Emotion Understanding in Deaf Children with a Cochlear Implant

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It is still largely unknown how receiving a cochlear implant affects the emotion understanding in deaf children. We examined indices for emotion understanding and their associations with communication skills in children aged 2.5–5 years, both hearing children (n = 52) and deaf children with a cochlear implant (n = 57). 2 aspects of emotion understanding were examined: (a) emotion recognition in facial expressions and (b) emotion attribution in a situational context. On all emotion-understanding tasks, children with a cochlear implant were less proficient than children with normal hearing. In children with normal hearing, performance and language skills were positively associated. In children with cochlear implants, language was positively associated only with tasks in which a verbal demand was made on children. These findings indicate that hearing loss in children, despite a cochlear implant, affects all aspects of emotion understanding measured in this study, including their nonverbal emotion-understanding skills.

Emotions play an important role in daily life: The way they are understood and expressed influences social relationships, the way people act in difficult situations, and the way interpersonal conflicts are solved. In children and adults alike, problems in emotion understanding have been shown to be related to developing symptoms of psychopathology or poor social functioning later in life (Eisenberg, Spinrad, & Eggum, 2010).

In children for instance, social competence, peer-rated popularity, and academic achievement are strongly related to the ability to recognize the facial expression of emotions in other people and the ability to understand the causes of these emotions (Denham, McKinley, Couchoud, & Holt, 1990).

There are also strong indications that communication plays a crucial role in the development of emotion understanding (Bosacki & Moore, 2004), which could negatively affect deaf children’s emotion understanding (Rieffe & Meerum Terwogt, 2006). However, since the late 1990s, deaf children’s hearing can be improved via a cochlear implant (CI), which bypasses the damaged part of the ear and electrically stimulates the auditory nerve. Ultimately, signals from the auditory nerve are perceived as sounds by the brain. Today, up to 94% of young, profoundly deaf children in the Flemish part of Belgium receive a CI (De Raeve & Lichtert, 2011). Moreover, preliminary results of a study among 14 European countries indicate that about 80–90% of the children in these countries receive a CI. However, this high percentage is probably mostly true for industrialized countries. Good results have been obtained with respect to speech and language outcomes, especially in children who received the implant before the age of 2 years, although many children still have a delayed language development (Colletti, Mandalà,
Moreover, many implanted children are even able to attend mainstream schools, mostly with extra support (De Raeve & Lichtert, 2011). To date, however, the effect of receiving a CI on deaf children’s emotion understanding has not been examined.

In this study, we examined two aspects of the ability to understand emotions in young deaf children with a CI: emotion recognition in facial expressions, and emotion attribution in a situational context. We assessed this ability for four of the six basic emotions: happiness, anger, sadness, and fear (Vicari, Reilly, Pasqualetti, Vizzotto, & Caltagirone, 2000). Furthermore, we assessed the relationship of language skills with emotion understanding.

Communication and Emotion Understanding

Children’s development is strongly influenced by parent–child interaction (Bronfenbrenner, 1979), which, in turn, is influenced by language skills of parent and child. Research on the quality and quantity of the interaction between hearing parents and their deaf child without a CI shows that these parents generally interact with their child in a different way than parents of hearing children. For example, deaf children and their hearing parents usually spend less time communicating with each other, and these children cannot overhear conversations in which they are not directly involved (Gray, Hosie, Russell, Scott, & Hunter, 2007). Parents—who are used to interacting with others by means of spoken language—may have problems finding other ways to interact with a deaf child. In short, the interactions between hearing parents and deaf children are often of a lower quality and quantity compared to hearing parents with hearing children. This, in turn, could negatively affect various aspects of development even in young deaf children with a CI (DesJardin & Eisenberg, 2007).

Additionally, a language delay in deaf children might influence the quality of social interactions with relatives and peers. Poor language skills can cause difficulties in understanding the social environment and, in turn, are related to an impaired emotion understanding (Quirin & Lane, 2012). The well-documented delays in language development of hearing parents’ deaf children without a CI seem indeed related to severe difficulties in developing proper emotion understanding (Meerum Terwogt & Rieffe, 2004; Moeller, Tomblin, Yoshinaga-Itano, McDonald Connor, & Jerger, 2007; Rieffe & Meerum Terwogt, 2000, 2006). Although many deaf children with a CI have the ability to understand spoken language to some degree, they are deprived of it before they receive their CI, usually in the first 1 or 2 years of their life. Consequently, the emotional and social development of children who have access to spoken language after receiving their CI is likely to be delayed due to communication problems.

