Beyond hearing : social-emotional outcomes following cochlear implantation in young children

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Does hearing lead to understanding? Theory of mind in toddlers and preschoolers with cochlear implants

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Abstract

Theory of Mind (ToM) refers to the ability to understand the subjectivity of people's intentions, desires, and beliefs. Research shows that ToM in deaf children is delayed, yet the few studies that examined ToM in deaf children with a cochlear implant (CI) report contradictory results. This study examined multiple aspects of ToM in early-implanted children. Three intention tasks were administered to 72 children with CI and 69 normal-hearing (NH) children (12 – 60 months old). Furthermore, three desire and belief tasks were administered to a subsample of children aged 30 months or over. Children with CI showed intention-understanding skills equal to NH children, but lagged behind on desire and belief understanding, even after excluding children with language delays. Children with CI appear to master the initial stages of ToM development, but fall behind on more advanced ToM abilities. Yet, both groups showed similar patterns of development.

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Introduction

The ability to understand that people's actions and emotions are governed by their mental states, i.e., their subjective experience of reality rather than an objective reality, is essential for adequate social functioning. This skill – called a Theory of Mind (ToM) – usually develops during early childhood (Premack & Woodruff, 1978; Wellman, 1990) and is clearly linked to language abilities (Astington & Jenkins, 1999). Research has shown that the development of a ToM in children with communicative disorders, such as children with an autism spectrum disorder, specific language impairment, or deaf children, is significantly delayed (Farrant, Fletcher, & Maybery, 2006; Peterson & Siegal, 2000). With respect to this latter group of deaf children, exposure to language is often diminished. Over 90% of deaf children are born to hearing parents (Mitchell & Karchmer, 2004) who are not skilled in sign language, which could account for language and, in turn, ToM delays in these children (Peterson & Siegal, 2000). However, nowadays over 80% of young, profoundly deaf children growing up in Western countries receive a cochlear implant (CI) (De Raeve & Lichtert, 2011; Hyde & Power, 2006). This device bypasses the damaged part of the ear by directly stimulating the auditory nerve, and enables these children to perceive sounds, although not to the same extent as people without hearing impairments. How this affects ToM development is as yet unclear, and is therefore the focus of this study.

Rehabilitation programs following cochlear implantation provide insight into the CI's efficacy in individual children by monitoring their sound perception, language acquisition, and social skills. Scientific studies have shown that cochlear implantation improves children's language and communicative skills, especially when children are implanted early, yet many children still fall behind their normal-hearing (NH) peers (Ganek et al., 2012). Other studies have shown improvements in quality of life (Loy, Warner-Czyz, Tong, Tobey, & Roland, 2010) and social competence (Ketelaar, Rieffe, Wiefferink, & Frijns, 2013; Martin et al., 2011). Improved language skills and social competence as a consequence of (early) cochlear implantation could be indicative of corresponding improvements in ToM in these children. Yet, to date, little research has been dedicated to ToM in children with CIs. Moreover, previous studies (Macaulay & Ford, 2006; Peters, Remmel, & Richards, 2009; Peterson, 2004; Remmel & Peters, 2009; Tasker et al., 2010) have reported mixed findings, and most have solely focused on false belief understanding as indicator of ToM. Therefore, this study aims to contribute to the existing body of literature by a) assessing different aspects of ToM functioning of early-implanted children with CI compared to NH peers by employing a broad range of tasks, and b) examining the relation between language aspects and ToM in children with CI.

Theory of Mind

A ToM is grounded on three fundamental mental concepts that develop in a fixed order in typically-developing children (Colonnesi, Rieffe, Koops, & Perucchini, 2008; Wellman & Liu, 2004): intentions, desires, and beliefs. Intentions refer to what we are directed at or are trying to accomplish. Desires refer to wishes, hopes, and needs. Beliefs refer to thoughts, expectations, convictions, and ideas. Together, these provide a framework for understanding complex concepts like figurative speech, white lies, jokes, mistakes, and so on (Wellman, 1990). Deficits in ToM have been related to a wide variety of negative outcomes in early childhood and beyond, including, but not limited to, peer problems (Caputi et al., 2012), externalizing behavior problems (Olson et al., 2011; Sharp, 2008), and internalizing behavior problems (Wolkenstein, Schonenberg, Schirm, & Hautzinger, 2011). Although a fully-fledged ToM is not present until children understand the subjective character of all three states, the development of children's ToM understanding varies per construct and will be discussed separately.

