



# The Comparison of Executive functions and the Theory of Mind among the Hearing and Deaf Children

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## Abstract

*The present study aimed to compare executive function and theory of mind in deaf and hearing children. The study sample consisted of 30 hearing children and 30 deaf children aged 8 to 12 years old in Tehran being intelligence and age-peered. The present study was causal-comparative design. The data were collected by Wisconsin Card and theory of mind test was analyzed using descriptive statistics and multivariate (MANOVA) test. The results showed that in the theory of mind test and executive function test, the deaf children had poor performance compared to the hearing children. The results of Pearson correlation coefficient showed that there was a reverse relation between autism error and the theory of mind.*

**Keywords:** Executive function, the theory of mind, Autism error, Deaf Children, Wisconsin Cards.

## Introduction

Considering that how and when the children are aware of their mental beliefs and inclinations and others mental states leads to the better perception of their behavior and it is discussed in the theory of mind of children<sup>1</sup>. The theory of mind doesn't depend upon the cognitive ability<sup>2</sup>, emotional confusion or language representation disorders<sup>3</sup> but language is the main requirement in the theory of mind test. How and when the children feel others have different beliefs about them as the factor of their behavior? To investigate this question, various researchers developed various assignments to define how the children can predict the others thought and deeds and what they know about others mind<sup>4</sup>. One of the issues being responded in the present study is the comparison of deaf and hearing children in terms of achieving the theory of mind in these two groups. Hearing is one of the most important senses of a person without which adaptation with the environment is disturbed and delay in mental processes changes is occurred. One of the important capabilities being affected considerably by hearing is speech and language. This ability is considered as one of the main abilities of human being to be adapted with the environment. It is obvious that hearing impairment leads to limitation in social interaction and delay in social growth. Despite the image bombardment in our life, language is considered as the most important communication instrument. If there is any dysfunction in this area, the personal relation is disturbed. Talking with each other and exchanging views is one of the main requirements of human being<sup>5</sup>.

In addition, thinking is closely associated with language. According to Vigotsky, the linguistic communication is the first tool of thinking and learning for human being. But all thinking is not dependent upon language. It is possible that an architect benefits sorting some models in computer screen for idea of

construction project plan, the *sculpture* can make an sculpture by forming the mud and a child can use his ideas in painting but human mind gets powerful by using the language for learning namely with communicating with a symbolic powerful memory as making a person capable to manipulate the objects and affairs, re-definition, concentration and innovation and recalling new concepts and it is assumed that among the deaf children, the quality and behavioral disorder is frequently observed<sup>6</sup>.

One of the important issues in this study is the investigation of executive function among hearing and deaf children. The executive function is the high cognitive and meta cognitive function doing a set of excellent abilities, inhibition, self-initiation, strategic planning, cognitive flexibility and impulse control and some functions as organizing, decision making, working memory, keeping motor control, time perception, future prediction, recovery, internal language and problem solving are the most important neurological executive functions helping a person in the life and learning assignment and intelligence actions<sup>7</sup>.

The executive function reviews showed that these functions i. Are manifested from the early growth period (probably the end of the first year of life) ii. They grow gradually and important changes are occurred at 2 to 5 and 12 years old, the performance of the child is mostly similar to the performance of the adults. iii. The failure of the child in executive functions is determined based on the complexity of the assignments. iv. Executive function problems are the outcomes of the disorder in epigenetic process and one of the most important processes in perception of executive function and performance of the children is the better understanding of the concept of flexibility/inflexibility. Inflexibility is the process disturbing the problem solving and it is studied as autism in neurology studies<sup>8</sup>. The change studies showed that inflexibility is occurred in various contexts and

ages. One of the most important studies on autism of infants is A-not-B error. This error is described by Piaget and it is occurred when the babies at 8 to 10 months can remember the object successfully at location A and when it is completely hidden at location B although the child has seen it at location B, he searches for it again at location A. Piaget considered this error due to the inadequate growth in recognition of the concept of object but the new interpretation of this error is that the children have problems in mental recalling of the location of the object to inhibit the dominant response<sup>9</sup> at 3 to 5 years, flexibility function is created and the child performance is increased in complex assignment including problem and control feeling. The researchers prefer to study these changes under executive functions. Generally, executive functions are occurred in the framework of thinking and awareness with some stages<sup>10</sup>. Based on awareness level, self- contemplation level is increased with the age increase and the children can have better performance in response to the environmental requirements. Thus, the increase of awareness level, the increase of the quality of experience, the potential ability for recalling, control, thinking awareness, the complexity of the knowledge of child of emotional and action structures are useful.