Emotion Recognition in Facial Expressions

An understanding of the facial expression of emotions develops through the interplay between neurobehavioral maturation and environmental influences (McClure, 2000). Neurobehavioral research has shown that the amygdala plays a prominent part in the recognition of faces in very early development, whereas the cortical areas may play an essential role during later stages. According to the social constructivist theory, social interaction—including exposure to and modeling after adults—is important for developing a proper understanding of facial expressions (McClure, 2000).

Two important phases mark the development of facial expression recognition. First, children must be able to discriminate between different facial expressions. In other words, they must be able to see that there is a difference between a picture of a woman with a happy expression and a picture of the same woman with a sad expression. However, the ability to discriminate between those two faces does not imply that the child also knows that these differences concern two different emotional states. Second, children must therefore be able to identify and label the facial expressions—they have to associate the facial expression with the corresponding emotion (McClure, 2000).

The development of facial expression recognition is impaired by deficits in both maturational and experiential factors. While maturational deficits are commonly seen in children with an autism spectrum disorder (a neurodevelopmental disorder characterized by impairments in emotional and social interaction;
American Psychiatric Association, 2000), most children with severe to profound hearing loss without a CI have difficulties with experiential factors, because they have had fewer opportunities than their hearing counterparts to communicate with their parents, siblings, and peers (Lederberg & Mobley, 1990). According to Hosie, Gray, Russell, Scott, and Hunter (1998), research on the lateralization of face-processing abilities suggests that the emotional development of deaf children without a CI may differ from that of hearing children, because their experience with modeling from adults deviates from that of hearing children. However, it is unknown how this difference affects deaf children’s recognition of the facial expressions of emotions.

One possible consequence of diminished verbal communication between deaf children and their hearing parents is that these children may be more sensitive to the facial expression of emotions (Barker, Quittner, Fink, Eisenberg, Tobey, & Niparko, 2009). Ludlow, Heaton, Rosset, Hills, and Deruelle (2010) hypothesize that, in general, deaf children are more dependent on visual information than hearing children, because facial patterns are essential for sign language, and many words share the same sign but are accompanied by different facial expressions. Alternatively, deaf children might have more difficulties in acquiring the skills needed to recognize the facial expression of discrete emotions, because these skills develop within the auditory and linguistic context (Quirin & Lane, 2012). Young children with normal hearing not only observe the facial expressions of others but also listen to others in order to learn how such expressions are interpreted. Deaf children without a CI do not get this verbal information. Their lack of exposure to daily conversation deprives them of models who facilitate their development (Rieffe & Meerum Terwogt, 2006).

Nowadays, however, most deaf children in Western countries receive a CI before their second birthday (De Raeve, 2010). A CI makes it possible for them to learn spoken language more easily than without a CI. Because there is a positive relation between language development and emotion understanding (Bosacki & Moore, 2004), these children can be expected to develop a better understanding of emotions than deaf children without a CI. To date, few studies have examined facial emotion discrimination in hearing-impaired children with a CI (HI/CI children) (Hopyan-Misakyan, Gordon, Dennis, & Papsin, 2009; Wang, Su, Fang, & Zhou, 2011). Hopyan-Misakyan et al. (2009) showed that when asked to match photos with drawings of facial emotion expressions (happiness, anger, sadness, and fear), a group of 10-year-old children who had received their CI prelingually were just as accurate as their hearing peers in discriminating between different facial expressions. However, normally hearing preschool children performed significantly better on facial expression recognition than prelingually implanted HI/CI children (Wang et al., 2011), suggesting that there is a delayed development in deaf children with CI.

**Emotion Attribution in a Situational Context**

The recognition of other people’s emotions does not depend solely on distinguishing and interpreting facial expressions. Observers can attribute emotions correctly only when they know the antecedents of the emotion expression—that is, they can correctly predict an emotion only when they have some knowledge about the situational context in which the emotion is expressed. Therefore, besides the ability to recognize emotions in facial expressions, it is equally important for children to develop knowledge about the types of situations that typically evoke a certain type of emotion.

In prototypical situations, most hearing 4-year-old children can correctly attribute the basic emotions to a protagonist (Rieffe, Meerum Terwogt, & Cowan, 2005). In contrast, a study by Gray et al. (2007) showed that deaf children aged 5–8 years without a CI found it considerably more difficult than their hearing peers to assign emotions to prototypical situations. The deaf children in this study were instructed in sign language. The ability to understand the basic emotions in a prototypical situational context has not yet been studied in HI/CI children.

