

EMPIRICAL MANUSCRIPT

Factors Affecting Psychosocial and Motor Development in 3-Year-Old Children Who Are Deaf or Hard of Hearing

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Abstract

Previous research has shown an association between children's development of psychosocial and motor skills. This study evaluated the development of these skills in 301 three-year-old deaf and hard of hearing children (*M*: 37.8 months) and considered a range of possible predictors including gender, birth weight, age at first fitting with hearing devices, hearing device used, presence of additional disabilities, severity of hearing loss, maternal education, socio-economic status (SES), language ability, and communication mode. Caregivers reported on children's development using the Child Development Inventory (CDI). On average, both psychosocial and motor development quotients were within the typical range for hearing children, with large individual differences. There was a positive correlation between language ability and both social and motor development, and also between social and motor development. Age at first fitting of hearing aids (as an indicator of age at identification of hearing loss), SES, degree of hearing loss, and maternal education were not significant predictors of social skill or motor development, whereas presence of additional disabilities and birth weight were. Girls performed better than boys on all but the Gross Motor subscale of the CDI. Children with hearing aids tended to perform better than those with cochlear implants on the Gross Motor subscale.

An extensive body of literature has demonstrated the developmental consequences of early childhood hearing loss for communication, language, cognitive, and educational outcomes (Joint Committee on Infant Hearing, 2007). Hearing loss has also been associated with poorer developmental outcomes in psychosocial development (Korver et al., 2010; Moeller, 2000, 2007; van Eldik, Treffers, Veerman, & Verhulst, 2004) and motor development (Hartman, Houwen, & Visscher, 2011; Rajendran & Roy, 2011). These two areas of development have received relatively less attention in the literature, particularly in literature describing developmental outcomes for very young deaf and hard of hearing (DHH) children. In this research, we considered the development of both psychosocial and motor skills in 3-year-old

children with hearing loss relative to both a range of possible predictor variables and to each other. The latter consideration acknowledges that numerous studies have found an association between psychosocial and motor development in children with typical hearing (Bart, Hajami, & Bar-Haim, 2007; Cummins, Piek, & Dyck, 2005; Lingam et al., 2010).

Psychosocial Development and Hearing Loss

Moeller (2007) undertook a review of studies investigating developmental outcomes in DHH children across a number of

psychosocial domains and concluded that this group was at greater risk of poorer developmental outcomes than their typically hearing peers. Subsequent studies have provided further support for this conclusion.

Hintermair (2007) used the Strength and Difficulties Questionnaire (SDQ) to study 213 German DHH children from 4 to 12 years of age and reported a 2.5-fold increase in the total difficulties score for DHH children relative to the normative data for hearing children. Fellingner, Holzinger, Sattel, and Laucht (2008) also used the SDQ to assess 99 DHH Austrian children and adolescents aged 6–16 years (mean age 11.1 years). Mean scores were significantly more negative than those of the normative sample, with 36% of DHH children reported by their parents to be in the borderline or abnormal category compared to 18% of the normative sample. In a similar study of 334 Danish DHH children (aged 6–19 years), Dammeyer (2010) used teacher-reported data for the SDQ and found the prevalence of psychosocial difficulties to be 3.7 times higher than for a Swedish normative sample.

Korver et al. (2010) studied a cohort of 150 Dutch children aged 3–5 years using parent reports generated by the Child Development Inventory (CDI) and the Pediatric Quality of Life Inventory (PedsQL). Mean developmental quotients for the Social Development Scale on the CDI and for both the Emotional Development and Psychosocial Development scales of the PedsQL were within the borderline range (i.e., a quotient between 70 and 80) relative to the normative sample. Their findings for this younger cohort were consistent with those from both the studies of older children reviewed here and with the overall conclusion that DHH children are at risk of poorer outcomes across a range of aspects of psychosocial development when compared with their hearing peers.

Motor Development and Hearing Loss

As for psychosocial development, several studies of motor abilities in DHH children have reported difficulties or delays—most often in regard to balance and sensory integration (Cushing, Papsin, Rutka, James, & Gordon, 2008; De Kegel et al., 2010; Engel-Yeger & Weissman, 2009). Other studies, however, have identified issues in regard to motor performance more broadly, including gross motor abilities.

Gheysen, Loots, and Van Waelvelde (2008) assessed 36 DHH Belgian children aged 4–12 years and a comparison group of 43 children with typical hearing using the Movement Assessment Battery for Children (MABC). The DHH children scored significantly worse on all scales including Manual Dexterity, Ball Skills, and Balance. Similarly, Hartman et al. (2011) assessed 42 DHH Dutch children aged 6–12 years with the same instrument and found that they had significantly more “borderline” and “definite” motor skill problems than the normative sample. Livingstone and McPhillips (2011) investigated the gross motor skills of 25 DHH Irish children aged 6–12 years, using the MABC and reported scores for the DHH group that were significantly lower than that for a matched sample of hearing children. In contrast with these findings, Korver et al. (2010) found that, on average, their younger sample of children aged 3–5 years had developmental quotients in the typical range for the Fine Motor and Gross Motor Scales of the CDI and also for the Physical scale of the PedsQL.

Gheysen et al. (2008) and Wiegersma and Van der Velde (1983) speculated about a variety of possible causes for the motor problems or developmental deficits observed in some DHH children, including: (a) neurological or vestibular problems, (b) sensory

deprivation, (c) language difficulties (resulting in a lack of verbal representations of motor skills and motor performance strategies), and (d) emotional issues associated with parental behaviors such as overprotection. Other researchers, including Lieberman, Volding, and Winnick (2004) and Horn, Pisoni, and Miyamoto (2006), have argued that findings of atypical motor development in DHH children are likely to be the result of differences in types of intervention/education or factors such as the age at identification of hearing loss and commencement of intervention.

Given the diversity in motor skills that has been reported for DHH children, there is a need to further investigate the nature of motor skill development in this group and the potential predictors of that observed variability.

