Theory of Mind and Language in Children With Cochlear Implants

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Thirty children with cochlear implants (CI children), age range 3–12 years, and 30 children with normal hearing (NH children), age range 4–6 years, were tested on theory of mind and language measures. The CI children showed little to no delay on either theory of mind, relative to the NH children, or spoken language, relative to hearing norms. The CI children showed a slightly atypical sequence of acquisition of theory of mind concepts. The CI children's theory of mind performance was associated with general syntactic proficiency more than measures of complement syntax, and with time since implantation more than age at implantation. Results suggest that cochlear implantation can benefit spoken language ability, which may then benefit theory of mind, perhaps by increasing access to mental state language.

Theory of mind refers to our folk understanding of how the mind works and how mental states (beliefs, desires, emotions, etc.) are influenced by perception and influence behavior (see Wellman, 2002, for a review). A mature theory of mind is necessary for a mature understanding of social situations and social relationships and allows one to more accurately predict and explain people's behavior. For example, in the most-researched but by no means only aspect of theory of mind, children between ages 3 and 5 seem to develop an understanding that people can hold false beliefs that can cause them to behave in otherwise inexplicable ways (e.g., to look for an object in one location when the child knows the object is in a different location). The fact that children's performance on standard theory of mind tasks, such as the false belief task, improves with age is well documented (Wellman, Cross, & Watson, 2001), but the cognitive processes underlying that improvement are very much in debate. For example, Leslie (2005; Scholl & Leslie, 1999, 2001) argues that theory of mind competence develops relatively early (during the second year) and relatively independent of experience (although some environmental triggering may be needed for the theory of mind "module" to "come on-line") and that later performance improvements are due to domain-general developments in executive function (inhibition and selection among alternatives). In contrast, a number of authors argue that improvements in children's theory of mind performance during the preschool years reflect fundamental changes in conceptualizations of the mind and that these are related to language experience (see Harris, de Rosnay, & Pons, 2005; Milligan, Astington, & Dack, 2007, for reviews). Language plays a role in both theoretical accounts by providing fodder for conceptual developments and by modifying the performance demands of the tasks (cf. Yazdi, German, Defeyter, & Siegal, 2006).

Children with cochlear implants (CIs) are a unique population with atypical language experience and thus provide an opportunity to illuminate the relationship between language ability and theory of mind performance. Given the importance of theory of mind to successful social functioning (Watson, Nixon, Wilson, & Capage, 1999), it is important to understand whether

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certain sorts of language experience are necessary for theory of mind development. There is strong evidence that exposure to mental state language (references to beliefs, desires, emotions, etc.) directly predicts children's later theory of mind understanding (Adrian, Clemente, & Villaneuva, 2007; Ruffman, Slade, & Crowe, 2002; Slaughter, Peterson, & Mackintosh, 2007; Taumoepeau & Ruffman, 2006). Jill de Villiers, however, argues that the critical factor in theory of mind development is not general conversational exposure to language about mental states and different perspectives but the acquisition of certain syntactic forms (de Villiers & de Villiers, 2000; de Villiers & Pyers, 2002; Schick, de Villiers, de Villiers, & Hoffmeister, 2007). Specifically, de Villiers argues that the acquisition of complement syntax, in which a proposition is embedded under a mental state verb (e.g., "He thinks that the chocolate is in the cupboard") or communication verb (e.g., "She says the box contains candy"), is necessary to represent false beliefs. In support of this hypothesis, two studies found that training on complement syntax improved children's performance on false belief tasks (Hale & Tager-Flusberg, 2003; Lohmann & Tomasello, 2003). However, a number of other studies have found evidence that false belief performance is related to language ability more generally and not mastery of complement syntax specifically (Cheung et al., 2004; Perner, Sprung, Zauner, & Haider, 2003; Ruffman, Slade, Rowlandson, Rumsey, & Garnham, 2003; Smith, Apperly, & White, 2003; Tardif, So, & Kaciroti, 2007).

Research with deaf children supports the idea that language experience affects theory of mind development (see Peterson & Siegal, 2000; Remmel, Bettger, & Weinberg, 2001, for reviews). Native-signing deaf children of deaf parents, who acquire sign language at the same rate that hearing children acquire spoken language (Newport & Meier, 1985), are not delayed in their theory of mind performance (Courtin, 2000; Peterson & Siegal, 1999; Remmel, 2003; Schick et al., 2007; Woolfe, Want, & Siegal, 2002). Deaf children of hearing parents, however, are typically delayed in their acquisition of either spoken or sign language (Marschark, 1993) and are also typically delayed in their theory of mind performance (Courtin, 2000; de Villiers & de Villiers, 2000; Peterson & Siegal, 1999; Schick et al., 2007; Woolfe et al., 2002). Furthermore, maternal mental state talk predicts theory of mind performance in deaf children of hearing parents (Moeller & Schick, 2006).

In recent years, however, deaf children of hearing parents are increasingly likely to receive CIs and at younger ages (see Spencer & Marschark, 2003, for a review). CIs are electronic devices that are surgically implanted in the cochlea, directly stimulate the auditory nerve, and provide sensitivity to sound even to profoundly deaf individuals. CIs do not confer natural hearing—despite ongoing improvements in the technology, current implants provide relatively coarse auditory information, extensive speech-language therapy and implant tuning are needed, and outcomes are variable (Christiansen & Leigh, 2002; Ouellet & Cohen, 1999). Nevertheless, on average, cochlear implantation appears to accelerate the acquisition of spoken language (Geers, 2006; Svirsky, Robbins, Kirk, Pisoni, & Miyamoto, 2000). Implantation of children remains controversial, however, and the National Association of the Deaf (2000) cautions that implants should not be viewed as a "cure" for deafness and that implants may not be appropriate and effective for all deaf children.

Given that cochlear implantation can promote spoken language acquisition, if the ability to comprehend mental state references and/or acquire complement syntax underlies theory of mind development, then cochlear implantation could also promote theory of mind development. The large majority of research on children with CIs has focused on language outcomes, and relatively little research has focused on psychological outcomes, although a few studies suggest positive effects of cochlear implantation on both cognitive measures (Edwards, Khan, Broxholme, & Langdon, 2006; Khan, Edwards, & Langdon, 2005; Knutson, Wald, Ehlers, & Tyler, 2000) and social measures (Bat-Chava, Martin, & Kosciw, 2005; Nicholas & Geers, 2003; but see Boyd, Knutson, & Dahlstrom, 2000). Only four previous studies (Lundy, 2002; Macaulay & Ford, 2006; Moeller & Schick, 2006; Peterson, 2004) have specifically examined theory of mind in children with CIs (a few other studies, such as Schick et al., 2007, included some children with CIs in groups with nonimplanted deaf children, but did not examine their performance separately). In

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all four studies, children with CIs showed delayed performance on false belief tasks, relative to hearing norms. Three of the studies (Lundy, 2002; Moeller & Schick, 2006; Peterson, 2004) also compared their false belief performance to that of deaf children with conventional hearing aids and found no significant differences. As implant technology improves and the average age of implantation decreases, however, theory of mind outcomes may change as well.

