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Understanding minds: Early cochlear implantation and the development of theory of mind in children with profound hearing impairment

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ABSTRACT

Objective: The present study investigates how auditory stimulation from cochlear implants (CI) is associated with the development of Theory of Mind (ToM) in severely and profoundly hearing impaired children with hearing parents. Previous research has shown that deaf children of hearing parents have a delayed ToM development. This is, however, not always the case with deaf children of deaf parents, who presumably are immersed in a more vivid signing environment.

Methods: Sixteen children with CI (4.25 to 9.5 years of age) were tested on measures of cognitive and emotional ToM, language and cognition. Eight of the children received their first implant relatively early (before 27 months) and half of them late (after 27 months). The two groups did not differ in age, gender, language or cognition at entry of the study. ToM tests included the unexpected location task and a newly developed Swedish social–emotional ToM test. The tests aimed to test both cognitive and emotional ToM. A comparison group of typically developing hearing age matched children was also added ($n = 18$).

Results: Compared to the comparison group, the early CI-group did not differ in emotional ToM. The late CI-group differed significantly from the comparison group on both the cognitive and emotional ToM tests.

Conclusion: The results revealed that children with early cochlear implants solved ToM problems to a significantly higher degree than children with late implants, although the groups did not differ on language or cognitive measures at baseline. The outcome suggests that early cochlear implantation for deaf children in hearing families, in conjunction with early social and communicative stimulation in a language that is native to the parents, can provide a foundation for a more normalized ToM development.

1. Introduction

A caregiver's early social interaction is a powerful catalyst for the infant's learning and development [1]. The way a caregiver talks to and interacts with an infant will have an impact on the child's social development and learning. The ability to understand and react to thoughts, emotions and feelings in oneself and in others is often referred to as Theory of Mind (ToM) [2]. The development of ToM has been tied to how a mother uses language when interacting with her infant as early as 6 months of age [3]. Thus, a child's experiences of social interaction together with an early exposure to language have been proposed to be important prerequisites for development of ToM during the first years of life [4–6]. This implies that infants and children not exposed to verbal language, such as children with various degrees of sensory impairment (e.g., hearing loss), may receive limited interactional experiences [7–11]. Deaf children, with hearing parents not fluent in sign language, often display a delayed development of ToM compared to typically developing hearing children. This difference is also evident when compared to deaf children with deaf parents [8]. The present study will further explore the effects of age of cochlear implantation and, specifically, how this is related to the development of cognitive and emotional aspects of ToM.

The ability to attach a subjective meaning to inner events is dependent on the child's ability to understand that his or her own, as well as other individuals' feelings, thoughts and actions are guided by mental operations not visible to other people [12]. Humans are not able to see what other people think or plan, but can understand that intentions as well as perspectives are different for

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other people compared to what we ourselves experience. ToM research to date has mainly focused on the cognitive aspects of ToM, i.e., the understanding of desires and knowledge of others while the emotional aspect of ToM has received less focus [13]. The understanding of emotional ToM is, however, also of vital importance for the development of communication and interactional practices. In an interaction one needs not only to consider the other persons' thoughts and desires, but also the other persons' feelings and emotional motives [14].

The development of ToM is often described as occurring in stages [15], where early interactional abilities such as imitation and joint attention are referred to as precursory ToM abilities [16]. Wellman and Liu [15], propose that theory of mind develops in a stepwise fashion and the first step includes an understanding that different people *want* different things, which is understood by children around the age of three. This is followed by an understanding that different people may have different *beliefs* about the same thing and by an understanding that different people may have different access to knowledge to help them to understand a certain situation. By age 4 the child usually understands that people may hold false beliefs about an event or an object. This ability to understand that another person may think in perhaps a contrasting way to what the child knows is true is called first order ToM and is an important prerequisite for efficient communication [8]. A year later, the child can correctly recognize different emotions and may understand their external cause [17], and at around 7 years of age the child understands that another person's different beliefs and desires will evoke different emotions. Furthermore, the child now understands that these emotions might trigger different actions in that individual [16]. By the age of 7 the child is also able to understand second order ToM which means that the child can reason about what another person may think about a third person's thoughts and feelings [18]. The child is now able to make sense of an individual's reactions to a situation as well as of other people's reactions to the child's behaviour within an interaction [19]. ToM continues to develop throughout the school years but is dependent on the cultural and social stimulation that the child experiences [12]. Advanced ToM abilities that develop around 8–11 years of age are, for example, understanding of irony and understanding of faux pas (social blunders) [15,19,20].