**This Study**

The aim of our study was to compare the capacity for emotion recognition and emotion attribution in prototypical situations between young normally hearing (NH) and HI/CI children aged 2.5–5 years who had hearing parents. We also examined the relation between
emotion recognition/attribution and language development. Today, the vast majority of young deaf children are fitted with a CI (De Raeve & Lichtert, 2011), making it difficult to compare HI/CI children with deaf children who did not receive a CI. Therefore, we included NH children as a comparison group.

Based on the consequences of delayed language development (Colletti, 2009; DesJardin & Eisenberg 2007; Hosie et al., 1998; Rieffe & Meerum Terwogt, 2006), we expected that the performance of HI/CI children would be delayed, compared to their NH peers, on various tasks that examine children’s capacity for emotion understanding.

Method

Participants

The total sample consisted of 57 HI/CI children (34 boys, 23 girls, aged 2.5–5 years, mean age = 3 years 10 months) and 52 NH children (30 boys, 22 girls, aged 2.5–5 years, mean age = 3 years 9 months). HI/CI children were matched with their hearing controls on age and gender. All HI/CI children were born to hearing parents, had profound prelingual hearing loss with no other known disabling conditions, and received their implant before the age of 43 months, with the exception of one child, who had received it at 57 months (range = 6–57 months, M = 20 [standard deviation, SD = 10.1] months). At the start of the study, the mean duration of CI use was 25 months; 85% of the children had had their CI for more than 12 months (range = 1–44 months, M = 25 [SD = 11.3] months).

NH children were recruited through day-care centers, playgroups, and primary schools in the Netherlands. HI/CI children were recruited through hospitals and family counseling services in the Netherlands and the Dutch-speaking part of Belgium. Informed consent was obtained from all parents and the study was approved by the medical ethical committee of Leiden University Medical Center.

General development was assessed with the Dutch version of the Child Development Inventory, a standardized instrument for children aged 15–72 months (Ireton & Glascoe, 1995). Motor development scales were used as an indication of cognitive development, because it is impossible to obtain reliable intelligence quotient (IQ) scores for children this young (Pick, Dawson, Smith, & Gasson, 2008). Because deaf children usually have problems with the organ of balance (Gheysen, Loots, & Van Waelvelde, 2008), which is situated in the inner ear, five items referring to balancing skills were removed from the gross motor scale. The questionnaires were filled out by parents (n = 36 NH; n = 39 HI/CI). No significant differences were found for fine motor skills, but HI/CI children scored lower on gross motor skills than NH children, with a medium effect size (NH children 21.4 [SD = 2.9]; HI/CI children 19.5 [SD = 3.7]; t(71) = 2.45, p = .02, Cohen’s d = .57).

Materials and Procedure

Children were tested individually in a quiet room. HI/CI children who communicated wholly or partly in Sign Language were tested by a researcher who was familiar with both spoken and Sign Languages. More than half of the HI/CI children (53%) were tested by means of spoken Dutch supported with signs, 29% by spoken Dutch, and 18% by Sign Language. No differences in performance were found on any of the tasks concerning language mode. Tasks requiring language (Emotion-Identification Task and Emotion-Attribution Task) were only administered if the language skills of the children were sufficient, that is, children had to understand the word “why.” All sessions were recorded on video and took approximately 30 min, including other tasks that are not presented in this article. After the sessions, the researcher made transcripts of the tapes. Note that this study is part of a larger research project that also includes other variables examining the multiple aspects of social and emotional development in young HI/CI children (Ketelaar, Rieffe, Wiefferink, & Frijns, 2012a, 2012b; Wiefferink, Rieffe, Ketelaar, & Frijns, 2012).

Emotion recognition in facial expression. Two tasks were used to assess emotion recognition in facial expression: a discrimination task, and an identification task.