Intentions

At around age one, typically-developing children start to understand that people's actions are intentional. Meltzoff (1995) demonstrated that 18-month-old toddlers already make the distinction between human and inanimate agents. Toddlers who saw a mechanical device trying but failing to perform an action on an object produced the intended act less often than toddlers who saw the same behavior performed by a human agent. Several studies using Meltzoff's paradigm for intention understanding have shown that toddlers become increasingly able to comprehend other people's intentions as they grow older (Bellagamba, Camaioni, & Colonnesi, 2006; Meltzoff, 1995).

Another indicator of children's understanding of intentions is joint attention: the process of coordinated visual attention between two people and an object or event. Infants start to reliably track an adult's gaze or pointing gesture to an object late in their first year of life, which is interpreted as the ability to understand other people's intent to share something (e.g., Tomasello, Carpenter, & Liszkowski, 2007). Within the joint-attention paradigm, declarative comprehension refers to a child's ability to understand that another person wants to show them something, whereas imperative comprehension refers to the child's ability to understand that someone is directing their attention in order to request an object.

In children with hearing impairments, the development of intention understanding is relatively understudied. From the few studies available, it appears this ability develops normally in deaf children without implants until the age of 18 months (Spencer, 2000), but delays have been noted in older deaf children (Prezbindowski et al., 1998). To our knowledge, intention understanding in children with CI has only been examined in one study with nine children with a mean age of 30 months, which indicated that children with CI showed joint-attention skills to the same extent as NH children (Tasker et al., 2010).

Desires

In one of his ground-breaking studies, Wellman (1990) presented typically-developing two-year-olds with a story in which the protagonist likes to swim. The protagonist can either go to the park or to the swimming pool. When children were asked where they thought the protagonist would go, most were able to answer correctly. However, although these results show that two-year-olds acknowledge that desires motivate people to act or feel in a certain way, it is more difficult to assess whether children also appreciate the subjectivity of desires. It is possible that children correctly interpret the causal relationship between desires and actions or emotions, but still perceive desires as objective features (Perner, 1991). Therefore, some researchers investigated desires that were expected to be judged undesirable by children (Moore et al., 1995; Rieffe et al., 2001). These studies demonstrated that a majority of three- and four-year-old children neglected the protagonist's desire in their predictions of the protagonist's behavior or emotions. Instead, children's own desires formed the basis for their predictions of others' (emotional) behavior.

To this day, little research has examined desire understanding in children with CI. To the best of our knowledge, only one study included a measure of desire understanding amongst a range of ToM tests (Remmel & Peters, 2009). Results from this study indicated that children with CI performed equal to NH children. However, this study included only 15 children who were age-matched to the NH control group, with ages ranging from 3 to 7 years old, and ages at implantation from 1 to 5 years old.

Beliefs

Although children grasp the subjectivity of desires before they acknowledge the subjectivity of beliefs (Wellman, 1990; Wellman & Liu, 2004), the developmental pattern of belief understanding resembles that of desire understanding. Whereas almost all typically-developing three-year-olds can correctly predict that the protagonist will look under the porch and not in the kitchen if the protagonist is looking for his dog and thinks the dog is under the porch (Wellman, 1990), this does not necessarily reflect children's understanding of the subjectivity of beliefs. The ultimate test in this regard is the classical false-belief task, originally developed by Wimmer and Perner (1983). In this task, participants have to understand that the protagonist holds a belief about reality that contradicts their own belief. Although participants know that mother moved Maxi's chocolate from the blue to the green cupboard in his absence, they should understand that Maxi does not know this, and should consequently predict Maxi's actions on the basis of his (false) belief instead of their own when Maxi returns to get his chocolate. Around the age of four children are able to correctly predict that Maxi will go to the blue cupboard. Alternative belief tasks, such as the so-called 'changed-belief task' which examines children's capacity to acknowledge their own changed beliefs about real features of the world (i.e., a rock that turns out to be a sponge, Flavell, Flavell, & Green, 1983), show the same age pattern.