The change of executive function including representation, change and self-initiation was considerably dependent upon the growth stages in pre-elementary years. Although the main duty of the executive functions is participation in cognitive control and it is studied mostly in general field of cognitive function, it is emphasized that executive functions include the sub-functions (e.g. working memory, flexibility and attention). The sub-functions collaborate for self-directing behavior and problem solving and they act in accordance with the theory of mind<sup>11</sup> to create the goal-based behavior and understand the meaning of the terms and symbols<sup>12</sup>. Generally, executive functions are summarized in various periods as following; in elementary school as following the simple statement, simple inhibition and then in the next years as decision making of spending money or raising hand before talking, then at 9 to 11 years, saving money, going to store and providing report for the school, at 12- 15 years, the ability to attend for 60 to 90 min, using notebook and doing the work without the supervisor<sup>8</sup>.

Based on the items, the researcher attempted to answer the question, is there any significant difference between executive functions and the theory of mind among the deaf and hearing children?

## Methodology

**Study method:** The study was non-experimental causal-comparative design and the theory of mind and executive function in hearing and deaf children were compared.

**Study population:** The study population in the present study was deaf children aged 8 to 12 years in Tehran city and hearing children of district 4 in 2012 being peered in terms of age and

intelligence with the deaf children. In causal-comparative methods, at least 15 people for each group were recommended<sup>13</sup>. 30 hearing and 30 deaf children were selected. The researcher obtained the permission from the University and referred to welfare organization and by obtaining the permission went to Tehran welfare centers and two centers stated their approval to collaborate with the researcher. The inclusion criteria were as following: The deaf children with no physical or intelligence problems (hyperactive), learning in Baghcheban deaf center, having hearing parents, not only child and being in the required age range. The expert called the parents of the deaf children and most of them didn't agree to be included in the study and only 15 families were agreed to perform the tests. The researcher performed the tests with the deaf experts in the deaf center and as more deaf children were required in the present study, the researcher obtained the permission from the university and went to Loghman hospital, cochlear implant ward and selected the deaf children candidate of cochlear implantation. The criterion for cochlear implantation was bilateral severe-to-profound sensorineural hearing loss that couldn't have acceptable speech progress in a time period by conventional hearing aids. Determining the acceptable progress about children is a difficult issue and in this regard candidate criterion as low progress to no progress in hearing skill by hearing aid and empowerment training were suitable<sup>14</sup>. To select the hearing children, by stratified random sampling, district 4 of elementary school was chosen and after getting the permission from education department, the sampling was done.

**Measurement instrument:** The theory of mind measurement instrument: The study instrument in the theory of mind was the questions being answered by the child after hearing the story<sup>15</sup>. Two stories were read for the children and some drawings had explanations and then the questions were asked.

**First story:** Instruction: I read a short story for you, listen carefully. Ali is 1 year old. He plays on the floor in the house. His mother gave him a piece of apple. Suddenly, he bites his lip and put the apple on the floor. When the father came home, the mother was on the phone. The father hugged him and then put him again on the floor. He gave the piece of the apple on the table. Having watched the apple, Ali cried.

Question 1: Why Ali cried when his father gave a piece of Apple?

Question 2: Does father know why Ali is crying?

**Second story:** The parents are in a birthday party. They know only some people and they think the party is very noisy. The father said:" wow, it's great to be here.

Question 1: Why did the father meant really?

Question 2: Why the father said, it is really good to be here?

**Executive function measurement instrument:** The study instrument in executive function was Wisconsin Card Sorting Test (WCST) being done by computer. Four main cards (one red triangle, two green stars, three yellow crosses, and four blue circles) were displayed above the screen constantly to the end of

the test. 60 cards were appeared randomly one by one at the bottom of the screen, the right angle of the screen. When one card is displayed, the subject should take the decision; this card is under which main card. He presses one key of four keys on keyboard (JFGH) or click on the mouse on one of the four main cards and defines under which main card is the displayed card. After giving the response, the correct or false feedback is appeared on the screen as true or false. A voice of 2000 Hz for correct feedback and 100Hz for false feedback is heard. The distance between the response of the subject and feedback takes 100 milliseconds, the length of feedback is 200 milliseconds and the distance between the end of feedback and the next card takes 700 milliseconds. There is no time limitation except these items about various parts of the test. The test consists of four target stimuli which vary on the dimensions of color, number, shape. At first color was considered. After 6 consecutive cards have been sorted correctly, the sorting principle changes. Thus, the software considers the 6 correct consecutive cards based on the change of sorting principle. The consecutiveness of the correct responses or correct feedbacks is important. Each of 60 cards is presented only once and no card is used twice.