Theory of mind research has often focused on performance on false belief tasks, despite the fact that theory of mind involves understanding a variety of concepts besides just false belief. Wellman and Liu (2004) developed a set of tasks to measure different theory of mind concepts and found that success on these tasks followed a predictable sequence in typical preschoolers. Peterson, Wellman, and Liu (2005) replicated these results in typical preschoolers and found that late-signing deaf children and native-signing deaf children followed the same sequence. The late signers were severely or profoundly deaf since birth, had no deaf family members, and attended classrooms for hearing-impaired children that used a Total Communication approach, described by Peterson et al. as "Signed English, supplemented by lipreading, fingerspelling, and Auslan (Australian Sign Language)" (p. 505). The native signers were severely or profoundly deaf since birth, grew up with at least one deaf family member who signed fluently, and attended the same Total Communication classrooms as the late signers. Although it was not stated in the study, 1 of the 11 native signers and 15 of the 36 late signers had CIs (C. C. Peterson, personal communication, January 9, 2008). However, Peterson et al. found that autistic children showed a slightly different pattern. Specifically, the typical preschoolers and signing deaf children performed better on false belief understanding than on understanding of real versus apparent emotion (that someone might try to prevent one's true emotion from showing on one's face), whereas autistic children showed the reverse pattern. Peterson et al. suggested that autistic children may progress through the steps of theory of mind development in a distinctive sequence.

Theory of mind tasks are typically administered verbally, which raises the question of whether the linguistic demands of the tasks may mask some deaf children's conceptual competence. Figueras-Costa and Harris (2001) found that oral (i.e., spoken-language-using) deaf children performed significantly better on a nonverbal false belief task than on a verbal false belief task, suggesting that verbal theory of mind tasks may underestimate some deaf children's understanding. The deaf children in the Figueras-Costa and Harris study all had hearing parents, used spoken Catalan or Spanish, and used hearing aids, except for one who had a CI. Even on the nonverbal false belief task, however, the deaf children's performance was delayed by about 4 years relative to hearing norms. Other studies have also found that deaf children of hearing parents, both signing and oral, perform poorly for their age on theory of mind tasks even when the verbal demands are reduced (Schick et al., 2007; Woolfe et al., 2002). Deaf children of hearing parents, both signing and oral, also perform better on "false photograph" tasks (understanding of physical representations) than on false belief tasks (understanding of mental representations), although the verbal demands of the tasks are very similar (de Villiers, Pyers, & Salkind, 1999; Peterson & Siegal, 1998; Woolfe et al., 2002).

This study examined theory of mind, language ability, and the relationship between them in children with CIs. We aimed to recruit a larger sample than the four previous studies of theory of mind in children with CIs, in which samples ranged from 9 to 13 children. The previous studies focused on false belief performance, whereas we used a broader range of theory of mind tasks to try to get a more complete picture of the children's competence. We used the theory of mind scale by Wellman and Liu (2004) because it measures a number of different theory of mind concepts and allows for comparisons with typically developing hearing children and also with the deaf and autistic children in Peterson et al. (2005). In addition to average group performance, the scale allows us to examine individual sequences of developments—that is, whether children with CIs tend to acquire theory of mind concepts in the same order as other groups of children. We also used an explanation of action task that assessed the children's ability to explain people's behavior in mental state terms, which is a more naturalistic measure of theory of mind. To control for the

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possibility that delayed theory of mind performance could be due to difficulty with the verbal demands of the tasks or to domain-general cognitive delay, we also employed a nonverbal false belief task and a cognitive task outside of the theory of mind domain (a false photograph task).

Language ability was assessed with standard receptive and expressive measures, a measure of syntactic complexity, and measures of comprehension and production of complement syntax. Children with CIs are an interesting population for studying the relationship between theory of mind and language because they have limited access to spoken language early in life, but their spoken language ability typically increases after implantation (Geers, 2006; Svirsky et al., 2000). For both theoretical and practical reasons, it is important to understand whether these language gains are accompanied by gains in psychological variables, such as theory of mind. Such gains seem plausible, given that cochlear implantation seems likely to increase access to parental mental state talk, and exposure to parental mental state talk predicts theory of mind (Ruffman et al., 2002; Moeller & Schick, 2006). However, age at implantation may also play a role, as some studies have found that earlier implantation is associated with better spoken language ability (Nicholas & Geers, 2006a, 2006b). We examined whether theory of mind performance was more associated with age at implantation (which would suggest a critical period for theory of mind development, such that later implantation results in permanent deficits) or time since implantation (which would suggest that theory of mind improves with language exposure, regardless of when the exposure begins). We also examined whether theory of mind performance was more associated with general linguistic proficiency or the acquisition of complement syntax specifically, as proposed by de Villiers (de Villiers & de Villiers, 2000).

Method

Participants

Participants were 30 children with CIs and 30 children with normal hearing (NH children). The CI children (15 boys and 15 girls) ranged in age from 3.1 to 12.0 years (M = 7.5, SD = 2.2). A wide age range was recruited in order to maximize the sample size. Only one CI child was younger than 4, and we decided not to exclude her, despite her young age, because she scored above the group mean on most measures. The NH children (15 boys and 15 girls) ranged in age from 4.5 to 6.4 years (M = 5.2, SD = 0.5). This age range was recruited in order to avoid floor or ceiling effects on the theory of mind measures. Preliminary analyses indicated that gender was not a significant factor in any of the results, so it will not be discussed further.

Fifteen of the CI children were recruited from one aural rehabilitation clinic in the Northeast United States. This represented all the CI children in this age range seen at that clinic at that time, excluding some with known cognitive disabilities. The other 15 CI children were recruited through other aural rehabilitation clinics in the Northeast and Pacific Northwest United States and western Canada. Although we attempted to recruit as many CI children as possible, this obviously represents only a small fraction of the children with CIs in these regions. We cannot be sure that the CI children whose parents volunteered to participate are typical of CI children seen at those clinics, all children currently using implants, or all children who have been implanted. We can attest that we did not selectively recruit, select, or screen CI children; we tested every CI child that we could. The NH children were recruited from child care centers in the Pacific Northwest United States.

A majority of the children were White (26 of the CI children and 19 of the NH children); the other children represented a wide range of ethnic backgrounds. All children used spoken English as their primary mode of communication. None of the CI children had used American Sign Language (ASL). Three of the CI children had used some signed communication (e.g., Total Communication) in the past, but they were not reported by their parents to use signed communication any longer and they did not use any signs during data collection. None of the children had any diagnosed psychological, cognitive, or behavioral disorders.

All parents had normal hearing and used spoken English as their primary mode of communication. None of the parents used ASL with their children.

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Parental education was coded as follows: high school diploma/General Education Development (GED) credential = 1, some college/associates degree = 2, bachelors degree = 3, graduate degree = 4. The CI and NH groups were similar in parental education (*M*s = 3.0 and 2.8, *SD*s = 0.9 and 0.9, respectively, $t(58) = 0.76$, *ns*, not significant).