Influences on Psychosocial and Motor Development

Across the range of studies that have considered psychosocial and/or motor development in DHH children, various factors have been considered as potential contributors to within-group variability. Principal among these potential predictors are the variables considered below.

Level of Hearing Loss

As for other areas of development, numerous researchers have investigated level of hearing loss as a potential predictor of psychosocial development and behavioral problems. Fellingner et al. (2008), for example, reported a higher incidence of “externalizing problems” (conduct problems and hyperactivity) among children with severe hearing loss than among those with moderate or profound losses. By contrast, Stevenson, McCann, Watkin, Worsfold, and Kennedy (2010) found no significant effect of degree of hearing loss in their study of parent- and teacher-reported behavior problems of 120 English DHH children aged 5.4–11.7 years ($M = 8$ years).

Language Development and Mode of Communication

In the same study, Stevenson et al. (2010) investigated associations between language development and behavior problems and found that the latter were more prevalent among children with the least developed language abilities. That conclusion is consistent with other studies that have investigated the effect of communication abilities—particularly the effectiveness of children’s communication with their family members—on psychosocial development. Dammeyer (2010), van Eldik et al. (2004), and Fellingner, Holzinger, Sattel, Laucht, and Goldberg (2009) all found that poorer language and communication skills in either spoken or signed language were associated with an increased prevalence of psychosocial difficulties or mental health problems in DHH children.

Closely related to the issue of language and communication ability, some researchers have considered whether parental hearing status and/or the mode of communication used by DHH children may be associated with psychosocial development. Polat (2003) reported that parental hearing status was a significant predictor of DHH children’s social adjustment, self-image, and emotional adjustment, with children of Deaf parents being better adjusted than those with hearing parents. Dammeyer (2010), however, found that parental hearing status was not related to children’s level of psychosocial difficulties. Hintermair

(2006) considered the same issue and also the contribution of children's mode of communication (i.e., signed or spoken) in a study of 213 mothers and 213 fathers and their DHH children (age: 4.0–12.9 years). He examined possible associations between parental resources, various socio-demographic variables, and the children's socio-emotional development. He concluded that, although the children's and parents' communicative competence had an effect on the children's socio-emotional development, there was no effect of the modality of that communication (i.e., signed, spoken, or mixed). Nevertheless, the effect of mode of communication did approach significance and this issue would still appear to warrant further investigation.

With regard to motor development, the potential influence of language and communication abilities has most frequently been considered among children who use cochlear implants. Horn, Pisoni, Sanders, and Miyamoto (2005) studied a sample of 42 children with cochlear implants aged between 5 months and 5 years. Children with higher scores on a range of language measures, including vocabulary and speech perception, performed significantly better in regard to motor abilities. Building on those findings, Horn et al. (2006) used the Vineland Adaptive Behavioral Scales, to assess the gross and fine motor skills of DHH children aged between 6 months and 4 years before they received a cochlear implant. They described a strong, positive correlation between the children's fine motor skills and their postimplant receptive and expressive language skills as assessed using the Reynell Developmental Language Scales. They also reported that, as those children advanced in age, their fine motor skills showed increasing signs of delay. Conway et al. (2011) examined the fine motor development of 5- to 9-year-old children with cochlear implants and found that motor sequencing ability was significantly positively correlated with language skills.

In sum, there would appear to be good reasons to continue to investigate both language competence and mode of communication in regard to their potential relationship with the development of psychosocial and motor abilities in young DHH children.

Cognitive Ability

Because of the difficulties associated with the reliable assessment of cognitive abilities in very young children, this variable has most commonly been considered in studies of children over the age of 5 years. Van Eldik (2005) reported on the results for 202 Dutch children aged 11–18 years who were administered the Youth Self Report (YSR). The children with moderate to high IQ scores showed significantly fewer internalizing and social problems than those with low scores. In their investigation of the gross motor skills of children aged 6- to 12- years, Livingstone and McPhillips (2011) found that, although the DHH children in their study performed significantly more poorly than a matched group of hearing peers, there was no effect of cognitive ability.

Gender

Some authors have suggested a potential relationship between gender and psychosocial problems, with boys most often being identified as having more difficulties than girls (e.g., Cartledge, Paul, Jackson, & Cochran, 1991; Meadow, 1980, 1983). In contrast, Polat (2003), van Eldik (2005), and Dammeyer (2010) all considered gender as a potential factor accounting for variability in psychosocial difficulties among DHH children but found no significant effect. Similarly, in regard to motor abilities, Livingstone

and McPhillips (2011) found no significant association between gender and the gross motor skills of the children in their study.

Additional Disability

Some studies have addressed the issue of additional disability as a potential factor accounting for psychosocial difficulties. Dammeyer (2010) found that children with hearing loss and additional disability had psychosocial difficulties reported by their teachers at a rate 3 times higher than that of their counterparts with hearing loss alone. Rajendran and Roy (2010) compared scores on the PedsQL for three groups of 100 age-matched children—typically hearing children, children with hearing loss only, and children with hearing loss and motor impairment. Their results indicated that the physical and social health scores for children with hearing loss alone did not differ significantly from scores for the sample of children with typical hearing. There was, however, a statistically significant difference between the scores of these two groups and the children with both hearing loss and motor impairment.

Hearing Device

Another factor that has been investigated as a potential influence on psychosocial and motor development in young DHH children is the nature of the hearing device used. In their review of the literature on this issue, P. E. Spencer, Marschark, and L. J. Spencer (2011) concluded that available evidence suggested no negative effects of using a cochlear implant on the social or emotional development of DHH children. Neither, they concluded, was there any reason to suggest that there were particular benefits of using a cochlear implant in ameliorating the “social interaction difficulties” experienced by DHH children (p. 464). Similarly, in the motor domain, numerous researchers have investigated the motor skills of children who have received cochlear implants.

