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RESEARCH ARTICLE

Basic and advanced theory of mind in school-aged children with cochlear implants

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Abstract

Background and Aim: Theory of Mind (TOM) refers to the ability for attributing mental states and beliefs to ourselves and others, and understanding that the others' mental states can be different from ours. However, this ability seems to be delayed in children with the history of hearing impairment. Based on the evidence, there is a mutual association between language development and social experiences. The present study aimed to assess TOM and the effect of speech therapy in 8- to 9-year-old children with cochlear implants (CIs).

Methods: The present study was descriptive and cross-sectional in design. A total of 18 Persian-speaking children with CIs and 18 normal children aged 8-9 years participated in the current study. Children with CIs were selected through convenience method from Amir Alam Hospital and normal peers from their playground. The participants had no history of sensory, anatomical, neuronal, and speech disorders. The basic and advanced TOM was assessed with Ghamarani TOM test and a comparison was done between normal children and children with CIs. The obtained data were analyzed by SPSS 21.

Results: The performance of the two groups with regard to the basic and advanced TOM was significantly different ($p<0.001$). Moreover, there was a significant positive correlation between the duration of speech therapy and TOM abilities ($r=0.46$, $p=0.041$).

Conclusion: Hearing impairment affects the ability of TOM in children with CIs. The duration of speech therapy has a positive effect on the development of TOM.

Keywords: Cochlear implant; basic theory of mind; advanced theory of mind; speech therapy

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Introduction

Theory of mind (TOM) is one of the aspects of social cognition that differentiate humans from animals and is the foundation of capabilities like deception, empathy, and body language interpretation. In addition, TOM enables us to predict others' behaviors correctly. TOM is the base of our ability to explain or predict our or other's behaviors that works through attributing mental states. Mental states include beliefs, desires, affects, and intentions [1]. This function is an automatic and higher-order function that is essential for perception of the environment and social behaviors [2]. Because of the basic role of the language in TOM development [3],

cognitive social skills such as TOM in hearing-impaired children, encounter difficulties [4]. TOM can be described as two levels: basic (first order) and advanced (second and third orders) TOM.

The basic of TOM can help us to reason with others' mental states [5]. Child starts false representation in this stage. This ability appears at 4 years of age [6]. There are several tasks for assessment of this stage such as Sally-Ann and Smarties Box [7]. Sally-Ann task was first developed by Perner and Wimmer (1983) and was modified by Baron-Cohen in 1989. In this task, some pictures are displayed to child and two dolls are introduced. A short story is told and some questions are asked about it. Children under 3-4 years old fail this test. This test is the first test for the evaluation of false beliefs [5]. Smarties box task (unexpected content) was first developed by Gopnik and Astington. In this task, a Smarties box is shown to the child. Then the child is asked "what is inside the box?" and child will answer "smarties." Then, the box is opened and child will see that there are some colored pencils inside the box. Colored pencils are put back inside the box. Examiner asks "if I ask another child to tell me what inside the box is, what will be her/his answer?" A child who is in false belief stage will reply "smarties." Four years old children pass this test successfully [8].

The second order of TOM let us reason with others' thoughts and our mental states. A 6 to 7 years old child learns how to use this skill. John and Mary's task is one of the second-order TOM evaluations. John and Mary's false belief was developed by Perner and Wimmer in 1985. In this task, a photo of a village which has a park, horse and church is shown to the examinee. Then John and Mary are introduced to the child and it is mentioned that they are in the park. Then the relevant questions are asked [9].

The Third order of TOM includes humor, metaphors, and sarcasm for adults TOM. Some researchers believe that 8- to 9-year-old children can answer the task [10], but others believe that children cannot perform the task up to 11 years [7]. Happe test that includes 12 stories is designed for the third order TOM [10]. This test was developed by Happe. She developed first and second-order false belief task successfully based on a study of higher functioning Asperger and autism. Then she developed a more challenging and complex test for evaluation of third order TOM which includes humor, bluff, lie, sarcasm, and wordplay understanding. The valid and reliable test is available for children of 8 to 9 years old [11].

In childhood, TOM, like other skills, develops in a chronological order and passes from basic to prerequisite skills and finally advanced skills of understanding mental states and behavioral interactions. The stages of development are infancy, toddler, belief emergence, false belief perception, and embedded understanding [12].