For the purposes of some analyses, the CI children were split into a younger group and an older group. The 15 younger CI children ranged in age from 3.1 to 7.8 years ($M = 5.7$, $SD = 1.3$), and the 15 older CI children ranged in age from 8.0 to 12.0 years ($M = 9.4$, $SD = 1.2$). The younger and older CI groups were similar in parental education [*M*s = 2.9 and 3.1, *SD*s = 1.0 and 0.7, respectively, $t(28) = 0.64$, *ns*]. Eight of the younger CI children were in mainstream classrooms with hearing children, four were in integrated classrooms with both hearing children and deaf children, one was in a self-contained classroom with deaf children, and one was home-schooled. Fourteen of the older CI children were in mainstream classrooms and one was in an integrated classroom.

The CI children all had preimplant hearing levels in the profoundly deaf range (unaided three-frequency pure tone average between 90 and 120 dB HL) and were prelinguistically deafened (27 children congenitally and 3 children prior to 12 months). The CI children used a variety of multichannel implants, and one child was bilaterally implanted. Values for variables regarding age at and time since amplification and implantation can be seen in Table 1. Amplification refers to the use of hearing aids, sometimes in conjunction with other assistive technology such as FM radio-based systems. Amplification can provide increased access to sound even for some profoundly deaf children, and United States Food and Drug Administration guidelines require that all children try amplification before cochlear implantation to determine whether amplification provides sufficient benefit to make implantation unnecessary. The time that children in this study had been amplified before being implanted ranged from 2 months to 4.6 years ($M = 1.7$ years, $SD = 1.2$). Preliminary analyses indicated that this variable (years of amplification before implantation) was not significantly correlated with any of the theory of mind or language variables, and thus it will not be considered further. The fact that all these children were eventually implanted suggests that amplification did not provide, or was not expected to provide, sufficient benefit to preclude implantation. Nevertheless, we included the variables "age at amplification" and "years since amplification" (this includes years of amplification plus years of implantation, i.e., all time from first amplification through implantation to child's age at testing) in further analyses to examine whether theory of mind and language performance are related to implantation specifically or whether the initial period of amplification might have also provided some benefit.

Procedure

The CI children were tested individually by the second author, an audiologist/speech-language pathologist with extensive experience evaluating children who are deaf and hard of hearing. The NH children were tested individually by graduate and undergraduate research assistants. All children were tested using spoken English.

All children were tested on the following tasks:

1. Theory of Mind Scale. We used the five-item version of Wellman and Liu's (2004) scale, which consists of the following tasks. We followed the Wellman and Liu's script and scoring procedures exactly, including asking control questions to check for comprehension and memory. The tasks were administered in the following order:

Table 1 Amplification and implantation variables for children with CIs

	All CI children			Younger CI children			Older CI children		
Variable	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range
Age at amplification	1.2	0.6	0.2–3.0	1.1	0.7	0.2–3.0	1.3	0.6	0.3–2.4
Years since amplification	6.3	2.2	1.8–10.5	4.6	1.3	1.8–6.9	8.1	1.3	6.2–10.5
Age at implantation	2.9	1.4	1.1–6.0	2.4	1.2	1.1–5.0	3.5	1.3	1.6–6.0
Years since implantation	4.5	1.9	1.2–9.0	3.3	1.3	1.2–5.4	5.9	1.5	3.7–9.0

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(a) Diverse Desires: tests the child's understanding that different people may have different desires. The child is asked which of two foods (carrot or cookie) he/she would want for a snack. Then the child is told that a character (Mr. Jones) prefers the other food (e.g., carrot if the child prefers cookie). Then the child is asked which food Mr. Jones will pick for his snack. The child is scored as correct if he/she chooses the food that Mr. Jones wants, rather than the food that the child wants.

(b) Diverse Beliefs: tests the child's understanding that different people can have different beliefs. The child is told that a character (Linda) wants to find her cat, and asked to guess in which of two locations (bushes or garage) the cat is hiding. Then the child is told that Linda thinks the cat is in the other location (e.g., bushes if the child thinks garage). Then the child is asked where Linda will look for the cat. The child is scored as correct if he/she chooses the location where Linda believes the cat is, rather than the location where the child believes the cat is (note: the true location of the cat is unknown).

(c) Knowledge Access: tests the child's understanding that perceptual access leads to knowledge. The child is asked to guess what is inside an unmarked can (no child guessed correctly). Then the child is shown that the can actually contains a small toy dog. Then the child is told that a character (Polly) has never seen inside the can, and asked if Polly knows what is inside. The child is scored as correct if he/she responds that Polly does not know, even though the child has seen inside and does know.

(d) Contents False Belief: tests the child's understanding that people may hold false beliefs. The child is shown a Band-Aid box and asked what is inside (all children said Band-Aids). Then the child is shown that the box actually contains a small toy pig. Then the child is told that a character (Peter) has never seen inside the box, and asked what Peter thinks is inside. The child is scored as correct if he/she responds that Peter thinks there are Band-Aids inside, even though the child knows that belief is false.

(e) Real-Apparent Emotion: tests the child's understanding that people's facial expressions may not match how they feel inside. The child is told a story about a boy (Matt) who is being teased by some other children but does not want the other children to know that he is upset. The child is shown drawings of a happy face, a sad face, and a neutral face and asked to indicate how Matt really feels and how Matt tries to look on his face. The child is scored as correct if he/she indicates that Matt feels more negative than he looks.

Verbatim scripts, including control questions, for these tasks can be found in Wellman and Liu (2004). If a child answered any control question incorrectly, he/she was scored as incorrect on that task. Scores were not obtained for one CI child on Contents False Belief due to experimenter error and for another CI child on Real-Apparent Emotion due to refusal to respond.

Wellman and Liu found that these five items formed a reliable scale, such that average performance by typical preschoolers decreased across the five tasks in the order they were presented here (Diverse Desires, Diverse Beliefs, Knowledge Access, Contents False Belief, Real-Apparent Emotion). Furthermore, Wellman and Liu used Guttman scalogram analysis to show that the performance of a majority of the typical preschoolers conformed to the expected sequence, such that a child who passed any task passed all previous tasks. These results suggest that these concepts typically develop in this order. Peterson et al. (2005) replicated these results in typical preschoolers and found that majorities of the deaf native signers and deaf late signers also matched the standard sequence. The autistic children in the Peterson et al. study showed a slightly different sequence, however, with better average performance on Real-Apparent Emotion than on Contents False Belief.

2. Hiding and Finding Game. This task was based on the nonverbal false belief task of Call and Tomasello (1999) as adapted by Figueras-Costa and Harris (2001). The task involved two experimenters: the primary experimenter (the "hider") and a second experimenter (the "communicator"). The task consisted of multiple trials in which the hider hid a penny in one of two identical boxes and then asked the child to find the penny, with the help of the communicator.

The game began with three pretest trials, in which the hider put up a screen to block view of the boxes

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from the child (but not the communicator), placed the penny in one box, and then removed the screen. The communicator watched the hiding process, and then pointed to the box containing the penny, whereupon the hider asked the child "Where is the penny?" The hider then opened the box chosen by the child, and, if it was the incorrect box, the other box as well, to reveal the penny. If a child missed one pretest trial, he/she was given one additional trial. No child missed more than one pretest trial.