What little research has been conducted on ToM in children with CI has focused mostly on false-belief understanding. Conclusions from these studies have not been uniform, with some (Macaulay & Ford, 2006; Peterson, 2004) reporting impairments, whereas others report that children with CI do understand false beliefs (Peters et al., 2009) and even find no delays compared to NH children (Remmel & Peters, 2009). These studies were conducted with small groups of children with a wide age range, both chronologically (3–12 years) and at implantation (1-6 years). Given the fact that deaf children today are implanted at ever-younger ages – which could positively affect their ToM development because of earlier access to spoken language – it is important to replicate previous research with a large group of early-implanted children.

Current Study

The main goal of this study was to compare ToM skills of young children with CI to NH children, and to examine the relations between these skills and age, timing of implantation, and language comprehension. Ideally, we would have liked to include a group of deaf children never fitted with a CI in order to determine its effects. However, nowadays the vast majority of young, profoundly deaf children are fitted with a CI (De Raeve & Lichtert, 2011; Hyde & Power, 2006). The few that do not receive an implant are often not comparable to the ones that do because they have additional handicaps or have one or two deaf parents.

Compared to previous studies, this study included a large sample of young children with CI who were implanted at an early age. Additionally, a variety of ToM measures were employed to ensure construct validity, as well as to identify group differences on each of the concepts separately. Three nonverbal intention tasks, as well as two desire tasks and one false belief task that placed minimal demand on language comprehension and production were administered. We expected that the intention-understanding skills of children with CI would be comparable to those of their NH peers because these skills in typically-developing children are first seen at a preverbal age (around the first birthday) (Bellagamba et al., 2006; Tomasello et al., 2007). Moreover, findings from the Tasker and colleagues (2010) study indicated no differences between children with CI and NH children with regard to an aspect of intention understanding: joint attention. In contrast, we expected children with CI to fall behind their NH peers on desire and belief understanding because language is required as a tool for mental reasoning, and language skills are often still impaired in children with CI (Ganek et al., 2012). We expected to find a relation between language skills and performance on ToM tasks and, because previous studies have demonstrated a relation between language and timing of implantation (cf. Ganek et al., 2012), we also expected early implantation to benefit ToM skills. Finally, we assumed that children with CI who used spoken language as opposed to sign language would have more opportunities to communicate with others, which, in turn, would benefit their ToM development.

Method

Participants and Procedure

This study included 72 children with CI from nine different counseling services and hospitals all over the Netherlands and from one counseling service in the Dutch-speaking part of Belgium. Seventy-two percent of the sample was recruited directly by health care professionals who were involved in the rehabilitation of these children. A positive response rate of 84% (16% chose not to participate) implies that this part of the sample is representative of the population of children with CI in the Netherlands. The remaining 29% of the sample was recruited via letters dispersed by the counseling services that participated in the study. The response rate was much lower; 26% chose to participate, 5% refused to participate and 69% did not respond at all. Since no information is available on the non-respondents, it is unknown whether this part of the sample is representative of the population. Additionally, 69 NH children from schools and day-care centers all over the Netherlands were included. All children were between 1 and 6 years old, were born to hearing parents, had no apparent (additional) disabilities, and children in both groups came from similar middle to high socio-economic backgrounds (judging from household income and maternal education). Table 1 shows descriptive statistics. No age differences were found between the CI and NH group. Additionally, both groups showed comparable gross and fine motor skills, which was taken as an indication of comparable cognitive functioning (Piek, Dawson, Smith, & Gasson, 2008) because it is impossible to obtain reliable IQ scores at this young age.