Livingstone and McPhillips (2011) reported that children using cochlear implants performed significantly worse than those using hearing aids on the ball skills and static and dynamic balance subtests of the MABC, but not on the manual dexterity subtest. They noted, however, that differences between children with implants and those with hearing aids were less definitive in regard to performance on the Balance Master clinical procedures. Gheysen et al. (2008) considered the motor development of 36 mainstreamed DHH children aged 12 years, including 20 children who had received cochlear implants, and a comparison group of 43 hearing children. They concluded that there was no significant difference in the gross motor performance of the children with cochlear implants and those without. Schlumberger, Narbona, and Manrique (2004) also reported no significant relationship between cochlear implantation and complex motor sequencing and balance in 5- to 9-year-old children. In contrast, Cushing, Chia, James, Papsin, & Gordon (2008) reported evidence suggesting a positive influence of electrical cochlear stimulation on the balance skills of 4- to 17-year-old children with cochlear implants. In that study, children displayed better balance when their implants were turned on, rather than off. With respect to fine motor skills, Shin et al. (2007) reported that children with cochlear implants in their study (mean age 7 years) showed a marked increase in speedy and delicate motor coordination skills 6 months after cochlear implantation. It is evident that the issue of hearing device type warrants further consideration in regard to development of young DHH children in both the psychosocial and motor domains.

Age at Identification

Several studies have considered the effect of the age at which children's hearing loss was identified as a factor in both psychosocial and motor development. Wake, Hughes, Collins, and Poulakis (2004) used the Child Health Questionnaire (CHQ) to evaluate 85 Australian DHH children aged 7–8 years and found that earlier identification did not contribute significantly to variance in their participants' overall Psychosocial Summary scores. Their results are in contrast with those of Korver et al. (2010). In that study, developmental outcomes for 80 children who were identified through universal newborn hearing screening (UNHS) (mean age at amplification 15.7 months) were compared with those of 70 children identified later through distraction testing (mean age at amplification 29.2 months). Korver et al. found that children who were identified earlier scored better on the Social Development but not the Self Help scale of the CDI. They also found that the early-identified children scored better on the Gross Motor scale. Scores on the PedsQL were significantly better for the early-identified group on the Social, Psychosocial, and Physical scales but not the Emotional scale.

Other Potential Predictors

An additional child variable that has been shown to be associated with outcomes for hearing children across a range of developmental domains is birth weight (Boardman, Powers, Padilla, & Hummer, 2002; Boulet, Schieve, & Boyle, 2011; Hediger, Overpeck, Ruan, & Troendle, 2002). Specifically, Hediger et al. (2002) reported significant negative associations between birth weight and both social and motor skill development in their study of 4,621 US-born children aged 2–47 months. In each of these studies, there have also been effects noted for additional socio-demographic variables including socio-economic status (SES) and parental/maternal level of education (Boardman et al., 2002; Boulet et al., 2011). Notably, maternal level of education was also found to be a variable associated with both and social and motor skill development in the study of DHH children conducted by Korver et al. (2010).

Questions to Be Addressed

The studies reviewed to this point strongly suggest that DHH children may demonstrate poorer psychosocial and motor development outcomes than children with typical hearing. Further, they suggest the potential for those outcomes to be associated with a number of factors. For the most part, however, the evidence for those associations is either inconclusive or relates to children of school age, and often high school age.

With the exception of the study conducted by Korver et al. (2010), there has been little consideration of the effect of hearing loss on psychosocial and motor outcomes among children of preschool age. Further, although there has been some consideration of age at identification and commencement of intervention as potential factors in psychosocial and motor development (e.g., Korver et al., 2010; Stevenson et al., 2010), few studies have considered samples with a high proportion of children that might be considered to be early-identified relative to the standards established by newborn hearing screening. To address this gap in the literature, the current study considered a large sample of 3-year-old DHH children in order to examine their psychosocial and motor development and a range of potential predictors of that development. Specifically, it sought to address the following questions as they relate to this group:

1. Are levels of psychosocial and motor development within the expected range for typically developing children of the same age;
2. Do associations exist among parent-reported levels of psychosocial, motor, and language and communication skill development; and
3. Are there relationships between levels of both psychosocial and motor development and a range of other child and family characteristics including presence of additional disabilities, birth weight, gender, hearing device used, age at first fitting with hearing device/s age (as an indicator of age at identification of hearing loss), severity of hearing loss, maternal level of education, SES, and communication mode used in intervention?

Method

Context of the Current Research

Data presented in this paper were collected as part of the Longitudinal Outcomes of Children with Hearing Impairment (LOCHI) study (Ching, Leigh, & Dillon, 2013). The LOCHI study is a prospective, population-based study of DHH children that commenced in 2005. All families with children born between May 2002 and August 2007 in the Australian states of New South Wales, Victoria and Queensland (excluding regional areas) who were identified before 3 years of age with hearing loss sufficient to require the fitting of amplification were invited to participate in the study. Children who had not been fitted with a hearing aid or cochlear implant were excluded from the study sample. Parents reported that most children (85% of those with hearing aids, and all but one child with cochlear implants) used their devices for more than 75% of their waking hours (Ching, Dillon, et al. 2013; Marnane & Ching, 2015). Detailed information about the broader LOCHI study has been presented by Ching, Leigh et al. (2013).

Participants

Data were available for 301 children enrolled in the LOCHI study when they were 3 years old ($M = 37.8$ months, $SD = 1.7$; range 35–43 months). Demographic information describing these children and their caregivers is presented in Table 1. There were slightly more males than females, with hearing losses ranging in severity from mild to profound—the largest percentage (just over 1/3) having a moderate loss. More children used hearing aids (72.3%) than cochlear implants (27.2%) and one child did not use an amplification device at the time of testing. All children (including those who later received a cochlear implant) were fitted with hearing aids initially with their age at first fitting indicating their age at identification of their hearing loss. Mean age at first fitting was 7.7 months ($SD = 7.9$), with 187 (62.1%) children fitted before 6 months of age, and the remaining between 6 months and 30 months of age.