Two control trials followed. The "invisible displacement" control trial tested the child's ability to keep track of the penny's location while inside a box that is moved (in Piagetian terms, the penny's movement, or "displacement," is "invisible" because it cannot be seen directly, but must be inferred from the movement of the box). As in the pretest trials, the hider hid the penny in one box, and the communicator pointed to the correct box. But then the communicator covered her eyes with her hands, and the hider switched the locations of the boxes (in full view of the child) before asking the child to find the penny (note: the correct choice is the box to which the communicator pointed, not the box now occupying that location). The "ignore communicator" control trial tested the child's ability to ignore the communicator's hint when clearly incorrect (i.e., to understand that the communicator can be mistaken due to outdated information). After the hider hid the penny, the communicator covered her eyes, and the hider took the penny out of its box and moved it to the other box (in full view of the child). The communicator uncovered her eyes and pointed to the now-empty box (where she saw the penny hidden), whereupon the hider asked the child to find the penny (note: the correct choice is the box to which the penny was moved, not the box to which the communicator pointed). If either control task was failed, it was repeated. If failed again, the task was terminated. One CI child and four NH children failed two invisible displacement control trials and two NH children failed two ignore communicator trials; these children were dropped from this task.

Another pretest trial followed, similar to the earlier ones, in order to reestablish the credibility of the communicator. However, on this pretest trial the communicator covered and then uncovered her eyes before pointing, in order to demonstrate that the communicator was not always incorrect whenever she covered her eyes.

A "nonverbal" false belief trial followed, which was identical to the ignore communicator control trial except that, while the communicator's eyes were covered, the hider switched the locations of the boxes (as in the invisible displacement control trial), rather than taking the penny out and moving it. When the communicator uncovered her eyes and pointed to a box, the child needed to infer that the communicator was incorrect because she did not see that the boxes were switched and so the child should choose the other box. The trial was not completely nonverbal because the test question (Where is the penny?) was still asked verbally, but the child could infer and indicate the correct answer (by pointing) without needing any language.

A "verbal" false belief trial followed, which was identical to the ignore communicator trial (i.e., the hider moved the penny while the communicator's eyes were covered) except that, before the communicator uncovered her eyes, the hider asked the child two test questions: "When [communicator's name] uncovers her eyes, which box will she point to?" and "Where does [communicator's name] think that the penny is?" The child should choose the now-empty box in response to both questions, reasoning that the communicator did not see the penny moved and thus she falsely believes it to be in its initial location. The communicator then uncovered her eyes and pointed to the now-empty box, whereupon the hider asked the child to find the penny. To receive credit on the test questions, the child had to indicate where the penny really was; all children did so. With one NH child, the verbal false belief trial was skipped due to experimenter error.

3. False Photograph task. False photograph tasks, originally developed by Zaitchik (1990), test children's understanding that physical representations (photographs) can be "false," in the sense that they can misrepresent current reality, if things have changed since the photograph was taken. For example, a photograph may portray an object in one location even though it has subsequently been moved to another location. Performance on false photograph tasks can be compared to performance on false belief tasks to distinguish children's understanding of representations in general

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from their understanding of mental representations (beliefs) specifically.

The experimenter introduced a Polaroid camera and explained and demonstrated how it works. In the first test trial, the experimenter took a picture of a boy doll sitting on a toy chair, moved the doll to a toy bed, and then asked the child where the boy is in the picture (before showing the picture to the child). To get credit for the correct answer (the chair), the child had to also answer two control questions correctly: about the boy's current location (the bed) and initial location (the chair). The second test trial was similar, except the experimenter took a picture of the boy doll on the toy bed, replaced him with a girl doll, and then asked the child who is on the bed in the picture (correct answer: the boy). The control questions concerned who was on the bed now (the girl) and initially (the boy).

4. Memory for Complements. This task, adapted from de Villiers and de Villiers (2000), measured the child's ability to process complement syntax with verbs of communication (say) and mental state (think). The task consisted of four trials in which the child was told that a character either says or thinks something that the child can see to be false.

Examples:

> Polly is over here and she can't see the rock. Polly says that the rock is in the box, but look, really the rock is in the can.
>
> Peter is over here and he can't see the girl. Peter thinks that the girl is in the chair, but look, really the girl is in the bed.

The child is then asked what the character said/thinks. de Villiers and de Villiers have found that before children understand false beliefs, they usually claim (incorrectly) that the character said/thinks what the child knows to be true. In two trials (one communication and one mental state), the test question was syntactically simpler (e.g., "What did Polly say?") but required the full complement clause in response (e.g., "[that] the rock is in the box"). In the other two trials (one communication and one mental state), the test question was more syntactically complex ("Where does Peter think the girl is?") but required only a simple phrase in response (e.g., "in the chair").

One NH child did not receive the task due to experimenter error.

The CI children (but not the NH children) were also tested on the following tasks:

1. Explanation of Action. This task, adapted from de Villiers and de Villiers (2000), measured the child's ability to explain a character's anomalous action by referring to the character's mental state. The child saw five short silent video clips. After each clip, the experimenter asked the child to describe what happened in the movie. If the child did not refer to the character's mental state in response to this general prompt, the experimenter provided up to three increasingly specific prompts to try to elicit a mental state explanation.

Example: In one video, a girl empties her Halloween candy onto a table, but then leaves the room. Another girl enters, replaces a piece of candy with a plastic toy frog, and then leaves. The first girl returns and, without looking directly at the pile of candy, picks up the frog, lifts it to her mouth, bites down on it, and then the video freezes as she looks surprised.

> General prompt: "Tell me what happened in the movie."
>
> First specific prompt: "Why did she bite the frog?"
>
> Second specific prompt: "Why is she surprised?"
>
> Third specific prompt: "What is she thinking here?"

The child received a score of 4 for producing the target mental state explanation (in this case, "She thinks the frog is candy" or something semantically equivalent) in response to the general prompt and lost one point for each additional prompt needed, down to a score of zero if the target mental state explanation was not produced after the third and final prompt.

2. Phonetically Balanced Kindergarten (PBK) Test. This test of open-set spoken word recognition without visual cues is often used by audiologists to assess children's hearing (Haskins, 1949). The experimenter presented 25 words via monitored live voice without visual cues at 65 dB SPL. The child received a score based on the percentage of whole words repeated correctly.

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3. Index of Productive Syntax (IPSyn). We collected language samples from the CI children by asking them to narrate a wordless children's picture book (Mercer Mayer's "Frog, Where Are You?"). If needed, the experimenter used general prompts (e.g., "Tell me more") to encourage the child to produce at least three to four sentences per double-page spread.

These language samples were transcribed and coded for syntactic complexity using the Index of Productive Syntax (Scarborough, 1990). The IPSyn is a checklist of 60 syntactic forms, and children receive subscores of 0–2 based on how often they use each form (never, once, or twice or more). For the purposes of this study, we focused on the total scores (summed over all syntactic forms) and the subscores for use of complement syntax.