The majority of children with CI were born deaf. The remaining children became deaf before their second birthday, creating a homogeneous sample of children with prelingual (i.e., before language starts developing) and profound (i.e., over 90 dB in the better ear) hearing loss. Including only children with prelingual hearing loss avoided the potentially beneficial influence of language skills that developed before the onset of deafness. In addition, children had received their (first) implant at an early age, i.e., before age three, except for one child who was implanted at 3;3 years old. Two thirds of the CI group was unilaterally implanted, the others were bilaterally implanted. Parents indicated that their children wore their CI (almost) always, except for two children who wore it often. As is customary in the Netherlands and the Dutch-speaking part of Belgium, all implanted children in the sample entered a rehabilitation

Table 1 Demographic and Medical Profile of Participants

	CI (*n* = 72)	NH (*n* = 69)
Age, mean (SD), mo	37.39 (13.49)	39.51 (12.87)
Age, range, mo	14 – 60	12 – 60
Male, No. (%)	42 (58%)	39 (57%)
Socioeconomic status		
Maternal education, mean (SD)[a]	3.37 (0.89)	3.59 (0.64)
Net household income, mean (SD)[b]	3.72 (1.12)	3.54 (0.85)
Age at implantation, mean (SD), mo	16.94 (7.66)	
Age at implantation, range, mo	6 – 39	
Time with (first) CI, mean (SD), mo	19.04 (12.67)	
Time with (first) CI, range, mo	1 – 44	
Etiology of hearing loss, No. (%)		
Unknown congenital	33 (46%)	
Infection (meningitis, cytomegalovirus)	14 (19%)	
Genetic (connexin mutation, Waardenburg syndrome, large vestibular aqueduct syndrome)	6 (9%)	
Prematurity	3 (4%)	
Information unavailable	16 (22%)	
Preferred mode of communication, No. (%)		
Spoken language only	26 (36%)	
Sign or sign-supported language	46 (64%)	

[a](1 = *no / primary education*, 2 = *lower general secondary education*, 3 = *higher general secondary education*, 4 = *college / university*)

[b](1 = l*ess than €15,000*, 2 = *€15,000 – €30,000*, 3 = *€30,000 – €45,000*, 4 = *€45,000 – €60,000*, 5 = *More than €60,000*)

program. Such programs are tailored to the individual child's needs and include specialized playgroups for the deaf, monitoring (and adjustment if necessary) of the CI by an audiologist, and speech therapy.

The study was approved by the university's medical ethics committee. NH children were recruited through day-care centers, playgroups, and primary schools in the Netherlands. Children with CI were recruited through hospitals and family council services in the Netherlands and the Dutch speaking part of Belgium. Parents received information on the study in writing and were required to sign an informed consent form.

The tasks were administered to children in the CI group by one of two experimenters who were fluent in sign language and experienced in assessing language and cognitive skills of young deaf children. Depending on their preferred mode of communication, Children with CI were administered the tasks in SLN, SSD, or spoken Dutch.

The intention-understanding tasks were administered to all children regardless of age or language skills, whereas the desire and belief tasks were administered only to children aged 30 months or over, providing they met a preset level of language comprehension.

Materials

Motor and language development. The Child Development Inventory (CDI; Ireton & Glascoe, 1995) assesses general development. The scales Language Comprehension (spoken and/or signed, 50 items), Gross Motor (30 items), and Fine Motor (30 items) were used in this study. Since deaf children tend to have balance issues (Gheysen, Loots, & Van Waelvelde, 2008), seven items referring to balance were removed from the Gross Motor scale. Parents indicated for each item whether it described their child's behavior (0 = no, 1 = yes). The scales showed very high reliability (Cronbach's Alphas between .91 and .98).

To assess whether or not children had language-comprehension skills that were deemed sufficient to be administered the ToM tasks, language comprehension of children aged 30 months or over was further determined by the experimenter in two ways. First, the experimenter asked parents whether their children understood certain simple sentences (e.g., "The boy walks to his bike"). Second, children's passive vocabulary was assessed with a picture task. The experimenter named or signed 13 objects from the tasks (e.g., carrot, plane) and asked children to identify the corresponding pictures. Children were considered to have insufficient language-comprehension skills if parents reported that their children did not understand the sentences, or if children misidentified more than four pictures. ToM tasks were not administered to children younger than 30 months, or to children with insufficient language comprehension, because we assumed that they would not understand the stories and therefore, would not be able to succeed.