Different people have different TOM abilities on this continuum. In one end of the continuum lies advanced TOM and on the other end impaired TOM [7]. Language impairment can affect cognition functions including TOM [3]. Hearing impairment is one the possible underlying causes for language development delay, therefore TOM in hearing-impaired children with language deficit is highly affected [4]. Given TOM as an important social tool, its impairment may hinder interaction with others. People, who experience TOM deficit, have difficulty in expressing others' intentions. Also they do not understand how their behaviors affect others and why they have problems in social interactions [13]. Children with hearing impairment naturally develop speech and language acquisition disorders and so their cognitive skills such as TOM are impaired. TOM as a social interaction tool is essential so its evaluations and interventions in hearing-impaired children are absolutely vital. TOM study in subjects with cochlear implant was started by Peterson and Siegal since 1999. In this study, a group of Australian deaf children aged 8 to 13 years were not able to perform TOM tasks that 4-5 years old children do successfully. They inferred that deaf children are like autistic children in regards to TOM [10]. Currently, many related studies are conducted abroad [14-17] and recently in Iran [18,19]. These children experience difficulties in language acquisition and consequently higher-level cognitive

skills such as TOM [5]. Unlike previous studies, we studied advanced TOM in addition to basic TOM by a valid and reliable tool developed by Ghamarani et al. [13]. The present study aimed at comparing basic and advanced TOM in 8-9 years old Persian speaking children with cochlear implant (CI) with normal peers. As children above 8 years old can perform second and third order tasks successfully, this age range was selected. One of the important factors that impact CI success is auditory training and speech therapy which include language training and group therapy with emphasis on natural interactions [10]. Therefore, in this study, the effect of duration of post-implantation speech therapy on TOM was studied, as well.

Methods

Study population comprised eighteen 8-9 years old Persian-speaking children with CI and 18 normal matched peers. Children with CI were selected by convenience sampling method from Amir Alam Hospital Cochlear Implant Center considering their medical records. Inclusion criteria comprised using CI for at least two years, lacking any other sensory impairments like blindness, having normal IQ, and being monolingual. If children or their family did not cooperate, they were excluded from the study. Normal children were matched for age with CI children. For controlling socioeconomic status, normal children were selected from the same living place as CI users. For normal-hearing children, the inclusion criteria comprised being 8-9 years old and monolingual, lacking any other uncompensated sensory difficulties such as blindness or psychiatric disorder based on interview, and having normal speech and language development. All CI users had only one cochlear implant. Each group had 18 subjects (8 girls and 10 boys). The mean (SD) age of the cochlear implantation in the study participants was 50.83 (4.21) months (range: 26-72 months). Ghamarani et al. [13] developed a TOM test with the validity of 0.89 and reliability of 0.86. This test can evaluate more extended age range as well as more complicated and advanced TOM than older tests such as Smarties box, dolls' house task, etc. Also, it can evaluate several TOM areas helpful for screening and diagnosis. Actually, it has been designed based on developmental view. In addition it is helpful in the evaluation of treatment efficacy and has a potential use for hearing impaired children. It takes only 35 minutes and its original form has 78 questions with three subtests:

1- First scale subtest: preliminary TOM, i.e. first level TOM or emotional recognition and pretensions.

2- Second scale subtest: first explanation of a real TOM, i.e. second level TOM or first false belief.

3- Third scale subtest: more advanced TOM, i.e. third level TOM or secondary false belief and humor perception.

This test includes pictures and or short stories. Questions reveal that the aim of the basic TOM evaluation is to assess the second and or third order TOM. Each picture is printed on a separate page in a black and white format and large scale. After obtaining parents' consent form, demographic information of the participants was collected. Parents could stay or leave the test room. This test does not need any equipment. Child and the examiner sit in front of each other and questions are asked orally and slowly. If child does not understand the question, it will be repeated. Child's answers were recorded on a related form. Every correct answer gets "1" point and every wrong answer "0" point. The total score is calculated out of 38. According to medical records of the participants and filled questionnaires by parents, the information about the extent of using speech therapy services after CI was recorded. Speech therapy was conducted three time a week, each session lasted half an hour. Data analysis was done by SPSS 17. For analysis of normal distribution of TOM score data in both groups, Kolmogorov- Smirnov test was used. The independent t-test was used for comparing basic and advanced TOM between normal children and CI children. In addition, the Pearson test was used for determining the relationship between speech therapy duration after CI and TOM ability. The significant level was set at 0.05 for statistic tests.

Table 1. Mean (standard deviation) scores of basic and advanced levels of theory of mind in children with cochlear implant and normal children (n=36)

	Mean (SD) score		
	CI	**Normal**	**p**
Basic TOM (level 1)	11.55 (5.63)	19.11 (3.27)	≤0.001
Advanced TOM (levels 2 and 3)	5.23 (3.69)	15.47 (2.27)	≤0.001

CI; cochlear implant, TOM; theory of mind

Results

Statistic results showed a significant difference between two groups in terms of basic and advanced TOM ($p<0.05$).

