cognitive ability.

Thirty-seven children had normal cognitive ability, and five had low cognitive ability. Twenty-two children with normal cognitive ability (59%) had age-appropriate receptive language, and 17 (46%) children had age-appropriate expressive language. Of

<table>
<thead>
<tr>
<th>Cognitive ability</th>
<th>Receptive LQ</th>
<th>Expressive LQ</th>
<th>Total LQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Normal</td>
<td>Low</td>
<td>Normal</td>
</tr>
<tr>
<td>Mean</td>
<td>80.0</td>
<td>62.0</td>
<td>79.0</td>
</tr>
<tr>
<td>SD</td>
<td>20.7</td>
<td>11.4</td>
<td>19.2</td>
</tr>
</tbody>
</table>

Table 3 CDI results for 42 children aged 23–50 months

<table>
<thead>
<tr>
<th>Cognitive ability</th>
<th>Receptive LQ</th>
<th>Expressive LQ</th>
<th>Total LQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Normal</td>
<td>Low</td>
<td>Normal</td>
</tr>
<tr>
<td>Mean</td>
<td>50.0</td>
<td>40.0</td>
<td>45.0</td>
</tr>
<tr>
<td>SD</td>
<td>10.0</td>
<td>15.0</td>
<td>12.0</td>
</tr>
</tbody>
</table>

Table 4 CELF-Preschool standard scores for 42 children aged 39–75 months
five children with low cognitive ability, one had age-appropriate receptive language and four were delayed in their receptive language development. All five children with low cognitive ability were delayed in their expressive language development.

Vocabulary and Language Skills at School Entry

Table 5 shows standard scores on all measures for 20 children with normal nonverbal IQ and no additional learning disabilities, aged 55–75 months, who exited Taralye to attend school during the study. This group of children was not selected but comprised all children who qualified by leaving Taralye to enter primary school during the course of the study. Of these children, only three were diagnosed before 6 months of age. Thirteen children (65%) had age-appropriate vocabulary (PPVT) scores (including two of the three early-diagnosed children), whereas seven (35%) were at least 1.5 SD below their normally hearing peers. Eight children (40%) had language skills in the normal range on the CELF-Preschool, six (30%) were mildly delayed, and a further six (30%) were severely delayed in their overall language development at school entry. Two of the three early-diagnosed children had age-appropriate language.

Regression Analyses

Best subsets regression was used to determine the most appropriate regression models to use in multiple linear regression analyses of CDI, PPVT, and CELF-Preschool language results. The combinations of independent variables identified as the best predictors by the best subsets regression models were entered into multiple linear regression analyses. Multiple linear regressions were used to explore the effects of combinations of degree of hearing loss (PTA), cognitive ability, family participation in children’s intervention programs, age at entry to early intervention, gender, maternal education, and use of hearing aids/cochlear implants on spoken language outcomes. All these factors have previously been reported to impact significantly on spoken language outcomes in preschool children (Blamey, 2003; Geers, 2002; Halpern, 2000; Moeller, 2000; Yoshinaga-Itano et al., 1998). Table 6 presents a summary of the multiple linear regression results.

The multiple regression model for CDI total LQ data fitted the data poorly. PTA, family participation, cognitive ability, parent education, and gender together accounted for only 36% of the variance in CDI scores. PTA was the only significant independent predictor of variance ($p < .050$) and accounted for 8.4% of the variance in scores.

The multiple linear regression model for PPVT standard scores showed that the combined variance of three independent variables accounted for 58% of the variance in the sample. PPVT scores were significantly negatively affected by PTA and this explained

| Table 5 | PPVT and CELF-Preschool standard scores for 20 children at school entry |
|---------|-----------------|-----------------|-----------------|-----------------|
|         | PPVT standard score | CELF receptive language standard score | CELF expressive language standard score | CELF total language standard score |
| Mean    | 87.7             | 84.6            | 76.7            | 80.3            |
| SD      | 14.8             | 19.6            | 15.4            | 17.2            |

Figure 3 CELF-Preschool standard scores for 42 children with regard to severity of language delay.
a large proportion of the variance (28.1%). Family participation and cognitive ability were both significant predictors, explaining 22.4% and 7.9% of the variance, respectively, with scores increasing with higher levels of family participation and cognitive ability.

Multiple linear regression analysis of factors contributing to CELF-Preschool Total Language standard scores accounted for 52% of the variance in the sample. CELF scores were again significantly negatively affected by PTA, which explained 22.2% of the variance in scores. As with PPVT scores, level of family participation was a significant predictor of CELF scores (scores increasing with a higher degree of family participation) and explained the majority of the variance accounted for by the model (25.2%). Cognitive ability accounted for 7.3% of variance in scores (scores again increased with higher cognitive ability). In this regression model, gender contributed to 2% of the overall variance but was not significant at the .05 level.