Intention tasks. The Intention-Understanding Task (Meltzoff, 1995) measures children's understanding of other people's intentions with regard to objects. The experimenter showed three separate intentions by repeatedly trying to perform an action but failing to succeed (e.g., dropping a string of beads into a cup). The materials were then handed to the children, who could earn a maximum of three points if they completed the intended actions.

The Imperative-Comprehension Task (Colonnesi et al., 2008) assesses joint attention by examining children's responses to the experimenter's pointing gesture towards an object on the table that was beyond the experimenter's but within the children's reach. Children passed when they handed the object or placed it near the experimenter, or refused to give it by saying "no" or shaking their head. The task was administered three times, or until the children passed. Children earned three points if they produced the target behavior the first time, one point was deducted for each additional trial needed, down to a score of zero if the target behavior was not produced after three trials.

During the Declarative-Comprehension Task (Colonnesi et al., 2008), which measures joint attention, the experimenter pointed towards an object in the room (e.g., a poster on the wall) outside children's direct field of vision. Children could earn three points, one for each of the following behaviors: (a) looking at the object, (b) eye contact with the experimenter after looking, and (c) smiling or vocalizing toward the object.

Desire tasks. In the Common- and Uncommon-Desire Tasks (Rieffe et al., 2001), children were presented with four vignettes. Children were shown a picture of a more and a less desirable food item (e.g., a carrot and a piece of cake) and asked which item they preferred to eat. In the next picture a boy was introduced. In the two vignettes used in the Common-Desire Task, the protagonist's preference was in accordance with the child's preference. In the two vignettes used in the Uncommon-Desire Task, the protagonist's preference conflicted with the child's preference. A test question: "Which food will the boy pick?" and two control questions: "Does the boy like [food A]?" and "Does the boy like [food B]?" were asked. Children could earn one point per vignette if all three questions were answered correctly. Mean scores were calculated for the two common- and the two uncommon-desire vignettes separately.

Belief task. The False-Belief Task was adapted from Baron-Cohen, Leslie, and Frith's (1985) Sally-Anne Task. A short picture story was presented about a boy that put his toy airplane in one location and while he was away, a girl placed it somewhere else. Next, the boy returned and the children were asked the test question: "Where will the boy look for his plane?" and two control questions: "Where is the plane really?" and "Where did the boy put the plane when he went away?". Children were awarded one point if they answered all three questions correctly.

Results

Intention Tasks

A 2 (Group: CI, NH) x 3 (Task: Intention Understanding, Imperative Comprehension, Declarative Comprehension) multivariate analysis of variance produced no main effect for Group, $F(1, 138) = 0.10$, $p = .752$, $\eta^2_p < .01$. In accordance with our hypothesis, the CI group performed as well as the NH group on the intention tasks. A main effect was found for Task, $F(2, 276) = 12.60$, $p < .001$, $\eta^2_p = .08$, indicating that the Intention-Understanding Task yielded lower scores than the two joint-attention tasks (Table 2).

To rule out that differences were masked by performances of the older children in the sample, independent t-tests were performed for each of the intention tasks with children under the age of 30 months only (21 CI, 14 NH). Results showed no differences between CI and NH children.

Table 2 Mean Scores on Intention and Desire and Belief Tasks as a Function of Group by Task