The software is designed as when the 60 cards are finished (ignoring the fact that the subject passed how many of 6 levels successfully) or when the subject completed the six levels successful before finishing the 60 cards (ignoring the fact how many of 60 cards remained), the test is finished and the results are recorded.

Executive function test is including two variability aspects, the internal aspect change including the change of response to the similar stimuli aspect (e.g. select circle instead of square) and the external aspect change and the response of the subject should be changed in different aspect of the presented stimuli (e.g. selection based on color when the criterion was the previous level of the figure)<sup>16</sup>.

The reliability and validity of Wisconsin Card Sorting Test (WCST): To compute the reliability of the software, the reliability of two outputs was computed by internal consistency (Cronbach's alpha) and split half. Cronbach's alpha coefficient for the completed levels was 0.73 and for autism error 0.74. The split half coefficient for the completed levels was 0.83 and for autism error 0.87.

**The reliability and validity of the theory of mind:** To evaluate the validity of the test, content validity methods, the correlation of the sub-tests with total score and concurrent validity was applied. The concurrent validity was estimated at 0.89 significant at 0.01. The correlation coefficients of the sub-test with total score were significant at all cases ranging 0.82 to 0.96. The reliability of the test was evaluated by test re-test, Cronbach's alpha and reliability coefficient of the scores. The reliability of re-test of the test was ranging 0.70 to 0.94 and all the coefficients were significant at 0.01. The internal consistency of the test by Cronbach's alpha for total test and

each of the first, second and third sub-test were 0.86, 0.72, 0.80 and 0.81. The reliability coefficient of the scores was 0.98 being significant at 0.01.

## Results and Discussion

Table-1 shows the mean and standard deviation of study variables among hearing and deaf groups

**Table-1**  
**The descriptive indices of executive functions and the theory of mind**

Variable	Mean	SD
The number of the levels of hearing children	1.008	1.29721
The number of the levels of deaf children	1.546	0.85383
The autism error of hearing children	13.4333	4.61395
The autism error of deaf children	18.2333	8.11845
Theory of mind of hearing children	3.0182	1.00905
Theory of mind of deaf children	1.8889	1.27827

As is shown, the mean of the scores of the number of levels among hearing children was 1.80 and among deaf children 1.064 and it shows that hearing children had high mean. The mean of the scores of autism error in hearing children was 13.43 and among deaf children 18.23 and it showed that deaf children had high mean. In addition, the mean of the theory of mind among hearing people was 3.01 and among deaf children as 1.88 and it showed that hearing children achieved high mean. The results of t-test to compare the deaf and hearing children were reported in table-2.

As is shown in table-2, the results of variances consistency test showed that the calculated F was not significant and the consistency of the variances hypothesis is observed. The results of t-test to compare two groups of the theory of mind showed that there is a difference between two groups and this difference is significant at 0.001 levels. The investigation of the calculated mean for two groups showed that this difference is for the benefit of the hearing children as the mean of the scores of the theory of mind was more than the mean of deaf children.

To investigate the difference of executive functions (the number of levels and autism error) among hearing and deaf children, MANOVA test was applied.

The results of table-3 for variance analysis showed that among the executive functions among hearing and deaf children, there is a significant difference among autism variable ( $P < 0.003$ ) and the number of levels ( $P < 0.04$ ). Table-4 showed the results of LSD test. The results showed that there is a significant difference between two groups. The correlation between executive functions and the theory of mind is reported in table 5.

**Table-2**  
**The results of t-test to compare the deaf and hearing children in the theory of mind**

Variable	Consistency of Levin variances	The results of t-test					
		Significance level	The difference of means	Difference standard error	t	Degree of freedom	Significance level
Theory of mind	F	0.369	1.13	0.30	3.76	70	0.001
		0.816					

**Table-3**  
**The table of effects between the subjects**

	Variance source	The sum of squares	Degree of freedom	The square of means	F	Significance level	Eta coefficient
Modified model	The number of levels	4.839	1	4.839	3.632	0.060	0.038
	Autism error	452.151	1	452.151	9.280	0.003	0.093
Intra-group	The number of levels	141.097	1	141.097	105.916	0.000	0.538
	Autism error	22418/086	1	22418.086	460.112	0.000	0.835
Inter-group	The number of levels	4.839	1	4.839	3.632	0.04	0.038
	Autism error	452.151	1	452.151	9.280	0.003	0.093
Error	The number of levels	121.226	58	1.332			
	Autism error	4433.4806	58	48.723			
Total	The number of levels	305.000	60				
	Autism error	27775.000	60				
Modified total	The number of levels	126.065	59				
	Autism error	4885.957	59				

**Table-4**  
**The results of LSD test**

Significance level	Standard error	The difference of means	Variable	
0.00	0.315	-1.258*	Hearing-Deaf	The number of levels
0.026	1.606	3.677*	Hearing-Deaf	Autism error

**Table-5**  
**The correlation between executive function and the theory of mind**

Variable	Number of levels	Autism error
The theory of mind	-0.017	-0.24*

The results of Pearson correlation coefficient showed that there is no significant relation between the theory of mind and the number of levels and the relation between two variables is close

to zero. There is a inverse significant relation between autism error and the theory of mind at  $P < 0.05$ . It can be said that by the increase of the scores of the theory of mind scores, the autism error is reduced and vice versa.