Maternal Education

The contribution of maternal education to level of family participation was examined using a Pearson product moment correlation. There was a significant positive correlation ($r = .76, p < .001$), with family participation increasing with higher educational attainment of the primary caregiver. No significant correlation was found between maternal education and children’s cognitive ability.

Discussion

Despite the fact that almost 60% of the children in this study had been diagnosed, fitted with hearing aids, and enrolled in early intervention by the age of 12 months, language development was delayed for around half of the children. For approximately a third of the children aged 1–3 years, this delay was severe (i.e., scores were more than 2 SDs below the mean for children with normal hearing), and only 28% of children demonstrated age-appropriate receptive and expressive language skills. The children showed similar degrees of delay, in terms of language skill development, to older children diagnosed at similar ages in other studies (Blamey et al., 2001b; Kennedy et al., 2006; Wake et al., 2005). There was also great variability in language outcomes between children in the present study, as has also been reported in these studies, and children with significant hearing loss and/or low cognitive ability showed greater language delays, as is commonly reported in the literature (Davis & Hind, 1999; Frush Holt & Iler-Kirk, 2005; Geers, 2002; Spencer, 2004).

The majority of the school-entry group, which comprised the older children in the study, was not linguistically ready for school. Given their relatively late ages of diagnosis, most of the children in the school-entry group had lost a significant amount of learning time by the time their hearing loss was diagnosed. In order to attain language competence commensurate with that of their normally hearing peers, they needed to learn language at a faster rate than
that of normally hearing children, and it is clear that most of these children were unable to do this during their limited time in early intervention. Further assessment of the school-entry group, along with others who will exit to attend school in the future, will continue. Results such as these highlight the need to closely examine and compare the effectiveness of various program elements and teaching techniques used in early intervention programs with children and their families, in order to maximize the effectiveness of early intervention in facilitating the “catch up” process that is required in order for many children with hearing loss to enter school with adequate language skills.

Family participation in children’s intervention programs was a significant predictor of spoken language abilities for children in this study. This finding supports previous research (Moeller, 2000) in suggesting that the best outcomes are achieved when there is strong family involvement in children’s learning. Family involvement was highly significant in the regression analyses of PPVT and CELF results, despite the restricted range of participation (all families were rated as “average” or “above average”), which would have decreased the sensitivity of the measure. This result suggests that an “average” level of support from parents may not be sufficient for children to achieve normal language outcomes. The fact that no family received a rating of less than average suggests that this population of families is reasonably involved in their children’s learning and may be unrepresentative of other populations in Australia and other countries in this regard. This relatively high level of involvement may be explained by the fact that almost all caregivers in this population were tertiary educated, and there was a strong positive correlation between maternal education and level of family participation.

PTA was the only significant independent predictor of variance in CDI results. However, family participation, cognitive ability, parent education, and gender together accounted for substantial shared variance in the CDI results. Combinations of these variables independently significantly affected language outcomes in other populations where the CDI has been used (Calderon, 2000; Yoshinaga-Itano et al., 1998). Given the great variability in language skills between children in this study, it is possible that with a larger group of participants, more of the variance in these results would be explained. A further explanation for these results could be that characteristics of particular families or home environments that were not measured may have contributed significantly to rates of language development. Given the relatively late mean age of diagnosis in this population, many children had been receiving intervention for only a short time by the age of 1–3 years when the CDI was administered, and it is possible that unmeasured, family-based factors were the greatest determinants of language skills for 1- to 3-year-old children.

Contrary to the findings of other studies (Kennedy et al., 2006; Moeller, 2000; Ramkalawan & Davis, 1992; Yoshinaga-Itano et al., 1998), language abilities did not differ significantly between children who entered early intervention early (prior to 6 months of age) and later (after 6 months of age) in this study. Given that family participation was such a strong predictive factor of language outcomes in this study and primary caregivers of early- and later-diagnosed children were equally involved in their children’s intervention programs, it is possible that the support provided by families of later-diagnosed children provided a buffer against the effects of late diagnosis on language development. The finding of Calderon (2000), in whose study there was a strong effect of diagnosis age, that mothers of children diagnosed before 6 months of age were more involved in their child’s intervention program than mothers of children diagnosed later lends support to this theory. Because it is extremely unlikely that early diagnosis alone would lead to age-appropriate language outcomes, a second explanation for the lack of a significant difference in language outcomes between early- and later-diagnosed children could be differences in the quality and/or quantity of early intervention received by the children in this study compared with that received by children who have participated in the studies conducted in the United States and the United Kingdom (Kennedy et al., 2006; Moeller, 2000; Yoshinaga-Itano et al., 1998). However, the difficulties of attempting to control and measure factors such as the quality of speech and language intervention provided in intervention centers by different therapists make this comparison an extremely difficult task.
The fact that age at diagnosis was not a significant predictor of language outcomes in this study could also be explained by several limitations of the study itself, the primary one being the relatively small number of participants, and in particular, the low number of early-diagnosed children. Small sample size, combined with the large degree of variance commonly found in language scores, offers an explanation for not finding a significant difference when there may have been one. Given these limitations and the contrary findings of others, no firm conclusions should be drawn about the effect of early diagnosis on language outcomes for Australian children based on these data, and these questions will again be addressed in the future, as data collection for a greater number of children, a greater proportion of whom are diagnosed early through neonatal hearing screening, continues.