Instrument (min-max)	CI Mean (SD)	NH Mean (SD)	Between-group difference (95% CI)	Total Mean (SD)
Intention tasks all children				
	n = 72	*n* = 68		*n* = 140
Intention-Understanding (0-3)	1.93 (1.17)	1.97 (1.15)	-.04 (-.43, .35)	1.95^{2} (1.15)
Imperative-Comprehension (0-3)	2.33 (1.04)	2.59 (0.85)	-.26 (-.57, .06)	2.46^{1} (0.96)
Declarative-Comprehension (0-3)	2.40 (0.62)	2.21 (0.64)	.20 (-.01, .41)	2.31^{1} (0.63)
ToM tasks all children ≥ 30 months old				
	n = 51	*n* = 52		*n* = 103
Common-Desire (0-1)	0.31^{b} (0.42)	0.67^{a} (0.44)	-.36 (-.53, -.19)	0.37^{1} (0.46)
Uncommon-Desire (0-1)	0.20^{b} (0.36)	0.62^{a} (0.43)	-.42 (-.57, -.26)	0.30^{2} (0.42)
False-Belief (0-1)	0^{b}	0.31^{a} (0.47)	-.31 (-.44, -.18)	0.12^{3} (0.32)
ToM tasks children with sufficient language comprehension				
	n = 22	*n* = 47		
Common-Desire (0-1)	0.73^{a1} (0.34)	0.75^{a1} (0.40)	-.02 (-.22, .18)	
Uncommon-Desire (0-1)	0.43^{b2} (0.44)	0.69^{a1} (0.40)	-.26 (-.47, -.05)	
False-Belief (0-1)	0^{b3}	0.34^{a2} (0.48)	-.34 (-.55, -.14)	

Note. Different letter-superscripts indicate differences at $p < .05$ on rows. Different number-superscripts indicate differences at $p < .05$ on columns.

Desire and Belief Tasks

The desire and belief tasks were administered to children aged 30 months or over, provided they had shown sufficient language comprehension as per the criteria described in the materials section. For the subsequent analysis, children with insufficient language comprehension according to these criteria were assumed to have failed these tasks and were consequently given the score 0. Two NH children refused to perform the False-Belief Task and were left out of all further analyses, leaving a total of 103 children (51 CI, 52 NH) that were included in a 2 (Group: CI, NH) x 3 (Task: Common Desire, Uncommon Desire, and False Belief) multivariate analysis of variance. The analysis showed main effects for Group, $F(1, 101) = 35.78$, $p < .001$, $\eta^2_p = .26$ and Task, $F(2, 202) = 37.46$, $p < .001$, $\eta^2_p = .27$. In line with our expectation, the NH group outperformed the CI group. Furthermore, children performed better on the Common- than on the Uncommon-Desire Task, while the False-Belief Task yielded the lowest scores (Table 2).

Table 3 Mean Scores on Age, Language Comprehension and Timing of Implantation as a Function of Group by Language-Comprehension Skills

	Insufficient language comprehension			Sufficient language comprehension		
	CI (n = 29)	NH (n = 5)	Between-group difference (95% CI)	CI (n = 22)	NH (n = 47)	Between-group difference (95% CI)
	Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)	
Age, mo	41.03^{bc} (8.18)	31.20^{c} (1.79)	9.83 (2.26, 17.41)	49.45^{a} (5.28)	45.83^{ab} (8.55)	3.63 (.27, 6.98)
CDI, LC (0-1)	0.61^{b} (0.23)	0.81^{ab} (0.06)	-.21 (-.50, .08)	0.79^{a} (0.11)	0.87^{a} (0.13)	-.08 (-.15, -.01)
Implant age, mo	16.13^{a} (7.57)			19.00^{a} (8.17)		
Implant use, mo	16.33^{b} (11.69)			29.61^{a} (8.05)		

Note. Different letter-superscripts indicate differences on rows at $p < .05$.

Note. CDI, LC: Child Development Inventory, Language Comprehension.

Desire and Belief Understanding of Children with Sufficient Language-Comprehension Skills

According to the formulated criteria described in the materials section, 29 out of 51 children with CI and 5 out of 52 NH children aged 30 months or over had insufficient language-comprehension skills. Oneway ANOVAs with Bonferroni correction showed that CI and NH children with insufficient language-comprehension skills were younger than their respective counterparts with sufficient skills, $F(3, 99) = 10.50$, $p < .001$, $\eta^2 = .24$ (Table 3). Moreover, in the CI group children judged to have insufficient comprehension skills were also scored lower by their parents on the CDI scale Language Comprehension than those with sufficient skills. Furthermore, this scale showed no differences between CI and NH children who were judged to have sufficient comprehension skills, $F(3, 73) = 11.99$, $p < .001$, $\eta^2 = .53$ (Table 3). Additionally, children with CI who had sufficient language-comprehension skills on average were implanted at the same age as children with CI who had insufficient skills, $t(45) = -.33$, $p = .746$, $\eta^2 < .01$, but they had been using their implant for a longer time, $t(45) = -2.61$, $p < .012$, $\eta^2 = .12$ (Table 3).