4. Oral and Written Language Scales (OWLS). We used this standardized language measure (Carrow-Woolfolk, 1995) to calculate standard scores for listening comprehension and oral expression. Due to time constraints, the listening comprehension scale was not administered to seven of the CI children and the oral expression scale was not administered to 11 of the CI children. For most of these children, however, the results of other recent (within 3 months of the experimental session) standardized language assessments were available, from which standard scores were calculated. The alternate comprehension measures were the Test for Auditory Comprehension of Language (TACL) and the Preschool Language Scale (PLS). The alternate expression measures were the PLS, the Comprehensive Assessment of Spoken Language (CASL), and the Clinical Evaluation of Language Fundamentals (CELF). For one CI child, expression scores were not available, and for another CI child neither comprehension nor expression scores were available.

Results

Theory of Mind Scale

Table 2 shows the percentage of correct responses for the CI children and the NH children and, for comparison, results obtained by Peterson et al. (2005) using a slightly modified version of the same scale. To allow for better age-matched comparisons, we split the CI children into younger and older groups. Across the five tasks, the younger CI children, older CI children, and NH children answered 87%, 100%, and 87% of the control questions correctly, respectively. This indicates that the children had little to no difficulty with the verbal and memory demands of the tasks.

Table 2 also shows the mean total score for each group. Total scores are the sum of correct scores on each of the five items of the scale. The mean total score of the younger CI children was significantly lower than that of the older CI children, $t(28) = 6.98$, $p < .001$, but did not differ significantly from that of the NH children, $t(48) = 1.16$, *ns*, or that of the deaf late signers in the Peterson et al. study, $t(49) = 0.24$, *ns*, even though the younger CI children were more than 4 years younger than the deaf late signers on average. The mean total score of the older CI children was significantly higher than that of the deaf

Table 2 Percentage of correct responses on Theory of Mind Scale

				Peterson, Wellman, and Liu (2005)			
Task	Younger CI children	Older CI children	Children with NH	Deaf native signers	Deaf late signers	Autistic children	Typical preschoolers
Diverse Desires	93	100	87	100	92	86	95
Diverse Beliefs	93	100	87	91	92	86	85
Knowledge Access	40	100	83	82	53	75	82
Contents False Belief	21	87	37	82	33	47	32
Real-Apparent Emotion	43	93	33	54	28	64	19
Mean total score (0–5)	2.87	4.80	3.27	4.09	2.97	3.58	3.15
SD total score	0.99	0.41	1.14	1.38	1.54	1.78	1.33
Mean age (years)	5.7	9.4	5.2	10.7	10.0	9.3	4.5
SD age	1.3	1.2	0.5	1.8	2.5	1.9	0.6
n	15	15	30	11	36	36	62

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late signers in the Peterson et al. study, $t(49) = 4.51$, $p < .001$, although the older CI children were slightly younger on average. The mean total score of the older CI children was almost but not quite significantly higher than that of the deaf native signers in the Peterson et al. study, $t(24) = 1.90$, $p = .07$, even though the older CI children were more than a year younger on average.

We were interested not only in average differences between groups but also in individual response patterns within groups, that is, sequences of development. The NH children in this study showed the standard sequence of development, with better average performance on Contents False Belief than on Real-Apparent Emotion (37% vs. 33% correct). The CI children, however, showed an alternative sequence of development, with better average performance on Real-Apparent Emotion than on Contents False Belief (69% vs. 55% correct across all 30 CI children). The CI children (older and younger combined) performed significantly better than the NH children on Real-Apparent Emotion (69% vs. 33%), χ^2 (1, $N = 59$) = 7.49, $p = .006$, but not on Contents False Belief (55% vs. 37%), χ^2 (1, $N = 59$) = 2.04, *ns*. Furthermore, the older CI children performed significantly better than the deaf native signers in the Peterson et al. study on Real-Apparent Emotion (93% vs. 54%), χ^2 (1, $N = 26$) = 5.38, $p = .02$, but not on Contents False Belief (87% vs. 82%), χ^2 (1, $N = 26$) = 0.12, *ns*.

A Guttman scalogram analysis of individual response patterns also suggests that the most common sequence of development differs for NH children and CI children (see Table 3). Among NH children, 19 of 30 (63%) conformed to the standard sequence, in which Contents False Belief is passed before Real-Apparent Emotion, whereas 17 of 30 (57%) conformed to the alternative sequence, with the order of difficulty of Contents False Belief and Real-Apparent Emotion reversed. Among CI children, 20 of 29 (69%) conformed to the standard sequence, whereas 23 of 29 (79%) conformed to the alternative sequence (the one CI child who did not complete the Real-Apparent Emotion task could not be considered).

Hiding and Finding Game

Table 4 shows the performance of the CI children and the NH children on the nonverbal false belief trials and the verbal false belief trials, as well as the performance of the deaf children in Figueras-Costa and Harris (2001) on a version of the same task. Performance between the three groups in this study (younger CI children, older CI children, and NH children) did not differ significantly on the nonverbal false belief trials, χ^2 (2, $N = 53$) = 2.77, *ns*, or on the verbal false belief trials, $F(2, 49) = 0.12$, *ns*. The CI children and the NH children did better on verbal trials than on nonverbal ones, whereas the deaf children in Figueras-Costa and Harris study did much worse on verbal trials than on nonverbal ones. Combining the younger

Table 3 Guttman scalogram analysis of Theory of Mind Scale

	Task					Group	
Response pattern	Diverse Desires	Diverse Beliefs	Knowledge Access	Contents False Belief	Real-Apparent Emotion	Children with CIs	Children with NH
1	−	−	−	−	−	0	0
2	+	−	−	−	−	0	0
3	+	+	−	−	−	5	3
4	+	+	+	−	−	1	6
5	+	+	+	+	−	1	6
6	+	+	+	+	+	13	4
	Number of children whose response patterns fit the standard sequence					20 (69%)	19 (63%)
7	+	+	+	−	+	4	4
	Number of children whose response patterns fit the alternative sequence					23 (79%)	17 (57%)
	Number of children whose response patterns did not fit either sequence					5 (17%)	7 (23%)

Note. A minus (−) sign means the child failed that task; a plus (+) sign means the child passed that task. Response patterns 1, 2, 3, 4, 5, and 6 (but not 7) fit the standard sequence. Response patterns 1, 2, 3, 4, 6, and 7 (but not 5) fit the alternative sequence. Only 29 of the 30 children with CIs were included because one could not be categorized due to refusal to respond in the Real-Apparent Emotion task.

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Table 4 Percentage of correct responses on Hiding and Finding Game

				Figueras-Costa and Harris (2001)	
Type of trial	Younger CI children	Older CI children	Children with NH	Younger deaf children	Older deaf children
Nonverbal	57	73	54	44	84
Verbal	82	77	74	9	50
Mean age (years)	5.7	9.4	5.2	5.5	9.6
SD age	1.3	1.2	0.5	0.6	2.0
n	15	15	30	11	10

and older CI children, 22 of the 29 (76%) who were asked the verbal false belief questions answered both correctly, which is significantly more than the 6 of 21 (29%) deaf children in the Figueras-Costa and Harris study (combining the younger and older groups, yielding an average age of 7.0 years) who passed the single verbal false belief question in their study, χ^2 (1, N = 50) = 11.06, $p < .001$.

False Photograph

The False Photograph scores of the younger CI children, older CI children, and NH children were near ceiling and did not differ significantly, $F(2, 57) = 2.18$, *ns* (see Table 5), indicating that all three groups had little to no difficulty comprehending and answering questions about physical representations.