First, children’s ability to discriminate between different facial emotion expressions was examined in the Emotion-Discrimination Task, consisting of two conditions, each covering two performance tasks of
increasing difficulty. In the neutral condition, children were tested on their ability to discriminate between cars and flowers (Task 1) and faces with hats versus faces with glasses (Task 2). It was assumed that the first task was easier than the second for both NH and HI/CI children, because the distinction between different objects was much more noticeable than the distinction between objects in otherwise similar faces. This neutral condition was also used to check whether children understood how to sort different cards. Children did not proceed to the second condition if they did not pass the first condition, because we assumed different objects are easier to distinguish than different facial expressions. The second (facial expression) condition was designed to test children’s ability to discriminate between different facial emotion expressions between valences (Task 1: happy versus sad) and within the same valence (Task 2: angry versus sad). It was assumed that the first task would be easier than the second, because the difference in facial expression is much more prominent between valences than within one valence.

In both conditions, children had a sheet in front of them with a sample drawing of one category in the top left corner (e.g., an angry face) and a drawing of the other category in the top right corner (e.g., a sad face). The children were then handed six cards one by one in fixed order (e.g., three drawings of an angry face and three drawings of a sad face) and nonverbally instructed to place each card in the correct category after a demonstration. The drawings of facial emotion expressions used in this task were all computer generated, in black and white, and based on photos of different 3- and 4-year-old boys, which were randomly chosen from a large database with photos of various facial expressions. Examples of drawings of the facial expressions “angry” and “sad” are presented in Figure 1. The cards that were placed correctly were counted, with a maximum of three per category.

To examine children’s ability to link emotion words to the facial expressions accompanying the four basic emotions (happiness, sadness, fear, and anger), they were presented with the Emotion-Identification Task. The task consists of eight drawings of facial emotion expressions, two for each emotion, designed especially for this study. The researcher showed two sheets with four drawings of facial emotion expressions on each sheet and asked the children: “Who looks happy?” Children had to point to the drawing with the correct facial expression. Next, the researcher asked: “Is there anybody else who looks happy?” After that, she repeated the same procedure for anger, sadness, and fear. The number of emotions correctly identified was recorded, with a maximum score of two per emotion.

Emotion attribution in prototypical situations. The material for the third task, the Emotion-Attribution Task, consists of eight vignettes depicting prototypical emotion-eliciting situations that had been designed especially for this study. Two vignettes were designed for each basic emotion (happiness, anger, sadness, and fear; Table 1).

Children were shown drawings accompanied by a simple signed or spoken explanation, such as “Boy sees
dog." They were first asked to say or sign how the protagonist would feel (verbal condition) and then to point to the drawing with the correct facial expression (visual condition). We used both visual and verbal conditions because it is possible that children who do not know the word or sign for an emotional state do recognize the facial expression belonging to that state. Their scores were calculated as proportions of correct responses for each condition separately. Instead of scoring discrete emotions, a correct answer was achieved when a child predicted an emotion within the intended valence domain, that is negative (anger, sadness, or fear) versus positive (happiness). There is often more than one correct answer in situations that cause a negative appraisal, because what is correct depends on the individual’s action tendency following the primary appraisal (Frijda, 1986; Rieffe, Meerum Terwogt, & Cowan, 2005). For example, in the story where the protagonist falls from his bicycle, the boy could be angry, because he is blaming someone for his fall, or sad, because he thinks he will never learn how to cycle. In other words, different action tendencies are related to different emotions, that is, anger for approaching a problem/violator and sadness when there is no hope for reinstatement of the goal (Rieffe, Meerum Terwogt, & Smit, 2003).

Next, children were asked to explain why the protagonist would feel that emotion (e.g., “Why is boy scared?”). All responses were coded by two raters. Interrater agreement was 98.7% and disagreements were resolved by discussion. Children’s scores were calculated as the proportion of correct emotion explanations.

Language development. Language development—spoken and/or Sign Language—was assessed with the Dutch version of the Child Development Inventory (Ireton & Glascoe, 1995), which consists of two language scales—an expressive scale and a receptive scale—of 50 items each. Examples of items on the expressive scale are “calls/signs you ‘mama’ or ‘dada’ or a similar name” and “uses at least five words/signs as names of familiar objects.” Examples of items on the receptive scale are “usually comes when called” and “follows simple instructions.” Parents answered the items by yes (1) or no (0).