The understanding of the mental states such as wants, beliefs, knowledge, and emotions of other people is essential for deep reciprocal interactions with others. Deaf children of deaf parents that are merged in a vibrant sign language world often display a ToM development comparable to that of typically developing hearing children whereas deaf children of hearing parents, not as proficient in sign language, often show a delay in the ToM development [21–23]. This still holds if the researchers use nonverbal or pictorial test material. It is, thus, not only a delay of language that is responsible for the theory of mind problems; it is also a deficient conceptual understanding of mental-state words [17]. Thus, early abundant exposure to spoken or signed language may promote the development of ToM [21].

The early communication and interactional patterns are equally important to the development of language and theory of mind in typically developing children [24,25]. Few studied have, however, examined ToM in deaf children who have received cochlear implant (CI), and the results from these studies are not cohesive. A CI is an implantable biomedical device providing auditory sensations to individuals with severe and profound sensorineural hearing loss [26]. A CI does not bring hearing to a normal level, but a relatively high proportion of deaf children with cochlear implants can participate and follow oral communication [27,28]. How the child's speech production and speech perception develop are related to the child's age of CI-implementation, where early implantation is more beneficial for development than later implantation [28–31]. Thus, the child's age at implantation may affect the course of development of ToM skills, as the auditory stimulation provided by the CI will give an opportunity to experience important social verbal interaction during a developmental period when the central pathways in the child's brain show maximal plasticity [32,33]. A recent study [11] examined the conversational experience in mother-infant dyads at 23 months. The interactional patterns of mothers of deaf children compared with mothers of the hearing children were different. Deaf children experience less talk about the mind and the interaction includes fewer mental-state words compared to hearing children. As numerous studies on hearing children have concluded before, the maternal use of mental-state language is a predictor of later developing ToM, the finding is of importance [3–6]. It is not caused by a lack of secure attachment [34], but seems rather to be caused by a maternal adjustment to the child's delayed communication and language skills [11].

Peterson [35] investigated ToM performance in four groups; children with cochlear implants, children with hearing aids, children with autism, and a group of normally hearing children. The findings indicated that the only significant difference in ToM outcome was between all three groups of children with disabilities and the hearing children, who performed significantly better. The children with CI in the study ranged from 4 to 11 years of age (age at implantation ranged from 2 to 5 years), but no information about the performance of children receiving CI early compared with those receiving CI at a later age was presented. The children with deafness using cochlear implants or hearing aids and those with autism displayed a delay in ToM performance of about 3 to 5 years compared to typically developing children. Peterson [35] suggested that the child's experience of early fluent interactions might be especially important for developing theory of mind and pointed out the importance of studying ToM development in deaf children having received their cochlear implant before two years of age. Early interactional input would promote language and theory of mind development. A similar finding was reported by Macaulay and Ford [36], who studied children implanted at about four years of age and reported a delay of approximately four years in ToM development. The children were between 4 and 11 years of age at the time of testing and they used total communication (sign and oral communication). In contrast, a study by Remmel and Peters [37] did not show any significant delay of ToM or language among 30 children with CI compared to hearing children. The children in this study were implanted at 2.9 years of age and were predominantly using speech and hearing as their main communicative mode.

The age at which a child is implanted is also important for how the auditory cortex is activated, and how it develops. In their review article, Kral and Sharma [32] pointed out the existence of a sensitive period lasting from birth up to 3:6 years, during which the brain's plasticity is at its height. Cortical reorganizations are more likely at younger ages; thus the possibility for activation of the auditory cortex is reduced, as the child grows older. There also seems to be a sensitive period for the development of ToM that occurs in the formative early preschool years [8,38]. However, exactly at what time this critical period of ToM development occurs has not yet been determined.

Most of the children in the Macaulay and Ford [36] and Peterson [35] studies were implanted at 3:6 years or later, while most children in Remmel and Peter's [37] study had received their CI somewhat earlier, before 3 years of age. This difference in age at cochlear implantation between the children in the studies may partly explain the different results of the studies. That is, an earlier CI would promote a faster socio-communicative development and this in turn would affect how ToM develops. A fluent language could entail more possibilities to play and interact with both peers