The Effect of IQ on Spoken Language and Speech Perception Development in Children with Impaired Hearing

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Introduction
Cognitive ability, or Intelligence Quotient (IQ), has long been shown to have a significant effect on language development in preschool children with hearing loss. IQ has been reported to be the strongest predictor of language outcomes for children under 5 years of age with hearing loss (Mayne et al., 2000). Non-verbal cognitive ability continues to have a sustained effect on language development, literacy and academic outcomes throughout childhood (Geers et al., 2008). There is a need for a greater understanding of factors affecting speech perception and language development, and the most effective methods of improving language outcomes to enhance the educational and career prospects of children with hearing loss.

The aims of this study were to examine:

a) the effect of IQ on the rate of language development in preschool and school-aged children
b) the interaction between IQ and degree of hearing loss
c) the effect of IQ on speech perception performance
d) the variation over time of the difference between IQ and Language Quotient initially observed in preschool.

Methods
Participants
Sixty-two children (28 males, 34 females) participated in the study. The children ranged in age between 5 and 12 years. Twenty-six children attended preschool and 36 were school-aged. All children used oral communication and attended oral early intervention or school settings. Forty-one children wore hearing aids, and 21 used the Nucleus cochlear implant (CI). Fifty-eight children had congenital hearing loss, 2 had
prelingual loss, and 2 had perilingual hearing loss. All children had parents with normal hearing and the primary language spoken at home was English.

**Intelligence (IQ) assessment**

Two intelligence scales were used to assess non-verbal intelligence quotients. The Weschler Preschool and Primary Scale of Intelligence (WPPSI) was used to assess the cognitive abilities of children in early intervention, and the Kaufman Assessment Battery for Children (K-ABC) was used to assess school-aged children. In both cases, in order to minimize the effect of hearing loss on the test results, the Performance Scale (non-verbal scale) score was used to estimate the cognitive abilities of the children. Items in these scales are administered using demonstration, and verbal instructions are minimized. Both the WPPSI-3 Performance Scale and the K-ABC Nonverbal scale are standardized with a mean of 100 and a standard deviation of 15.

**Language assessment**

The children’s language from age 3 years was assessed using 2 standardized tests; The Peabody Picture Vocabulary Test (PPVT) (Dunn & Dunn, 1997) and the Clinical Evaluation of Language Fundamentals (CELF). The PPVT is a closed-set test of receptive vocabulary. The CELF assesses receptive and expressive language skills. Two forms of the CELF were used: the CELF-Preschool (Semel et al., 1992) for children aged under 6.5 years, and the CELF-3 (Semel et al., 1995) for children aged 6.5 years and older.

**Speech perception assessment**

Children’s speech perception was assessed by an experienced clinician using the Consonant-Nucleus-Consonant (CNC) word test. Each child was assessed in the audition-alone (A) condition, and also in the audition plus vision (AV) condition. The CNC test lists were scored both according to the number of phonemes correct and the number of words correct in each list.

**Results**

**IQ distribution**

Non-verbal IQ standard scores for the children in this study were normally distributed, with 68 per cent of the children in the average range for non-verbal IQ. Of the 62 children, 10 had below average non-verbal cognitive abilities (IQ) (greater than 1 standard deviation [SD] below the mean), 42 were in the average range, and 10 achieved above-average scores (greater than 1 SD above the mean).

**Language**

a) Rate of vocabulary and spoken language development

Figure 1 shows PPVT equivalent age compared to chronological age for the study children. It is clear that the children were learning vocabulary, on average, at just over 70 per cent of the rate of normally-hearing children, and therefore were delayed in their development compared to children with normal hearing of the same age.
Figure 2 shows CELF equivalent age compared to chronological age. Children were learning spoken language, on average, at approximately 65 per cent of the rate of normally hearing children. As expected due to the greater difficulty of this task, this is slightly less than the rate at which they were learning vocabulary.

b) Factors affecting language outcomes
IQ was positively correlated with language performance on the CELF (Pearson correlation coefficient, $r = 0.259$, $p = 0.001$). Multiple linear regression analysis accounted for 58.6 and 67.0 per cent of the variance in CELF and PPVT scores respectively.

The regression equations were:

\[
\text{CELFeq} = -2.43 + 0.0453 \text{IQ Std Score} - 0.0232 \text{PTA} - 0.127 \text{Onset Age}
+ 0.63 \text{Assessment Age}. \quad R^2 = 0.586
\]

\[
\text{PPVTeq} = -0.251 + 0.0462 \text{IQ Std Score} - 0.0260 \text{PTA} + 0.110 \text{Onset Age}
+ 0.702 \text{Assessment Age}. \quad R^2 = 0.67.
\]

Language outcomes were significantly affected by age and degree of hearing loss. Preschool children learned language at a faster rate than children attending primary school. On average, younger children attending preschool were learning at 0.78 of the rate for normal hearing children. School-aged children were learning at 0.67 of the normal rate.

There was a significant difference between IQ scores and Language Quotients for both the PPVT and CELF. These results would not be expected in normal hearing children. This was evident for both preschool and primary school children.

**Speech perception**

Figure 3 shows speech perception results in the audition-alone (A) condition on the CNC Word test compared to equivalent language age on the CELF. Speech perception scores did not plateau until children had, on average, the language ability of a normally hearing 7-year-old child. Multiple regression analysis of CNC scores were conducted to determine the factors affecting speech perception performance.
Once language was accounted for, neither IQ ($p > 0.16$) nor degree of hearing loss (PTA; $p > 0.13$) had a significant effect on speech perception performance. In the AV condition, similar results were obtained (IQ, $p > 0.4$; PTA, $p > 0.9$).

**Conclusions**

Children in this study were learning language, on average, at approximately two-thirds of the rate of their normally hearing peers. Younger children attending preschool had a slightly higher rate of language development than children attending primary school. There are strong relationships between IQ and language outcomes and between language skills and speech perception ability. After adjusting for the effect of language, IQ had no direct effect on speech perception performance. However, because IQ had a significant effect on language outcomes, it did have an indirect effect on speech perception performance. This is due to the fact that language is the medium through which speech perception assessments are conducted; children have to comprehend the language used in speech perception tests and respond using spoken
language (in either word or sentence form). It could reasonably be assumed that if children were unfamiliar with the language used in speech perception tests that this would have a detrimental effect on their performance.

Further research is needed to determine whether children with more severe cognitive impairment achieve similar results in terms of their language and speech perception outcomes.

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Bibliography


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