Mean score of both groups showed a significant difference between basic ($p\leq0.001$) and advanced ($p\leq0.001$) TOM between two groups. Table 1 presents the results.

The Pearson test showed that there is a significant relation between post-implantation speech therapy duration and TOM ability in 8-9 years old children ($r=0.46$; $p=0.041$).

Table 2 shows that 39% children with CI had two years of speech therapy post-implantation. There were fewer subjects who had received speech therapy for more than two years. In addition, 2% of children had no speech therapy after their post-implantation auditory training.

Discussion

Two main abilities that differentiate humans from other species are TOM and language [20]. TOM is a powerful tool for a child to discover, anticipate and change others' behaviors [21]. Language is symbolic and has a close relation with TOM and affects its development [3,22]. In TOM tests, linguistic abilities must be controlled between groups. TOM is usually expressed verbally and for the efficient use of language, supervision of listener's mental state and inferring mental states are needed. In adults, language is the most important tool through which TOM manifests itself. For example, clear reasoning of the mental states is dependent on verbal reasoning, representation, and finally expression [23]. Language development has a delay in deaf children and may lead to TOM deficit.

In the present study, for the evaluation of hearing impairment effects on TOM, children with CI in the age range of 8 to 9 years old were tested for TOM. The results showed that children with CI obtained significantly lower scores in basic and advanced TOM. Peterson and Siegal [24] showed that 8-13 years old Australian deaf children have difficulty in TOM tasks similar to autistic children, while 4-5 years old normal children can perform these tasks successfully. Autistic children show severe delay in TOM acquisition as a result of social and communication deficits, but deaf children because of difficulty in accessing the language show scores similar to autistic children. Peterson [4] compared results of twenty-six 4-12 years old deaf children (13 CI users and 13 hearing aid users) with 26 high functional autistic children in the same age range. False belief tasks showed that CI children have same amount of delay as autistic children in TOM development. Delkhah et al. showed that CI children in the age range of 5-6 years have weaker basic TOM function than normal peers and showed delayed TOM acquisition [18]. The results of the present study demonstrated that CI children have weaker performance in basic and advanced TOM tests compared to normal children. However, mean difference of scores in basic TOM

Table 2. Duration of speech therapy services for participants (n=18)

	Duration of training (month)						
	0	**12**	**24**	**28**	**36**	**48**	**60**
Number (%) of participants	2 (11.1%)	4 (22.2%)	7 (38.9%)	1 (5.6%)	2 (11.1%)	1 (5.6%)	1 (5.6%)

(7.55) was lower than advanced TOM (8.23) which is indicative of lower functional difference for basic TOM between CI children and their normal peers than advanced TOM. In other words, CI children are in TOM development trajectory and probably they might achieve higher levels of TOM in time. Children will achieve different levels of TOM. In the first years of elementary school, TOM becomes more advanced [25]. Exposure to every day conversations is an important factor for learning how to understand TOM. Exchange of information via every day conversation helps children understand different subjects and different beliefs for the same reality [24]. Limitation of social experience secondary to hearing loss in the first years of life results in delay TOM development, but it shows progression with increase in age and experience [26].

CI helps TOM development in children. CI effects on TOM are not conclusive and more research is needed in this regard [27]. In this study, the mean age of CI users was high. One of the positive factors of CI using on TOM is related to the age of implantation [28]. One reason for lower performance of CI children in the present study might be higher age of implantation. Therefore 8-9 years old children with CI had lower score because of their lower auditory experience. It is recommended that age of implantation be controlled in future studies. In addition TOM tests depend on the language, so deaf children might fail to show their TOM skills completely. Speech therapy after CI has significant correlation with TOM skills of 8-9 years old children. Auditory stimulation before 6 years old is vital for speech and auditory development in children with CI. Children with timely CI and appropriate rehabilitation after CI have more advanced speech and language skills than children without appropriate therapy [29]. Timely intervention can decrease CI consequences [30]. These findings are in agreement with previous studies. As there is a relation between language and TOM, any language improvement can improve TOM, too. This effect is clearly more pronounced in 8-9 years old children with CI who have received intervention for relatively long duration and have more auditory experience.

This study was conducted on a small number of participants and any generalization must be cautious. Furthermore, TOM test tool needs the child's verbal skill and in related studies, it is expected that child gives a verbal response [31]. Therefore newer tools are required for more precise evaluation of TOM in non-verbal or even verbal deaf children in future studies.

Conclusion

This study showed that CI children perform weaker than normal peers regarding basic and advanced TOM. In addition, in spite of CI, they still show lower score in TOM tasks. As there is a relation between TOM and language and cultural factors, newer tools are required with least dependency on expressive language in hearing-impaired children.

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Conflict of interest

The authors declare that they have no conflict of interest.

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