Data Analysis

Children who were unable to perform a task received a score of 0 for that particular task, because this means that they were not able to correctly recognize facial expressions and attribute emotions. Eight children could not perform the Discrimination task: two NH children (mean age: 30 months) and six HI/CI children (mean age: 40 months). Twenty-eight children were not able to perform the Identification and the Attribution tasks: five NH children (mean age: 31 months) and 23 HI/CI children (mean age: 42 months). To determine whether accuracies in the recognition of facial expressions and the attribution of emotions in prototypical situations differed between NH and HI/CI children, all scores were entered in a multivariate analysis of variance. Effect sizes are also reported: Effect sizes of approximately .01 are viewed as small, approximately .06 as medium, and approximately .14 as large (Cohen, 1988). These analyses were also repeated excluding children who were unable to perform one or more of the tasks, children who had received their CI after their third birthday, and children who had had their CI for less than 1 year. There were no differences between the outcomes when including or excluding these participants. For reasons of clarity, only analyses including all children are presented below. Furthermore, all multivariate analyses were also carried out including gender and age. According to Miller and Chapman (2001), this is only legitimate when the covariates (gender and age) and groups (HI/CI and NH) are independent and when assignment to group is based on the scores of the covariates. Both

<table>
<thead>
<tr>
<th>Table 1  Content of the eight stories</th>
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</thead>
<tbody>
<tr>
<td>Story content</td>
</tr>
<tr>
<td>1 Boy is building a tower; someone knocks it down (angry)</td>
</tr>
<tr>
<td>2 Boy receives an ice cream (happy)</td>
</tr>
<tr>
<td>3 Someone is pulling at the boy’s shirt (angry)</td>
</tr>
<tr>
<td>4 Boy falls from bicycle (sad)</td>
</tr>
<tr>
<td>5 Boy receives a present (happy)</td>
</tr>
<tr>
<td>6 Boy sees a frightening dog (fear)</td>
</tr>
<tr>
<td>7 The spade of the boy is broken (sad)</td>
</tr>
<tr>
<td>8 Boy sees a crocodile (fear)</td>
</tr>
</tbody>
</table>

assumptions were fulfilled in our study, because HI/CI children were matched with their hearing controls on age and gender. No differences were found in this respect either. For reasons of clarity, these analyses are not included in the manuscript.

Results

Emotion Recognition in Facial Expression

Emotion Discrimination. Table 2 presents the means and standard deviations of children’s performances on the Emotion-Discrimination Task. Children’s scores for the neutral condition were analyzed with a 2 (Group) × 2 (Difficulty: flower/car, glasses/hat) analysis of variance. A main effect was found for difficulty \( F(1,107) = 25.50, p < .01 \), both groups finding the flower/car task easier than the glasses/hat task. There was no significant difference between NH and HI/CI children.

Eight children (two NH children with mean age 30 months, six HI/CI with mean age 40 months) were unable to perform the facial expression condition and were consequently given the score 0. Children’s scores for the facial expression condition were analyzed with a 2 (Group) × 2 (Difficulty: positive/negative, sad/angry) analysis of variance; this revealed main effects for group \( F(1,107) = 5.12, p = .03 \) and difficulty \( F(1,107) = 29.70, p < .01 \). First, we found that HI/CI children were not as proficient as NH children at sorting faces that expressed emotion, in both positive versus negative expressions and sad versus angry expressions. Second, it was more difficult for children in both groups to distinguish between emotions within the negative domain (sadness and anger) than across valence domains (happiness and sadness). There were no other significant outcomes.

Emotion Identification. Table 3 presents the accuracy with which children identified the four basic facial emotion expressions. Five NH children (mean age: 31 months) and 23 HI/CI children (mean age: 42 months) were unable to perform this task, which

### Table 2

<table>
<thead>
<tr>
<th></th>
<th>NH children (n = 52)</th>
<th>CI children (n = 57)</th>
<th>Partial ( \eta^2 )</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neutral condition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flower/car</td>
<td>2.79 (0.67)</td>
<td>2.57 (0.88)</td>
<td>.019</td>
<td>2.67 (0.79)</td>
</tr>
<tr>
<td>Glasses/hat</td>
<td>2.42 (0.86)</td>
<td>2.22 (1.02)</td>
<td>.012</td>
<td>2.32 (0.95)</td>
</tr>
<tr>
<td><strong>Facial expression condition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive/negative</td>
<td>1.89 (0.92)</td>
<td>1.50 (1.11)</td>
<td>.037</td>
<td>1.69 (1.04)</td>
</tr>
<tr>
<td>Sad/angry</td>
<td>1.47 (0.99)</td>
<td>1.06 (1.03)</td>
<td>.040</td>
<td>1.26 (1.03)</td>
</tr>
</tbody>
</table>

Note: NH = normal hearing; CI = cochlear implant–children with cochlear implant.