A 2 (Group: CI, NH) x 3 (Task: Common Desire, Uncommon Desire, and False Belief) multivariate analysis of variance for children exclusively with sufficient language-comprehension skills showed a main effect for Group, $F(1, 67) = 7.08$, $p = .010$, $\eta^2_p = .10$ and Task, $F(2, 134) = 49.06$, $p < .001$, $\eta^2_p = .42$, which was qualified by a Group x Task interaction, $F(2, 134) = 4.13$, $p = .018$, $\eta^2_p = .06$. When only children with sufficient language-comprehension skills were included, children with CI were still outperformed by their NH peers on the Uncommon-Desire Task and the False-Belief Task, but not on the Common-Desire Task. Furthermore, children with CI performed better on the Common than on the Uncommon-Desire Task, whereas this difference was not present in the NH group. Both groups had higher scores on the desire tasks than on the belief task (Table 2).

Influence of Language and Implantation Timing on Task Performance

Relations of language and implantation timing with the belief task could not be assessed for the CI group because all children with CI failed this task.

To examine whether children who used spoken language performed better on the intention and the desire and belief tasks than children who used sign language, children with CI were divided into two groups: one group ($n = 26$) that relied solely on spoken Dutch and one group ($n = 46$) that relied on some form of sign language (i.e., Sign Language of the Netherlands, Sign-Supported Dutch, or a combination of modes). Contrary to our expectations, multivariate analyses of variance revealed no differences in scores on the intention tasks, $F(1, 70) = 0.04$, $p = .834$, $\eta^2_p < .01$ or the desire and belief tasks, $F(1, 49) = 0.83$, $p = .367$, $\eta^2_p = .02$ between children who did or did not use signs.

Table 4 shows correlations of Age, the CDI scale Language Comprehension, and implantation timing with the desire and belief tasks for each group separately. Correlations corrected for age were also calculated because age was assumed to be a confounding variable; older children tend to have better ToM skills, but also better language skills and, in the case of the CI group, probably more experience with their CI. Age correlated with all desire and belief tasks in both groups. Language Comprehension correlated with all tasks for both groups. Unexpectedly, however, after correcting for Age only the correlation with the Common-Desire Task for the NH group remained significant, although we did see a trend (p = .052) for the CI group. Contrary to findings from studies on language development (Ganek et al., 2012), and to our own expectations, age at implantation and duration of implant use were not related to performance on the desire and belief tasks. Because of the strong correlation between age and duration of implant use (r = .63, p < .001), correlations when controlled for duration of implant use are not reported.

Table 4 Correlation Coefficients (Partial Correlations Corrected for Age) of ToM Tasks with Age, Language, and Timing of Implantation per Group

	CI				NH	
	Age	CDI, LC	Implant Age	Implant Use	Age	CDI, LC
Common-Desire	.54**	.42* (.33)	.15 (.05)	.28 (-.09)	.60**	.64** (.41*)
Uncommon-Desire	.36*	.31 (.23)	.04 (-.04)	.22 (-.01)	.56**	.51** (.23)
False-Belief	[a]	[a]	[a]	[a]	.66**	.45* (.01)

*p < .01; **p < .001 (2-tailed).
[a]No correlations were computed because all children with CI failed the False-Belief Task.
Note. CDI, LC: Child Development Inventory, Language Comprehension.

Discussion

Theory of Mind (ToM) is a very important skill for social functioning which starts to develop in early childhood, and is known to be impaired in deaf children (Peterson & Siegal, 2000). Early cochlear implantation is thought to help deaf children develop a ToM, but the effect of a CI on young children's ToM functioning has been relatively underexamined. The current study therefore focused on ToM in a large group of early-implanted children. To date, the few studies that have been conducted with children with CI almost all focused on false-belief tasks as sole index for ToM (Macaulay & Ford, 2006; Peters et al., 2009; Peterson, 2004), whereas two other important aspects of ToM, intention understanding and desire understanding, have received very little attention (Remmel & Peters, 2009; Tasker et al., 2010). The current study aimed to measure children's performance on all three aspects of ToM in order to identify if, and where on the spectrum, children with CI show deficits.