The most frequent additional disabilities were developmental delay (39; 12.9%), cerebral palsy (23; 7.6%), and autism spectrum disorder (10; 3.3%). For 219 (72.8%) of the children, the mode of communication used in their early intervention program was aural/oral only. Only 2 (0.7%) children used Auslan (Australian Sign Language) only and 70 (23.3%) used a combination of oral and manual communication (typically manually coded English or another augmentative communication system

Table 1. Demographic characteristics of participants (N = 301)

Child characteristics	
Gender	
Male	160 (53.2%)
Female	141 (46.8%)
Birth weight (g)	
Mean	3,008
SD	962
Median	3,200
Interquartile range	2,590–3,645
Not reported (n)	25
Device	
Hearing aid	218 (72.3%)
Cochlear implant	82 (27.2%)
Unaided	1 (0.3%)
Additional disabilities	
Absent	194 (64.4%)
Present	78 (25.9%)
Unknown	29 (9.6%)
Severity of hearing loss ^a	
Mild (20–40 dB HL)	59 (19.6%)
Moderate (41–60 dB HL)	106 (35.2%)
Severe (61–80 dB HL)	51 (16.9%)
Profound (>80 dB HL)	85 (28.2%)
Age at first hearing aid fitting (months)	
Mean	7.7
SD	7.9
Median	4.3
Interquartile range	2.4–10.4
Age at first cochlear implant switch-on (months)	
Mean	16.8
SD	7.8
Median	14.5
Interquartile range	10.0–23.5
Family characteristics	
Maternal education	
School	100 (33.2%)
Diploma or certificate	71 (23.6%)
University	118 (39.2%)
Not reported	9 (3.0%)
Socio-economic status (IRSAD decile ^b)	
Mean	7
Median	7
Interquartile range	6–9
Intervention characteristics	
Communication mode in intervention	
Aural/oral only	219 (72.8%)
Oral and sign	70 (23.3%)
Sign only	2 (0.7%)
Not reported	10 (3.3%)

Note. ^aBetter ear average hearing threshold, 0.5–4 kHz.

^bIndex of Relative Socio-economic Advantage and Disadvantage (IRSAD; Australian Bureau of Statistics, 2006).

together with spoken English). SES was measured using the Index of Relative Socio-economic Advantage and Disadvantage (IRSAD; Australian Bureau of Statistics, 2006), which is scored in deciles (1–10) with higher scores indicating a relative lack of disadvantage and greater advantage. Children were generally from areas of less disadvantage with a median IRSAD decile of 7. Maternal education was specified in terms of three categories: school only (i.e., ≤12 years of schooling), diploma or certificate, and university qualification, with the largest proportion of children's female caregivers having attended university (39.2%).

Procedure

As part of children's 3-year-old assessment in the LOCHI study, each child's caregiver completed three questionnaires which were analyzed for this report: CDI (Iretton, 2005), Parents' Evaluation of Aural/Oral Performance of Children (PEACH; Ching & Hill, 2007), and a custom-designed demographic questionnaire. In addition to these questionnaires, data regarding children's age at first hearing aid fitting, degree of hearing loss, type of hearing device, and age at cochlear implant switch-on were provided by Australian Hearing (i.e., the Australian Government agency which provides audiological services for all Australian children who are resident or citizens).

The CDI (Iretton, 2005) is a standardized questionnaire designed to assess children's development from 15 months to 6 years. It contains 300 statements that describe observable aspects of child behavior. Caregivers are requested to state either Yes or No to indicate whether they have observed each behavior in their own child. CDI items are sufficiently generic to apply to both spoken and signed communication, and parents were instructed to consider their child's full communication system when completing it. Although the CDI has eight subscales (Social, Self Help, Gross Motor, Fine Motor, Expressive Language, Language Comprehension, Letters, and Numbers), the primary focus of this research was on four CDI subscales that describe aspects of psychosocial development (Social and Self Help) and motor development (Gross Motor and Fine Motor). Given the potential relationship between language and communication abilities and psychosocial outcomes, results for two other subscales—Language Comprehension and Expressive Language—were also included in the analysis.

The Social subscale of the CDI consists of 40 items that seek to measure aspects of personal and group interaction and social behaviors including care and concern for others, initiative, independence, and social interaction. The Self Help subscale contains 40 items that address self-care skills, independence, and personal responsibility in areas including eating, toileting, bathing, and dressing. Taken together, these scales represent discrete aspects of ability in the psychosocial domain. They reflect children's developing capabilities and independence in social and personal contexts. The Gross Motor subscale incorporates 30 items that address the development of locomotion and related behaviors involving strength, balance, and coordination. The Fine Motor subscale is made up of 30 items that measure visual-motor skills ranging from simple eye-hand coordination to the development of complex fine motor skills such as drawing. Taken together, these scales represent discrete aspects of ability in the motor domain. The Language Comprehension subscale comprises 50 items that measure children's understanding of language ranging from simple words to concepts. The Expressive Language subscale also contains 50 items that range from simple gestural and/or vocal behavior to complex language expression (achievable using spoken or signed communication).

The PEACH (Ching & Hill, 2007) is a measure of functional communicative performance in everyday life as judged by caregivers. The test contains 13 questions, 2 of which address the child's use of sensory devices. The remaining 11 questions solicit information about the child's ability to listen and communicate in quiet and in noise, to use the telephone, and to respond to environmental sounds in everyday situations. An overall functional performance score was calculated using the summed ratings provided by caregivers in response to the 11 questions.

The custom-designed questionnaire that was completed by caregivers provided demographic information, including

children's birth weight, diagnosed disabilities in addition to hearing loss, communication mode at early intervention, location (residential postcode), and the caregivers' own educational experience.