### Table 3

<table>
<thead>
<tr>
<th></th>
<th>NH children (n = 52)</th>
<th>CI children (n = 57)</th>
<th>Partial ( \eta^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emotion-Identification Task</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Happy</td>
<td>1.71 (0.64)</td>
<td>0.82 (0.93)</td>
<td>.237</td>
</tr>
<tr>
<td>Angry</td>
<td>1.58 (0.72)</td>
<td>0.91 (0.97)</td>
<td>.131</td>
</tr>
<tr>
<td>Sad</td>
<td>0.94 (0.83)</td>
<td>0.81 (0.90)</td>
<td>.006</td>
</tr>
<tr>
<td>Fear</td>
<td>1.02 (0.92)</td>
<td>0.77 (0.93)</td>
<td>.018</td>
</tr>
<tr>
<td><strong>Emotion-Attribution Task</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive emotion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal prediction</td>
<td>0.66 (0.44)</td>
<td>0.17 (0.35)</td>
<td>.291</td>
</tr>
<tr>
<td>Visual prediction</td>
<td>0.71 (0.40)</td>
<td>0.40 (0.47)</td>
<td>.112</td>
</tr>
<tr>
<td>Negative emotions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal prediction</td>
<td>0.66 (0.37)</td>
<td>0.23 (0.34)</td>
<td>.278</td>
</tr>
<tr>
<td>Visual prediction</td>
<td>0.69 (0.40)</td>
<td>0.42 (0.43)</td>
<td>.095</td>
</tr>
</tbody>
</table>

Note: NH = normal hearing; CI = cochlear implant–children with cochlear implant.
means that they were unable to link emotion words to drawings depicting emotions. These children were given the score 0 for this task. Post-hoc $t$ tests showed that the mean age of children unable to perform the task was lower than that of those able to perform the task ($t(107) = 4.11, p < .01$). All hearing children unable to perform this task were less than 3 years old; the age of the HI/CI children varied from 2.5 to 5 years.

A 2 (Group) × 4 (Emotion: happy, angry, sad, and fear) analysis of variance revealed main effects for Group [$F(1,107) = 12.96, p = .01$] and Emotion [$F(3,321) = 14.78, p < .01$], which were qualified by an interaction of Group × Emotion [$F(3,321) = 9.96, p < .01$]. For the emotions happy and angry, NH children performed better than HI/CI children in linking emotion words to facial expressions. No differences were found in sadness or fear. Post-hoc $t$ tests with Bonferroni correction also showed that NH children more easily identified happiness than sadness or fear—a difference that was not found in HI/CI children.

### Emotion Attribution in Prototypical Situations

Because five NH children and 23 HI/CI children were unable to perform the Emotion-Identification Task, they were also given the score 0 on the Emotion-Attribution Task because this task demands even more language skills. Children’s scores for the prediction of emotions in prototypical situations were analyzed by means of a 2 (Group) × 2 (Emotion: Positive, Negative) × 2 (Mode: Verbal, Visual) analysis of variance (Table 3). Main effects were found for Group [$F(1,107) = 31.99, p < .01$] and Mode [$F(1,107) = 23.28, p < .01$], which were qualified by an interaction of Group × Mode [$F(1,107) = 11.06, p < .01$]. Post-hoc $t$ tests showed that NH children performed better than HI/CI children on both the verbal condition (naming/signing the emotion) and the visual condition (pointing to the correct facial expression). Whereas HI/CI children performed better in the visual than in the verbal condition, there was no difference between the conditions for NH children.

A $t$ test was conducted to analyze differences in explanations of the predicted emotion between the two groups. Results show that more correct explanations were given by NH children ($M = .62, SD = .39$) than by HI/CI children ($M = .19, SD = .34$; $t(107) = 6.04, p < .01$).