Memory for Complements

The Memory for Complements scores of the younger CI children, older CI children, and NH children were also near ceiling and did not differ significantly, $F(2, 56) = 2.50$, *ns* (see Table 5), indicating that all three groups had little to no difficulty processing complement syntax.

Explanation of Action (CI Children)

The mean scores of the CI children on the individual Explanation of Action videos ranged from 1.6 to 2.5 (overall $M = 2.1$), indicating that, on average, children produced the target mental state explanation after about one general prompt and two specific prompts. All the CI children produced a valid mental state explanation to at least one video, and 15 of the 30 children did so without any specific prompting at least once. Total scores for each child were calculated by summing their scores across all five videos. Total scores ranged from 1 to 18 ($M = 10.4$, $SD = 5.1$), indicating considerable variability.

Table 5 Percentage of correct responses on False Photograph and Memory for Complements

Task	Younger CI children	Older CI children	Children with NH
False Photograph	87	100	87
Memory for Complements	87	100	85

Language Measures (CI Children)

See Table 6 for the performance of the CI children on the PBK, IPSyn, and OWLS. On the PBK, the CI children repeated 79% of the words correctly, on average, indicating good spoken word recognition. The younger CI children and older CI children did not differ significantly on any of the language measures, except that the older CI children scored significantly higher on the IPSyn-Total, $t(28) = 5.25$, $p < .001$. The IPSyn is not a standardized measure, and scores cannot be compared easily across studies, as scores vary with the size of the speech sample analyzed (the larger the speech sample, the more chance that different syntactic forms will be used). IPSyn scores can be used, however, as a measure of syntactic complexity between children within a study. Fourteen CI children did not produce any complements, eight children produced one, and eight children produced two or more. Recall, however, that the CI children showed excellent comprehension of complements on the Memory for Complements measure, so this production measure may underestimate some children's understanding of complement syntax. Still, it can be used as a measure of relative mastery of

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Table 6 Performance of children with CIs on language measures

	All CI children			Younger CI children			Older CI children		
Measure	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range
PBK (proportion correct)	0.79	0.19	0.28–1.0	0.74	0.23	0.28–1.0	0.83	0.12	0.56–1.0
IPSyn-Total (possible range: 0–120)	77.4	14.0	46–101	67.9	12.7	46–88	87.1	6.8	75–101
IPSyn-Complements (possible range: 0–2)	0.80	0.85	0–2	0.73	0.80	0–2	0.87	0.92	0–2
OWLS-Comprehension (standard score)	99.4	21.3	57–146	96.6	25.9	57–146	102.2	15.9	77–130
OWLS-Expression (standard score)	96.9	25.2	44–150	93.6	28.7	59–150	99.9	21.9	44–130

complementation, as all children were responding to the same stimulus (the picture book).

Mean standard scores for listening comprehension and oral expression were very close to 100, indicating that, on average, the CI children understood and produced spoken English just about as well as normally hearing children of the same age. In fact, 46% of the CI children performed at or above hearing norms on listening comprehension, and 48% of them performed at or above hearing norms on oral expression. Only two CI children (both younger) had standard scores below 70 on listening comprehension, and only four (three younger and one older) had standard scores below 70 on oral expression.

Relationships Between Variables for Children With CIs

Table 7 shows the correlations between the theory of mind variables (Theory of Mind Scale, Hiding and Finding Game, and Explanation of Action), language variables (PBK, IPSyn-Total, and IPSyn-Complements), age variables (chronological age, age at amplification, years since amplification, age at implantation, years since implantation), and parental education. Note that Theory of Mind Scale scores are the sum of scores on the five items, Hiding and Finding Game scores are the sum of scores on the verbal and nonverbal trials, and Explanation of Action scores are the sum of scores on the five videos. OWLS scores were not included because, as described earlier, scores from other standardized language tests were used for some CI children, and we did not want to mix scores from different tests together in the correlation matrix.

Relationships between theory of mind variables. Theory of Mind Scale and Explanation of Action scores were significantly positively correlated with each other but not with Hiding and Finding Game scores, which suggests that the Hiding and Finding Game was not reliably measuring the same set of skills as the other two tasks.

Table 7 Intercorrelations between variables for children with CIs

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Theory of Mind Scale	—	.14	.71**	.32	.68**	.20	.73**	.03	.72**	.22	.68**	.21
2. Hiding and Finding Game		—	.00	−.12	.13	−.31	.33	.14	.29	.26	.19	.10
3. Explanation of Action			—	.39*	.77**	.25	.68**	.07	.66**	.30	.57**	.36*
4. PBK				—	.51**	−.11	.17	−.37*	.28	−.46*	.53**	.50**
5. IPSyn-Total					—	.15	.57**	.02	.57**	.11	.58**	.46*
6. IPSyn-Complements						—	−.04	−.23	.03	.01	−.05	.06
7. Chronological age							—	.16	.96**	.52**	.79**	.04
8. Age at amplification								—	−.13	.45*	−.13	−.19
9. Years since amplification									—	.39*	.83**	.10
10. Age at implantation										—	−.12	−.11
11. Years since implantation											—	.12
12. Parental education												—

Note. $n = 30$ for all variables except the Hiding and Finding Game, for which $n = 29$.
$^{*}p < .05$. $^{**}p < .01$.

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Relationships between language variables. PBK and IPSyn-Total scores were significantly positively correlated with each other but not with IPSyn-Complement scores, indicating that children with better speech recognition produced a greater variety of syntactic forms overall, but not more complement structures specifically.

Relationships between age variables. Chronological age, years since amplification, and years since implantation were significantly positively intercorrelated, indicating that older children had been amplified and implanted longer. Age at implantation was also significantly positively correlated with chronological age, age at amplification, and years since amplification, indicating that children who were implanted at older ages tended to be older at the time of testing and have been amplified later and longer.

Relationships between theory of mind and age variables. Scores on the Theory of Mind Scale and Explanation of Action task were significantly positively correlated with chronological age, years since amplification, and years since implantation, indicating improvement with age. In contrast, neither age at amplification nor age at implantation significantly predicted performance. Scores on the Hiding and Finding Game were not significantly correlated with any of the age variables, although the correlation with chronological age approached significance ($p = .08$).

Relationships between language and age variables. PBK scores were significantly negatively correlated with age at amplification and age at implantation and significantly positively correlated with years since implantation, indicating that children with better speech recognition had been amplified and implanted at younger ages and had been implanted longer. IPSyn-Total scores were significantly positively correlated with chronological age, years since amplification, and years since implantation, indicating that older children produced a greater variety of syntactic forms. IPSyn-Complements scores were not significantly correlated with any of the age variables.

Relationships between theory of mind and language variables. PBK scores were significantly positively correlated with Explanation of Action scores, and their correlation with Theory of Mind Scale scores approached significance ($p = .08$). IPSyn-Total scores were significantly positively correlated with scores on the Theory of Mind Scale and Explanation of Action task but not on the Hiding and Finding Game. IPSyn-Complements scores were not significantly correlated with any of the theory of mind variables.