Four previous studies have used some of the same language measures (Yoshinago-Itano et al., 1998; Moeller, 2000; Blamey et al., 2001a; Wake et al., 2005) and found similar average levels of performance for children at younger and older ages. The effects of age at diagnosis and PTA are not consistent across the four studies, as discussed below. These differences may be because the effects of age at diagnosis and PTA are not particularly strong because the power of the statistical analyses in the tests differed between the studies, or because the children in the studies were drawn from different populations.

Average receptive, expressive, and total CDI LQs for Australian children aged 1–3 years were almost exactly equivalent, respectively, to the averaged LQs of early- and later-diagnosed children in the study of Yoshinago-Itano et al. (1998). This indicates that overall language outcomes in the two studies were very similar at young ages, despite the fact that close to half of the American children were diagnosed early, compared with just over 30% in the present study.

Children aged 3 years and older in the present study achieved similar PPVT standard scores to children in the Blamey et al. (2001a) and Wake et al. (2005) studies and to (later diagnosed) children who had entered intervention by 23 months in the Moeller (2000) study. These results suggest that the vocabulary development of children in all four studies was progressing at a similar rate when age at assessment was taken into account. Similar trends can be observed with regard to CELF results when compared with those from Blamey et al. (2001a) and Wake et al. (2005), although the average total language score derived from the present study was slightly higher. Age at diagnosis was not found to affect language outcomes for the children in this study, or in the Blamey et al. (2001a) and Wake et al. (2005) studies, and examination of the raw data in all three studies did not show a trend for earlier diagnosed children to do better. It is possible that the relatively small number of children in each study who were diagnosed with hearing loss before 6 months of age may have decreased the statistical power of all three studies to find an effect of age at diagnosis.

Finally, it is interesting to note that although the present study and Wake et al. (2005) found that PTA had a significant negative effect on language outcomes with increasing severity of hearing loss, Moeller (2000), Yoshinago-Itano et al. (1988), and Blamey et al. (2001a) did not. There is some inconsistency in the literature with regard to the significance of the effect of PTA (e.g., Davis, Elfenbein, Schum, & Bentler, 1986; Yoshinaga-Itano, 2003).

In comparing the results of this study with those of others, it is important to remember that results are dependent on the characteristics of the population examined and that variables that account for a large proportion of variance in one population may not be so important in another. As has been suggested previously, variables that predict success for a population of children of which a significant proportion were diagnosed early may not be the same as variables significantly related to success in a primarily later-diagnosed sample, such as this one. The fact that diagnosis of hearing loss for the children in this study occurred through mechanisms other than neonatal hearing screening may also mean that some of the characteristics of this population differ from those of others studied.

This article highlights the importance of family participation in intervention programs to enable children to achieve optimal language outcomes, and in doing so, provides support for the findings of Moeller (2000). Language outcomes for this population were found to be similar to those reported for other children who have been diagnosed later, with PTA and
cognitive ability explaining the remainder of the variance in the majority of language outcomes. Contrary to recent reports, early-diagnosed children in this population did not demonstrate significantly better language abilities than later-diagnosed children. Further work with a greater number of children will clarify whether or not early diagnosis in the Australian population has a significant effect on language outcomes and whether the findings of the present study were largely due to its restricted sample size and the large variance in outcomes between participants.

Many children with hearing loss have achieved a high standard of education through independent learning, despite the many obstacles they face. However, these successes still represent the minority, not the majority, as illustrated by the results of this study. It is imperative that we determine how to optimally assist these children to lay strong foundations of language during their early years, so that age-appropriate language is more easily attainable for all children with hearing loss, as well as the subsequent improved quality of life these children deserve.

Funding

Australian Research Council Linkage Project Grant (LP 0347418); the University of Melbourne, Department of Otolaryngology.

References


Language and literacy of children with hearing impairment.


Received August 15, 2007; revisions received June 18, 2008; accepted August 12, 2008.