### Associations with Background Variables

Language development in HI/CI children was delayed compared with that in NH children, for both expressive language (HI/CI children: 36.3 [SD = 9.1]; NH children: 46.7 [SD = 5.0]; $t(68) = 5.90, p < .01$) and receptive language (HI/CI children: 35.6 [SD = 10.1]; NH children: 43.9 [SD = 5.6]; $t(68) = 4.26, p < .01$). Pearson correlations were calculated to analyze the relation of age and language development (both expressive and receptive) with the Emotion-Discrimination Task, Emotion-Identification Task, and Emotion-Attribution Task. Age was significantly correlated to all emotion-understanding tasks. Table 4 shows that Emotion-Attribution Tasks were significantly correlated with expressive and receptive language development. For HI/CI and NH children alike, expressive and receptive language capacities were related to the Verbal Prediction and Explanation parts of this task. HI/CI children differed from NH children in one respect: HI/CI children’s expressive and receptive language was not related to the Visual Prediction and Explanation parts of the Emotion-Attribution Task. Language development was not significantly associated with emotion identification or emotion discrimination. After controlling for age, language skills were only related to the Verbal Prediction task in HI/CI children. In NH children, language comprehension was still related to all emotion attribution tasks, but expressive language was not related anymore to emotion attribution tasks.

The age at which HI/CI children had received their implant did not correlate with any of the emotion-understanding indices. Although the length of time since receiving their CI was correlated with all emotion-understanding measures (varying from $r = .30$ to $r = .50$), none of these significant correlations remained after controlling for chronological age.

### Discussion

In this study, we examined the ability of 2.5- to 5-year-old deaf children with a CI to recognize and attribute emotions in prototypical situations. We included only the basic emotions (happiness, sadness, anger, and fear),
because these are the first that children learn to recognize (Denham, 1998). Overall, performance of HI/CI children was delayed compared to that of their NH peers. HI/CI children were less proficient than NH children in emotion recognition in facial expressions, both discriminating and identifying, and in attributing emotions to a protagonist in prototypical situations. The effect size was small in emotion discrimination but medium to large in both identifying facial expressions and attributing emotions in prototypical situations.

Language delays are a likely contributor to the differences found between HI/CI and NH children, and indeed, receptive language was related to task performance for all tasks in the NH group and for the two tasks in which children had to respond verbally (either orally or in sign language). Yet, language skills do not seem to be the only explanation for the diminished emotion understanding skills of deaf children with CI. Several outcomes from this study support this claim. First, language demands in the tasks were kept to a minimum and HI/CI children also scored lower on measures that were administered nonverbally and that did not require a verbal response. Second, excluding children who were unable to perform the tasks, either because their language skills were deemed insufficient or they did not respond to the instructions (e.g., played with the material, did not answer the questions), produced the same difference in outcomes between HI/CI and NH children. Another factor that could explain the difference in performance is timing of implantation. Children who had experienced a lengthier time of deprivation or who had been using their CI for a shorter time period could have had less opportunity to learn about emotions. Yet, both age at implantation and length of time since receiving the CI (after controlling for chronological age) were unrelated to all measures of emotion understanding. Future research should be directed at other factors that possibly contribute to better emotion understanding in deaf children with CI.

Importantly, HI/CI children performed less well on all tasks measuring emotion understanding compared to their hearing peers, even in nonverbal tasks. In the Emotion-Discrimination Task, for example—in which children were asked to sort cards showing facial emotion expressions for emotion valence (positive versus negative) and for two emotions within the negative domain (anger versus sadness)—HI/CI children performed worse than NH children. This is in line with our expectation that HI/CI children would be outperformed by NH children. However, HI/CI and NH children performed equally well in the neutral, nonemotional condition (sorting cars and flowers, or distinguishing between faces with hats or with glasses), which emphasizes the fact that children did understand the task. In fact, the discrepancy in outcomes between the two neutral conditions versus the two emotion conditions suggests that it is not the understanding of the task that is problematic for deaf children—even if they have a CI—but that they have difficulties detecting differences in facial expressions. However, it is not clear from these outcomes whether the impaired performance of the HI/CI children denotes a focus on other aspects than the facial expression (e.g., hair style),

### Table 4

<table>
<thead>
<tr>
<th></th>
<th>NH children (n = 36)</th>
<th>CI children (n = 39)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Expressive language</td>
<td>Receptive language</td>
</tr>
<tr>
<td>Emotion-Discrimination Task</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive/negative</td>
<td>.23</td>
<td>.37**</td>
</tr>
<tr>
<td>Sad/angry</td>
<td>.11</td>
<td>.24</td>
</tr>
<tr>
<td>Emotion-Identification Task</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive facial expression</td>
<td>.16</td>
<td>.31**</td>
</tr>
<tr>
<td>Negative facial expression</td>
<td>.28</td>
<td>.49**</td>
</tr>
<tr>
<td>Emotion-Attribution Task</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal prediction</td>
<td>.47**</td>
<td>.59**</td>
</tr>
<tr>
<td>Visual prediction</td>
<td>.57**</td>
<td>.67**</td>
</tr>
<tr>
<td>Explanation</td>
<td>.51**</td>
<td>.59**</td>
</tr>
</tbody>
</table>

Note: NH = normal hearing; CI = cochlear implant–children with cochlear implant.