Data Analysis

All statistical analysis was conducted using R, version 2.13.1 and Statistica software. For all CDI subscales, the published normative data were used to recalculate children's individual results into developmental ages, which were then used to derive developmental quotients, which were calculated by dividing the child's developmental age by their chronological age, expressed as a percentage. Children whose developmental age for a particular subscale matched their chronological age received a quotient of 100. A developmental quotient of 80 or more represents typical development. A quotient between 70 and 80 is considered borderline. A difference of 4 points is generally regarded as clinically relevant (Ireton & Glascoe, 1995). For the PEACH, the group mean score and SD in children with typical hearing were used to derive z scores for participants. With respect to the variable of communication mode used in early intervention, children who used sign language only ($n = 2$) were grouped with children who used oral and manual communication ($n = 70$) for analysis purposes.

Spearman rank order correlation analysis was conducted to test for associations among the psychosocial (Social and Self Help) and motor subscales of the CDI (Gross Motor and Fine Motor), the two language subscales of the CDI (Language Comprehension and Expressive Language), and the PEACH. A conservative Type I error rate of $p < .002$ (two-tailed) was adopted to compensate for the number of statistical comparisons (21 in total).

To examine the influence of child, family, and intervention variables on psychosocial/motor outcomes, the data for each of the psychosocial (Social and Self Help) and motor (Gross Motor and Fine Motor) subscales of the CDI were analyzed using multiple regression. Four regression models were fitted, each having the quotient for a different CDI subscale as its dependent variable. There were 10 predictor variables (see Table 4) including 5 categorical variables and 5 continuous variables. The categorical variables were gender, additional disabilities, hearing device, communication mode in educational intervention, and maternal education. The five continuous variables were birth weight,

severity of hearing loss, age at first hearing aid fitting, age at switch-on of first cochlear implant (for children with cochlear implants), and SES of family (IRSAD). An interaction term between device and four frequency average hearing level (4FA) was also included. In these analyses, the required level of statistical significance was set at 0.05 (5%).

Results

Mean developmental quotients and SDs for the six subscales of the CDI and standard scores for the PEACH are provided in Table 2. Children's performance on the four measures of psychosocial and motor development was within the typical range on average; however, SDs were high, with some children achieving scores well below the mean. By contrast, mean quotients for the two measures of language ability and standard scores on the PEACH were, on average, below the range of typical development (see Table 2).

Language and communication abilities were significantly associated with outcomes across all four measures of psychosocial/motor performance. Table 3 shows the correlation coefficients (Spearman's rho) among each of the six developmental quotients derived from the CDI and z-scores for the PEACH. These analyses indicate that all four psychosocial and motor quotients were significantly positively associated with one another and with the CDI quotients for both Language Comprehension and Expressive Language skills, and also to functional communication performance as reflected in PEACH scores.

Table 2. Mean quotients and SDs for the six subscales of the CDI and standard scores for the PEACH ($N = 301$)

	Mean	SD
Psychosocial and motor measures (CDI)		
Social development quotient	86.5	36.2
Self-help quotient	88.8	33.4
Gross motor quotient	85.1	35.5
Fine motor quotient	92.9	28.9
Language outcomes (CDI)		
Expressive language quotient	72.2	28.1
Language comprehension quotient	75.8	30.6
Functional communication (PEACH)	71.1	21.2

Note. CDI = Child Development Inventory; PEACH = Parents' Evaluation of Aural/Oral Performance of Children.

Table 3. Correlations (Spearman's rho) between psychosocial/motor quotients and measures of language and communication ability

	Social development quotient	Self-help quotient	Gross motor quotient	Fine motor quotient	Expressive language quotient	Language comprehension quotient	PEACH
Social development quotient	1.00	0.644* ($n = 301$)	0.560* ($n = 301$)	0.587* ($n = 300$)	0.740* ($n = 283$)	0.748* ($n = 283$)	0.504* ($n = 222$)
Self-help quotient		1.00	0.712* ($n = 301$)	0.681* ($n = 300$)	0.551* ($n = 283$)	0.560* ($n = 283$)	0.368* ($n = 222$)
Gross motor quotient			1.00	0.586* ($n = 300$)	0.467* ($n = 283$)	0.444* ($n = 283$)	0.316* ($n = 222$)
Fine motor quotient				1.00	0.513* ($n = 283$)	0.534* ($n = 283$)	0.334* ($n = 222$)
Expressive language quotient					1.00	0.914* ($n = 283$)	0.523* ($n = 213$)
Language comprehension quotient						1.00	0.558* ($n = 213$)
PEACH							1.00

Note. The data for the number of participants varies for each correlation due to different numbers of children having complete data on each measure. PEACH = Parents' Evaluation of Aural/Oral Performance of Children.

*Significant correlations at $p < .001$.

Table 4 shows the results of separate multiple regression analyses conducted using the developmental quotients for each of the four psychosocial/motor subscales of the CDI as dependent variables. The table shows the effect estimate and 95% confidence interval (CI) for the change in mean of each developmental quotient that is associated with a change in each of the predictor variables while holding the other predictors constant. For the five categorical variables, the change in predictor is expressed in Table 4 as two values with the reference value first and the comparison value second (e.g., for gender the reference is male, and the comparison is female, and the table shows that a change from male to female results in an increase of 9.8 points on the developmental quotient of the CDI Social scale, CI from 1.9 to 17.8). For the predictors that are continuous, the effect estimate and 95% CI are for the change in mean of the developmental quotient associated with a change in the predictor from the first quartile value to the third quartile value (e.g., for birth weight a change from the first quartile value to the third quartile value results in an increase of 6.5 points on the developmental quotient of the CDI Social scale, CI from 1.8 to 11.4).