Table 8 Age-partialled intercorrelations for children with CIs ($n = 30$)

Variable	1	2	3	4
1. Theory of Mind Scale	—	.44*	.47*	.33
2. Explanation of Action		—	.63**	.38*
3. IPSyn-Total			—	.21
4. IPSyn-Complements				—

*$p < .05$. **$p < .01$.

We examined whether the relationships between theory of mind and language variables remained significant after controlling for chronological age (see Table 8). IPSyn-Total scores remained significantly positively correlated with Theory of Mind Scale and Explanation of Action scores. Also, the correlation of IPSyn-Complements with Explanation of Action became significant, and the correlation with Theory of Mind Scale approached significance ($p = .09$).

Relationships between parental education and other variables. Parental education was significantly positively correlated with Explanation of Action, PBK, and IPSyn-Total scores but not significantly correlated with the other theory of mind and language variables or with any of the age variables.

Relationships between recruitment site and other variables. We compared the 15 CI children who were recruited from one clinic in the Northeast United States to the 15 CI children who were recruited from a range of other clinics. The groups did not differ significantly on parental education or any of the age variables, theory of mind variables, or language variables with the following exceptions: the children from the Northeast clinic had been implanted significantly longer, $t(28) = 2.57$, $p = .02$, and scored significantly higher on the Explanation of Action Task, $t(28) = 2.13$, $p = .04$, and the PBK, $t(28) = 3.31$, $p = .003$.

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Discussion

On the Theory of Mind Scale, the CI children performed as well as the NH children in this study and the deaf native signers in the Peterson et al. (2005) study, and better than the deaf late signers in Peterson et al. The younger CI children's average age was similar to that of the NH children and much lower than that of the deaf late signers, and yet the younger CI children's average overall performance on the Theory of Mind Scale was not significantly different than that of the NH children or that of the deaf late signers. The older CI children's average age was slightly lower than that of the deaf late signers and that of the deaf native signers, and yet the older CI children's average overall performance on the Theory of Mind Scale was significantly better than that of the deaf late signers and better, although not quite significantly, than that of the deaf native signers. The younger CI children also performed as well as the NH children on both the verbal and nonverbal false belief trials of the Hiding and Finding Game.

These results suggest that theory of mind development in these children with CIs was not very delayed, if at all, relative to the children with NH, advanced relative to the late-signing deaf children with hearing parents, and at least comparable to the native-signing deaf children. This level of theory of mind performance demands an explanation, given that previous studies found that deaf children with hearing parents (whether oral or signing, and whether implanted or not) were quite delayed relative to both children with NH and native-signing deaf children. The most obvious explanation is that the CI children in this study had better language skills for their age than the deaf children of hearing parents in previous studies. For instance, the four previous studies that have examined theory of mind in children with CIs (Lundy, 2002; Macaulay & Ford, 2006; Moeller & Schick, 2006; Peterson, 2004) found that both false belief performance and language skills were considerably delayed relative to hearing norms. In this study, however, the CI children showed good open-set spoken word recognition, excellent comprehension of complement syntax, and virtually no delay in average performance on standardized measures of receptive and expressive language. Although we cannot claim that their spoken language skills were exactly equivalent to those of their hearing peers, they were clearly able to communicate effectively using spoken language, and most of them were functioning in fully mainstream educational settings without pull-out academic services.

The CI children also demonstrated their linguistic competence in a number of other ways during this study. First, they answered almost all the control questions correctly in the Theory of Mind Scale and passed almost all the pretest trials and control trials in the Hiding and Finding Game. Second, they did better on the verbal false belief trials than the nonverbal ones in the Hiding and Finding Game and significantly better on the verbal false belief trials than the oral deaf children of hearing parents in Figueras-Costa and Harris (2001). Figueras-Costa and Harris suggested that linguistic demands obscured their sample's competence on the verbal false belief trials, but that did not appear to be the case for the CI children in this study. Third, all the CI children gave a valid mental state explanation in the Explanation of Action task at least once, and half of them were able to do so without any specific prompting at least once. Fourth, the CI children were near ceiling on the False Photograph task, which has similar linguistic demands as verbal false belief tasks. The fact that the CI children performed as well as the NH children on a cognitive task outside the theory of mind domain (reasoning about physical representations) also suggests that their good performance within the theory of mind domain was not anomalous, but in line with their general level of cognitive development.

If our conjecture is correct that the CI children were not very delayed, if at all, in theory of mind because they were not very delayed, if at all, in language skills, two more questions are raised: Why would better language skills lead to better theory of mind? And why were the CI children not very delayed, if at all, in language skills? As to the first question, the two leading theoretical possibilities focus on different aspects of language: mastery of complement syntax (de Villiers & de Villiers, 2000; Schick et al., 2007), and exposure to mental state talk (Peterson & Siegal, 2000; Ruffman et al., 2002; Slaughter et al., 2007). The

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results of this study did not support the first possibility. The CI children and NH children were near ceiling on the Memory for Complements measure but not on the false belief measures (Contents False Belief and the Hiding and Finding Game), which is inconsistent with de Villiers's claim that the acquisition of complement syntax is tightly coupled to the development of false belief understanding. Furthermore, after controlling for age, the CI children's scores on the Theory of Mind Scale and Explanation of Action task were more highly correlated with IPSyn-Total scores than with IPSyn-Complements scores, which suggests that theory of mind competence was more related to syntactic proficiency in general than to complementation specifically (cf. Tardif et al., 2007). Therefore, we favor the second possibility: better language skills allow greater access to mental state talk, which promotes theory of mind development. Admittedly, we do not have data on exposure to mental state talk in this study, but given that parental mental state talk predicts theory of mind development in both hearing children (Ruffman et al., 2002) and deaf children (Moeller & Schick, 2006), we believe this theoretical possibility is a more promising direction for future research.

As to the second question (why were the CI children not as language-delayed as deaf children of hearing parents in previous theory of mind studies?), there are several possible factors. One possible factor is cochlear implantation. Nonimplanted deaf children of hearing parents are typically delayed in their acquisition of spoken language, due to limited auditory access, and signed language, due to late exposure (Marschark, 1993). Cochlear implantation enhances auditory access and thus ability to acquire spoken language (Geers, 2006; Svirsky et al., 2000). Another possible factor is primary communication mode. The CI children in this study all used spoken English as their primary mode of communication, whereas all the CI children in the Macaulay and Ford (2006) and Moeller and Schick (2006) studies and about half of the CI children in the Lundy (2002) and Peterson (2004) studies used Total Communication (a mixture of signed and spoken English) as their primary mode of communication. CI children who use primarily oral communication, rather than Total Communication, may develop better spoken language skills (Geers, 2002), which may lead to better theory of mind development due to greater access to parental language. Although this hypothesis requires further investigation, recall that the deaf children in the Peterson et al. (2005) study were also educated using Total Communication, and the CI children in this study showed better theory of mind performance than the late signers and comparable theory of mind performance to the native signers.