Even though children in the current study were implanted at a considerably earlier age than children in previous studies, their ToM was still affected. As expected, outcomes of this study show that children with CI can understand other people's intentions to the same extent as NH children. Yet, in contrast to some studies (Peters et al., 2009; Remmel & Peters, 2009), but in line with others (Macaulay & Ford, 2006; Peterson, 2004), we found that children with CI have difficulties understanding other people's desires and (false) beliefs in comparison to NH peers, even after correcting for verbal skills. Possibly, children with CI show a developmental delay with respect to ToM functioning. Alternatively, these children might follow a qualitatively different developmental path that allows them to master the initial stage of ToM (i.e., intention understanding), but does not allow them to grasp the more complex concepts of diverse desires and beliefs. The performance of the CI group on the various tasks resembles the pattern of development found in NH children, with understanding of intentions developing before understanding of desires and beliefs (Wellman, 1990), which supports the assumption of a delayed rather than a qualitatively different development. However, only longitudinal research can confirm this assumption.

Another question that remains to be answered is why children with CI have difficulties developing a fully functioning ToM. Although research with NH children has demonstrated a close link between language and ToM

(Astington & Jenkins, 1999), and language is often still impaired in children with CI (Ganek et al., 2012), our study demonstrated that ToM was also impaired in a subsample of children with CI with adequate language skills. Therefore, even though cochlear implantation is known to benefit language abilities (Ganek et al., 2012), we cannot expect interventions targeted at promoting language in children with CI to also improve their ToM. We suggest that attention be directed at the specific content of conversations between children with CI and their parents as it is unclear whether quality of conversation is comparable for children with CI and NH children. Mental-state conversations, for example during picture-book reading, are of particular interest because of the link to ToM development found in both NH children (Ruffman, Slade, & Crowe, 2002) and deaf children without CI (Moeller & Schick, 2006), and the fact that parents often report problems engaging in mentalistic conversations with their deaf children (Peterson & Siegal, 2000). If this assumed link is also present in children with CI, intervention and rehabilitation programs should try to boost parents' skills to communicate with their children about mental states.

This study significantly contributes to existing literature in this area because of our larger sample sizes, and thus greater statistical power. Therefore, we are able to draw firm conclusions regarding the ToM abilities of these children. However, generalizations to other children with CI should be made with caution because of the heterogeneity of this population. First, not all children benefit from their CI to the same extent, even when they are implanted at the same age and with the same device. Second, although some factors that could have influenced ToM development, such as age at implantation and duration of implant use, have been taken into account in this study, numerous other potential factors come to mind such as unilateral versus bilateral implantation, speech perception after implantation, and type of device implanted. A far larger sample would have been needed for a thorough study of the influence of each of these factors. Finally, research into speech development after implantation has shown a gradual improvement of abilities until five years post-implantation (O'Donoghue, Nikolopoulos, Archbold, & Tait, 1998). This might also apply to ToM development. Given the limited amount of experience the children had with their CI (19 months on average), it is possible that the ToM delay will gradually vanish when they have had more opportunity to take advantage of their implants. Consequently, replication of these findings is desirable, as well as collecting longitudinal data for several years after implantation.

Future studies should also address whether the early ToM impairments that we found in these children with CI affect other areas of functioning (e.g., peer relations), and contribute to the development of later psychopathology (e.g., aggression, depression), as has been observed in typically-developing children (Caputi et al., 2012; Olson et al., 2011; Sharp, 2008; Wolkenstein et al., 2011), or whether these negative outcomes can be prevented if children with CI indeed catch up to NH children on ToM skills. Nonetheless, this study is an initial effort to gain an understanding of the development of this growing group of children that seem to fall between two stools: not deaf, but not quite like NH children either. There are important practical implications for parents and professionals (e.g., teachers, counselors). They should be made aware of the developmental delays and be given tools to assist the children in building a ToM, especially since more and more children with CI attend mainstream schools and are treated as NH children.