Two factors were shown to be associated with all four psychosocial/motor quotients at the 5% level of significance. Mean developmental quotients were significantly lower for children with additional disabilities and, independent of that effect, for children with lower birth weight. For the two psychosocial subscales and the Fine Motor subscale, developmental quotients were also higher for girls than for boys. For both the Self Help and Gross Motor subscales, the developmental quotients were higher for children who used aural/oral communication than for children who used a combination of oral and manual communication.

For the Gross Motor subscale, the mean developmental quotient was higher for children with hearing aids than for those who had received a cochlear implant, although the difference only just met the level required for statistical significance ($p = .05$). Nevertheless, the effect estimate (-8.8 points) was substantial and suggests that the relationship between device type and gross motor abilities warrants further consideration. By contrast, there was no significant difference between these groups for the Fine Motor subscale.

Notably, neither age at first fitting with a hearing aid nor maternal level of education were significant predictors of outcomes for any of the four measures of psychosocial/motor development. For children using cochlear implants, age at switch-on was also not significant.

Discussion

The principal aims of this study were to evaluate the psychosocial and motor development of DHH children at 3 years of age relative to age norms and to examine the influence of a range of potential predictor variables on each developmental outcome. Against these aims, the principal conclusions of this investigation were that, at this early age: (a) children's psychosocial and motor performance were, on average, within the range of expectation for children without hearing loss; (b) there were significant positive associations between parent-reported measures of psychosocial and motor performance and also between both of those areas and language and communication ability; and (c) although there was no significant effect of age at first fitting

Table 4. Effect estimate and 95% confidence interval (CI) for the change in mean of each developmental quotient associated with a change in the predictor from Value 1 to Value 2 depicted in parentheses (Value 1: Value 2)^a

Predictor	Social		Self-help		Gross motor		Fine motor	
	Effect estimate (95% CI)	<i>p</i>	Effect estimate (95% CI)	<i>p</i>	Effect estimate (95% CI)	<i>p</i>	Effect estimate (95% CI)	<i>p</i>
Child								
Additional disability (none: one or more)	-21.6 (-30.0, -12.8)	<.001	-24.6 (-32.5, -16.8)	<.001	-33.9 (-42.0, -25.6)	<.001	-20.5 (-27.7, -13.3)	<.001
Birth weight ^b	6.5 (1.8, 11.4)	.005	8.2 (4.2, 12.2)	<.001	9.9 (4.9, 15.1)	<.001	5.6 (1.9, 9.3)	.003
Gender (male: female)	9.8 (1.9, 17.8)	.01	15.5 (8.8, 22.3)	<.001	6.6 (-1.1, 14.3)	.09	12.6 (6.7, 18.5)	<.001
Age at first fitting ^b	-3.6 (-10.2, 3.4)	.31	-0.6 (-6.6, 5.4)	.85	0.7 (-6.0, 7.7)	.84	0.4 (-4.9, 5.7)	.88
Age at first switch-on ^b	-6.3 (-17.1, 8.1)	.37	-0.7 (-12.5, 11.2)	.91	7.5 (-5.1, 22.8)	.27	-0.2 (-10.6, 10.2)	.97
Device (hearing aid: cochlear implant) ^c	4.2	.65	0.0	.98	-8.8	.05	-1.0	.99
4 frequency average (4FA) hearing level in the better ear ^c		.12		.96		.34		.88
4FA for hearing aide users ^b	-11.8		1.4		8.4		1.6	
4FA for cochlear implant users ^b	-5.6		0.0		-3.2		2.1	.88
Family								
Maternal education		.35		.31		.11		.06
School: diploma	5.5 (-4.6, 15.9)		1.1 (-7.9, 10.0)		4.9 (-5.3, 15.4)		9.5 (1.5, 17.5)	
School: university	6.5 (-2.9, 16.1)		-5.1 (-13.4, 3.1)		-5.6 (-14.4, 3.5)		5.3 (-1.9, 12.4)	
Socio-economic status ^a	2.4 (-2.7, 9.2)	.42	0.6 (-4.4, 5.6)	.83	-0.8 (-5.3, 5.3)	.77	0.6 (-3.7, 5.0)	.77
Educational intervention								
Communication mode (aural/oral: combined mode)	-10.6 (-24.3, 26.8)	.12	-11.3 (-22.5, 18.0)	.03	-11.9 (-10.0, 36.0)	.01	-7.2 (-10.6, 26.8)	.09

Note. ^aFor categorical variables, Value 1 is the reference category.

^bFor these variables, the effect estimate and 95% CI are for the change in the mean of the dependent variable associated with a change in the predictor from the first quartile value to the third quartile value, with the other predictors constant.

^cThere are no CIs specified separately for device and 4FA hearing level in the better ear because the model included nonlinearities and interactions between device and hearing level.

with a hearing aid (i.e., as an indicator of age at identification of hearing loss) for any of the four measures of psychosocial or motor development under consideration, poorer scores were evident on all measures for children with lower birth weight and/or an additional disabling condition.

The first of these conclusions stands in contrast with a substantial weight of previous research pointing to poorer psychosocial outcomes among DHH children (e.g., Dammeyer, 2010; Fellingner et al., 2008; Hintermair, 2007; Korver et al., 2010; Moeller, 2007). However, this study differs from previous studies in a number of ways that may have impacted on this finding. First, no previous studies have addressed this issue in a cohort of children as young as the one in the current study. Second, previous studies have not considered a cohort of children who were identified and received their assistive hearing devices at such an early average age. It may be that the children's young age/level of maturation resulted in their receiving higher levels of early intervention support designed to enhance their social development, such as speech-language therapy targeting early pragmatic aspects of communication through social interactions with adults and/or DHH peers. This interpretation would lead us to expect a decidedly different outcome for psychosocial development in these children from those that have been observed in previous studies of this type.