However, several caveats apply. We must be cautious in drawing conclusions from comparisons across studies. The samples no doubt varied on other characteristics besides implantation status and primary communication mode. For example, parental education (an indicator of socioeconomic status) may have been higher in our sample than in previous samples; we cannot say because most previous studies reported no, or only very vague, indicators of socioeconomic status. Differences in procedures may also have affected performance. For example, although this study and the Peterson et al. (2005) study used the same five tasks from the Wellman and Liu (2004) scale, Peterson et al. slightly modified the wording of the tasks and changed the control question in the Real-Apparent Emotion task. Also, in this study the experimenter presented the tasks directly to the children in spoken English, whereas Peterson et al. used sign language interpreters, which may have added an extra layer of difficulty for the children. We adapted the Hiding and Finding Game from Figueras-Costa and Harris (2001), but they included five nonverbal false belief trials, whereas we only included one (because the task was so time-consuming already), so our version may not have been as reliable a measure of false belief understanding, which may explain why performance did not correlate significantly with any of the other variables (although the correlation with age approached significance).

Furthermore, the relationship between primary communication mode and language skills is probably bidirectional. That is, practice in a communication mode may improve skills in that mode, but language skills may also influence choice of communication mode. For example, CI children who have difficulty using spoken language may be more likely to rely on some signed communication, as in the Total

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Communication approach. In addition, use of Total Communication is obviously not equivalent to use of a natural sign language such as ASL. We would expect deaf children of hearing parents who received early and continuous exposure to fluent natural sign language to show age-appropriate language skills (in the signed modality) and age-appropriate theory of mind development, as do children of signing deaf parents. In other words, children's ability to access the language around them is the key factor, not cochlear implantation or oral communication per se. Cochlear implantation simply makes the spoken language used by most hearing parents more accessible to their deaf children.

Another possible explanation for the good language skills of the CI children in this study is that they were an exceptional and atypical sample. As the parameters of the population of implanted children are not known, we cannot prove that our sample is representative. As random selection from the population is not possible, our sample is limited to those families willing to participate. Speech-language therapy and early intervention services for our sample may have been of above-average quality. Samples of children who are currently using implants may not be representative of the population of children who have received implants, as some children for whom implants and oral communication do not work well may stop using them (Bat-Chava & Deignan, 2001). More recent samples may show more positive outcomes than samples in older studies, as implant technology improves and children are implanted at younger ages (Geers, 2006; Spencer & Marschark, 2003). Therefore, we cannot claim that the outcomes observed in our sample are typical of all implanted children at all times in all places. However, we also have no reason to believe that such outcomes are atypical or unusual in the population of children currently using implants in North America. We did not selectively recruit CI children with good language skills; we recruited as many CI children as we could, and succeeded in recruiting a larger sample ($n = 30$) than any of the four previous studies of theory of mind, in which sample sizes ranged from 9 to 13. We recruited all the CI children seen at one Northeast clinic, so we know our sample is representative of CI children seen at that clinic at that time (excluding those with known cognitive disabilities). One might worry that the children recruited from other clinics might be more subject to volunteer bias, specifically, that parents of children with good language skills might be more willing to volunteer, but this did not appear to be the case. There were few significant differences between the CI children recruited from the one Northeast clinic and the other CI children, and those few differences favored the former group. Anecdotally, parents of CI children with relatively poor language skills were sometimes eager to participate to try to get more information and input about their child's development.

Previous research suggests that younger age at implantation is associated with better spoken language outcomes (Nicholas & Geers, 2006a, 2006b). In this study, earlier implantation and earlier amplification were associated with better speech perception, as measured by the PBK, but not better syntactic proficiency, as measured by the IPSyn-Total. IPSyn-Total scores were significantly positively correlated with chronological age, years since implantation, and years since amplification, which makes it difficult to tell whether syntactic proficiency improves with time in general or use of implants or hearing aids specifically. PBK scores were significantly positively correlated with years since implantation, but not chronological age or years since amplification, which suggests that speech perception improves with implant use specifically. Chronological age, years since implantation, and years since amplification were significantly positively correlated with theory of mind, as measured by the Theory of Mind Scale and the Explanation of Action task, but again it is unclear whether improvement is due to time in general or use of implants or hearing aids specifically. Age at implantation and age at amplification did not significantly predict theory of mind performance, which suggests that theory of mind development did not depend on the timing of implantation or amplification. Macaulay and Ford (2006) and Peterson (2004) also found that theory of mind performance was not associated with age of implantation (although Peterson did not have complete data on this variable). Although more research is needed, these results suggest that there may not be a critical period early in life during which full language access is necessary for theory of

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mind to develop, because the age at which language becomes more accessible seems to be less important than the time since language became more accessible. In other words, even if early language access is limited, theory of mind can still develop later, as also suggested by the fact that deaf adults who grew up with hearing parents organize mental state terms much like hearing adults do (Clark, Schwanenflugel, Everhart, & Bartini, 1996). However, the CI children in this study were all amplified by age 3 and implanted by age 6; so it is possible that limited language access until later ages might result in some permanent theory of mind deficits. For example, Morgan and Kegl (2006) found that deaf signing adults who had limited language exposure until after age 10 had normal nonverbal intelligence and were able to use mental state terms in narratives, yet many performed poorly on a false belief task.

Previous studies of theory of mind in CI children primarily focused on false belief performance. This study used a broader range of theory of mind measures and examined sequences of development of theory of mind concepts using the Theory of Mind Scale. On the Theory of Mind Scale, the NH children in this study showed the same sequence of development as the typically developing hearing children in the Wellman and Liu (2004) and Peterson et al. (2005) studies, as well as the deaf late signers and deaf native signers in the Peterson et al. study. The CI children in this study showed the same sequence, with one difference: success on Real-Apparent Emotion was more likely to precede than to follow success on Contents False Belief. This alternative sequence was also displayed by the autistic children in the Peterson et al. study (a finding recently replicated in eight autistic children and adolescents by Gaffney, 2007). Although this finding would need to be replicated in CI children before we could have confidence in it, we can speculate as to why both CI children and autistic children might do relatively well on Real-Apparent Emotion, given that CI children obviously do not share the symptoms of autistic children. The Real-Apparent Emotion task involves a story in which a child is teased by peers and tries to hide his sadness to avoid further teasing. Peterson et al. hypothesized that autistic children may develop a better understanding of such negative emotional situations, relative to their general level of understanding of mental states, because autistic children may have more experience with "negative emotions arising from social discomfort with peers" (p. 514). Sadly, autistic children are often teased, bullied, or shunned by nonautistic peers (Little, 2002). CI children can have difficulty interacting with hearing peers (Bat-Chava & Deignan, 2001; Boyd et al., 2000), so perhaps they too have more experience in managing negative emotions during peer interactions, which could lead to better understanding of situations such as depicted in the Real-Apparent Emotion task, relative to their general level of theory of mind development (and perhaps the signing deaf children in the Peterson et al. study did not show this pattern because they were educated with deaf peers and thus did not have as much experience feeling like the "odd man out"). However, this finding is based on small numbers of CI children, and so this hypothesis is advanced very tentatively, awaiting further research.

The results of this study are consistent with the hypothesis that cochlear implantation can enhance acquisition of spoken language, which then increases exposure to mental state references, which then enhances theory of mind development. If this hypothesis is borne out by future research, it would suggest that postimplantation intervention services should encourage use of mental state language by parents and service providers and recognize the importance of social cognition in addition to the typical focus on language outcomes.

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