* p < .05; ** p < .01.
a problem in concentrating on the task, or an inability to detect differences in facial expressions.

HI/CI children were less able to identify emotions compared to their NH peers. This was expected, because the identification of emotions is usually related to language. Some HI/CI children were instructed in Sign Language, which could have made the task easier for them because facial expressions form an integral part of Sign Language. However, if this is the case, the real differences between HI/CI children and NH children are even bigger, because NH children performed better than HI/CI children on the Emotion-Identification Task.

Also in line with our expectations, it was not only the recognition of facial expressions of emotion that was more difficult for HI/CI than NH children but also the interpretation of the emotional valence in prototypical emotion-evoking situations. When children were shown a drawing displaying an emotion-evoking event, asked (in either oral or in sign language) which emotion the protagonist would feel, and shown pictures of facial emotion expressions they could point to, HI/CI children again were outperformed by their hearing peers. Nevertheless, they did slightly better when they could point to one of the facial expressions depicting an emotion than when asked to produce the emotion word or sign.

The question is whether the differences we found between HI/CI and NH children indicate delayed emotion understanding or a qualitative difference in development. The outcomes on the Discrimination Task may hint at delayed development. HI/CI children were outperformed by NH children, but both groups were more proficient at discriminating between domains (positive versus negative) than within one emotion-valence domain (anger versus sadness). This is consistent with other research on the developmental pattern of emotion recognition in NH children (Gao & Maurer, 2009; Vicari et al., 2000). Conceivably, a positive facial expression can be distinguished from a negative one by its unique mouth pattern; in other words, happiness can be recognized by merely a smile. In contrast, discriminating between negative facial expressions, such as anger, fear, and sadness, is more demanding because it requires the integration of both the upper and lower face (Vicari et al., 2000).

The outcomes on the Emotion-Identification Task are less clear. They do not indicate whether the development of HI/CI children is delayed or qualitatively different. In line with other research, NH children in this study mastered the identification of positive emotions such as happiness before that of negative emotions and identified anger before sadness and fear (Gao & Maurer, 2009; Vicari et al., 2000). In contrast, HI/CI children performed equally poorly on all four basic emotions. Because professionals and other people dealing with HI/CI children need to know whether or not the development of these children is qualitatively different from that of NH children, this is an issue that might be examined more closely in future studies. For example, if HI/CI children do indeed develop differently, emotion indices might be expected to have a different adaptive or maladaptive function and thus may contribute differently to the development of psychopathological symptoms than they do in NH children. Gaining insight into the developmental pattern of emotion understanding in HI/CI children might help professionals in training these children in emotion understanding skills in order to prevent the development of psychopathology.

Taken together, our findings indicate that HI/CI children’s emotion understanding is negatively influenced by their deafness, even when a task does not directly require language skills. The fact that HI/CI children also performed less well than their NH peers on a nonverbal task in recognizing emotional expressions in faces emphasizes that, besides language skills, a social context is crucial for children’s emotional development, or so-called “emotion socialization” (Saarni, 1999). The delay in emotion understanding in HI/CI children might be explained by a poorer quality and quantity of the interaction between parents and their HI/CI child and by lower exposure and less modeling from adults before they received their CI and had access to spoken language. By using a longitudinal design, future studies might examine possible developmental pathways, thus shedding more light on the causal relation between language development and children’s emotional functioning. Possibly, HI/CI children “catch up” with their hearing peers when they have had the benefit of their implant for a longer period. Children in this study had been implanted
for a relatively short time, due to their young age. Moreover, the children in this study had received their implant relatively late according to current standards. As the age at implantation is still decreasing—a factor that has proved to be an important factor in children’s early spoken-language development—it is unclear how emotional development in younger implanted children will unfold. This study is only a first step toward increasing our understanding of the effect of deafness mediated by a CI and language development on children’s emotional development. Outcomes of this study might also be relevant to other clinical groups with language or communication impairments, such as children with specific language impairments or an autism spectrum disorder. Future studies could examine the extent to which the outcomes of this study indeed also apply to other groups with language issues.

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Conflicts of Interest

No conflicts of interest were reported.

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