An alternative possibility is that outcomes more consistent with previous research will be observed as this cohort matures. Certainly, there is evidence to suggest that factors that influence outcomes in very young children may impact differentially as children grow (Duchesne, Sutton, & Bergeron, 2009). In the present context, it may be that the language deficits reported here, at 3 years of age, could adversely impact on subsequent psychosocial or motor development, and thus result in poorer future outcomes. Another contributing factor might be the nature of the data available in the current study, which was based on the reports of children's parents/caregivers. In studies involving older children, there have been significant differences between such reports and children's self-reports. Fellingner et al. (2008), using The Inventory for the Assessment of Quality of Life in Children and Adolescents, found that children tended to be less satisfied with their general HRQoL, their physical health, and their social interests and recreational activities when compared with their parents' assessments. They also noted differences between the reports of parents and teachers in these same areas.

The longitudinal nature of the LOCHI study will afford the opportunity to investigate these alternative interpretations of the current results. Additional data on psychosocial and motor development outcomes as well as data relating to HRQoL will be elicited for this same cohort of children at 5, 9, and 11 years of age through administration of the same measures used here as well as child self-report versions of the PedsQL and both self-report and teacher-report versions of the SDQ. This design will enable us to evaluate the developmental trajectories of psychosocial and motor development for DHH children over time, and whether the typical psychosocial and motor performance observed here is maintained at later ages.

The second conclusion drawn from this research was that parent-reported measures of psychosocial and motor performance were significantly positively associated both with one another and with language and communication ability. As regards psychosocial development, the observed association with language and communication abilities is consistent with the majority of previous studies involving DHH children (e.g., Dammeyer, 2010; Fellingner et al., 2009; Stevenson et al., 2010;

van Eldik et al., 2004). In older children in particular, there has been considerable theoretical and empirical support for a link between poor communication skills and incidence of social-emotional and mental health problems (Fellingner et al., 2009; van Eldik et al., 2004). Notably, in the current study, there were significant correlations between the measures of receptive and expressive language ability and the measures of psychosocial development and also with functional communication performance as measured by the PEACH. On the latter measure, children who were rated as being better functional communicators tended to be rated more highly for both their social development and their self-help skills.

These correlations support the theoretical conclusion that there is a relationship between language and communication ability and incidence of psychosocial difficulties. What is surprising in the current study, however, is the finding that even though the language and functional communication measures were, on average, outside of the typical range for children at 3 years of age, the measures of psychosocial development were all within the expected range for children of that age. As suggested previously, however, if over time (i.e., at 5 years of age and beyond), the children's language performance scores continue to be outside the typical range then it may be expected that there will be a corresponding negative impact on the group averages for psychosocial development—particularly in areas such as social relations, emotional development, and the incidence of behavioral difficulties. On the other hand, further and sustained intervention in the children's language and communication development, as would be expected in the context of the early intervention and support programs in which the vast majority continue to be engaged, may over time prove to support the continuing age appropriateness of their psychosocial and motor skills. For now, we can conclude that the current results provide strong support for the existence of a relationship between better language and communication abilities and better outcomes on measures of psychosocial functioning. However, further longitudinal study is clearly required in order to obtain a deeper understanding of the nature of the observed inter-associations and their implications for children's future development.

Turning attention to the association observed in the current study between motor development and language and communication ability, explanations are less clear and more difficult to draw from the existing literature. As was suggested by Gheysen et al. (2008) and Wieggersma and Van der Velde (1983), it may be that motor difficulties experienced by some DHH children are associated with a lack of ability to verbally represent motor skills and motor performance strategies and/or a lack of self-confidence on the part of DHH children to explore their environment because of their lack of comprehension of instructions or other information associated with motor performance activities. Although tentative, these possible explanations are consistent with the data presented in this study, but warrant specific consideration in future research.

Another aspect of language and communication ability that proved to be a significant factor in the current study was the mode of communication used by children in their early intervention programs. Children who used only aural/oral communication scored significantly better than children who used some form of manual communication on the Gross Motor subscale of the CDI but not the Fine Motor subscale. They also scored significantly better on the Self Help subscale, which addresses behaviors that are more individual and personal in nature, but not on the Social Development subscale, which addresses interpersonal and group interaction skills in social situations. Even

for the two variables where the differences were not significant, average scores were higher for children who used only aural/oral communication with substantial effect estimates for both comparisons (-10.6 for Social Development and -7.2 for Fine Motor). The reasons for these differences are not immediately apparent and further investigation of these selective associations is clearly warranted. Notably, there were no data collected on the parents' abilities to use signed communication where that was applicable. It may have been that parents' judgments of the behavior and adjustment of their children who used signed communication were influenced by the extent to which they themselves were competent in the use of that mode of communication. This potential relationship begs further inquiry, as does the potential for parental hearing status to be a factor in explaining these findings and potentially some of the variance in results more broadly. As already noted, parental hearing status has been considered by several researchers (Dammeyer, 2010; Lieberman et al., 2004; Polat, 2003; Woolfe & Smith, 2001) as a potential influence on the psychosocial and motor development of DHH children, with mixed conclusions. Although not considered in the current study, this variable warrants further attention and investigation.

With respect to the third conclusion, the lack of relationship observed here between earlier fitting with a hearing aid (i.e., earlier identification of hearing loss) and psychosocial outcomes is consistent with the findings of Wake et al. (2004). They found that the age at which children's hearing loss was identified did not contribute significantly to variance in their psychosocial summary scores on the CHQ. Notably, however, only 11 of the 85 children in that study were identified before the age of 6 months and the average age at identification overall was relatively high (i.e., 21.8 vs. 7.7 months for the current study).

The current results are in contrast, however, with several studies that have reported poorer outcomes in psychosocial and motor development in later-identified children. Korver et al. (2010) used the same measures that were employed in the current study (i.e., subscales of the CDI) to investigate this relationship. They reported significant differences on both Social Development and Gross Motor quotients between DHH children who were identified through UNHS and those identified later through distraction testing. They also reported a significant difference between early- and later-identified children for scores on the Social, Psychosocial, and Physical Development subscale scores of the PedsQL inventory. Consistent with findings from the current study, however, they found no difference between early- and later-identified children for either the Self Help or Fine Motor subscales of the CDI. The children studied by Korver et al. ranged in age from 3 to 5 years. The average age at time of testing for the children in their early-identified group was 48 and was 60 months for the late-identified group. In contrast, the children in the current study were all just 3 years of age at the time of testing. It is possible that the effects reported by Korver et al. emerged in that cohort only after 3 years of age.

Regarding other possible predictors of psychosocial outcomes for children in the current study, several factors warrant consideration. It is noteworthy that there was no relationship observed between maternal level of education and any of the four psychosocial/motor outcomes. This finding is in apparent contrast with results reported by Ching, Dillon, et al. (2013) in their analysis of LOCHI children's global outcomes at 3 years of age. They reported that children whose mothers' education exceeded 12 years attained significantly better global outcomes than those in families with maternal education less than 12 years. In their analysis, global outcomes were quantified in

terms of factor scores that incorporated measures of speech, language, and functional auditory performance as well as social development. CDI scores for the self-help, gross motor, and fine motor scales were not included. Furthermore, the factor loading for the CDI social development scale was lower than for most other included measures. It seems likely therefore that the different pattern of results obtained here reflects the focus on social and motor development per se. Nevertheless, the influence of maternal education level, among other variables, warrants continuing attention in future research.

No association was found between the various measures of psychosocial/motor development and degree of hearing loss. This finding is consistent with results reported by Stevenson et al. (2010) who found no significant effect of degree of hearing loss on the incidence of behavior problems. Other authors have, however, observed a relationship between other psychosocial outcomes and degree of hearing loss. Fellinger et al. (2008) reported a significantly higher incidence of hyperactivity and conduct problems in children with severe hearing loss than those with moderate or profound losses. Notably, the ages of participants in their study ranged from 6.5 years to 16.0 years—that is, across the age range in which children are involved in school. There may be an interaction between level of hearing loss, engagement in school education, and impacts on psychosocial well-being, such that severity of hearing loss only begins to impact once children begin to engage with formal education and the dynamics and demands of group interactions. Alternatively, it is possible that such differential outcomes were a consequence of the way in which psychosocial functioning was measured in other studies. As noted earlier, there may be significant differences between parents' perceptions of their children's psychosocial functioning and those of the children's teachers, or the children themselves. Indeed, teacher-reported and child-reported data have been the basis of the assessments used in many studies investigating psychosocial adjustment at older ages.

One variable in the current study that accounted for substantial variance in Gross Motor abilities was the nature of the hearing device used. Although borderline in terms of statistical significance ($p = .05$), the mean developmental quotient was higher for children with hearing aids than for those who had received a cochlear implant with an effect estimate of -8.8 points. This finding is consistent with the findings of Livingstone and McPhillips (2011) who concluded that children who have received cochlear implants may experience some delay in the development of complex motor activities. It is in contrast, however, with several other studies that found no difference between the motor abilities of children with and without cochlear implants. This finding remains open to further investigation at later stages of development of this cohort. Moreover, based on the results reported here, there is good reason to continue to monitor this issue in future studies using direct assessment of motor abilities such as the MABC in addition to parent report measures such as the CDI.

One final factor that proved to be a significant predictor of outcomes in the psychosocial and motor domains in the current study was the presence of additional disabilities. Mean developmental quotients for all four of the targeted subscales were significantly lower for children with additional disabling conditions. This finding is consistent with the conclusions of Rajendran and Roy (2010) for children with motor impairments and those of Dammeyer (2010) who found that the presence of any disability in addition to hearing loss significantly increased the likelihood of psychosocial difficulties being reported. The

precise nature of these relationships requires further investigation. Of future interest will be the nature of the impact of specific additional disabilities and, in particular, the influence of relative intellectual ability in determining psychosocial and motor outcomes.

Conclusions

In summary, the average scores for the sample of children in this study were within the typical range on four psychosocial/motor subscales of the CDI. This pattern of results is in contrast with the findings from much previous research that has supported the conclusion that children with hearing loss have poorer psychosocial and motor outcomes than their hearing peers (e.g., Dammeyer, 2010; Fellingner et al., 2008; Hartman et al., 2011; Meadow, 1980; Moeller, 2007; van Eldik, 2005). As we have noted, it may be that the outcomes reported here are a function of the young age of the child participants and that outcomes more consistent with previous investigations will be observed at later stages of the LOCHI study. Alternatively, it may be that there are characteristics of this group of children, such as the low average age at identification, the high incidence and low average age at fitting of hearing devices (particularly cochlear implants), and high levels of engagement with early intervention and support services that will continue to account for a pattern of psychosocial development that is more similar to that observed in previous studies of children with typical hearing. Future stages of the LOCHI study will produce data that enables these and other questions to be more fully addressed.

Finally, the results of this study indicate that, at 3 years of age, there was no effect of age at first fitting with a hearing aid (i.e., as an indicator of age of identification and commencement of intervention) on outcomes relating to psychosocial or motor development for these DHH children. It is apparent, nevertheless, that there are several factors that do contribute significantly to variation in psychosocial and/or motor outcomes among children in this group. Those factors include the presence of additional disabilities, low birth weight, and, to a lesser and more limited extent, gender (i.e., with girls performing better than boys), hearing device, and the mode of communication used in intervention. What remains unclear at this stage is the extent to which these variables are likely to be robust predictors of outcomes in the longer term. It may well be that, with growth and maturation, other factors become more influential and have more significant effects on outcomes in these domains. The longitudinal nature of the LOCHI study provides an ideal platform to continue to investigate a broad range of issues that potentially impact on psychosocial and motor development across the years of childhood development and ultimately into adolescence and adulthood.

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Conflicts of Interest

No conflicts of interest were reported.

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