### Conclusion

The present study aimed to compare the executive functions and the theory of mind among the hearing and deaf children. The results of the study showed that there was a significant difference between two groups in terms of the theory of mind. This difference was for the benefit of the hearing people as the mean of the scores of the theory of mind of this group was more than deaf children. The results of the first hypothesis were consistent with the results of Hassanzade<sup>17</sup>, Russel<sup>18</sup>, and Rofman<sup>19</sup>. It seems that social interaction and communicating with others help the perception of the theory of mind and it plays an important role in the theory of mind. Talking with mother or the family of the child, sister, brother and friends about the mental conditions can increase the performance of the theory of mind among the children. Because the relation between social adequacy and the theory of mind is mutual. In

this mutual relation, the positive social interaction brings some opportunities for more learning about the relation between thinking and behavior and increasing perception of the mind and others leads into the successful social behavior, even the deaf children in interaction with their parents, use sign language and they achieve the theory of mind early compared to the deaf children not using sign language.

It is possible that linguistic capabilities lead into the growth of the theory of mind. The language is not the only facilitator of cognitive operation or performance among the children and it is having causal role in the growth of the theory of mind. Some studies showed the causal role of language in achieving the theory of mind, the children with the ability of hearing understand the words via hearing and they grow up from cognitive aspects but the children who cannot hear or they cannot hear well, this experience is less and they start school with the linguistic growth delay and some of them don't keep up with their peers in terms of linguistic and academic growth.

The results of the above study showed that among the variables of executive functions, among hearing and deaf children, there was a significant difference between autism error and the number of levels. The LSD test showed that there are significant differences between two groups. The result was consistent with the results of Zelazo<sup>20</sup>, Edwards<sup>21</sup>, Christopher et al.<sup>22</sup>, figueras<sup>23</sup>. As symbolic linguistic system among deaf children is different form that hearing children and the deaf child has some problems in planning, attention and flexibility compared to the hearing child, the executive function will be weak. The brain wave showed the difference between the brains in two sides of forehead, the areas associated with the executive functions and it is different among hearing and deaf children. In addition, the role of linguistic skills in processing of executive functions and cognitive control as memory capacity and inhibition can lead into weak executive functions.

Another result showed that there is a negatively significant correlation between autism error and the theory of mind. With the increase of the theory of mind scores, the autism error scores are reduced and vice versa. The results of the study were consistent with the results of the study of Baron-Cohen<sup>2</sup>, Hughes<sup>11</sup>, Michel<sup>24</sup>, Devilliers<sup>25</sup>, Carlson<sup>26</sup>, Adam<sup>27</sup>, Bayhan<sup>28</sup>. Between the theory of mind and executive function, "Social language" had intermediate role. The language is not the only condition or effective factor in thinking and other mind activities but language increases person ability in thinking and other mental activities. In addition, the theory of mind is a pre-requirement to perceive social environment and being involved in competitive behaviors. The theory of mind affects the self-regulation and problem solving skill, self-contemplation, social qualification and interpersonal skill. The children acting better in the theory of mind consider the multiple aspects of the problem and they keep target in their mind, plan and act in accordance with the aim.

The theory of mind assignments needs the executive performances even autism children with the problem in the

theory of mind have problems in executive performance. The relation between executive function and the theory of mind is assessed in balanced condition as the executive function refers to the potentials and the theory of mind refers to actual potentials and the ability of the affairs and both have complementary role in the theory of mind of the child.

The relation between the executive function theory and the theory of mind is challenging. There are some theories to explain the relation between these two theories showing that executive functions require the perception of the mental processes of a person and the theory of mind requires the ability in executive functions. In the growth process, the formation of the skill of the theory of mind requires the pre-defined skill. The skills include the face processing, emotional processing following the look direction, distinguishing between the alive and dead, perception of the others aims and common attention. The people with some problems in the above performances cannot do the tests of the theory of mind well and these performances depend upon some of the neural cycles responding to the social stimulations preferably. The outcome of the mentioned neural periods needs executive functions for deep processing. The executive functions are necessary to keep the social interaction components.

**Applied recommendations:** Based on the results of the study, the parents, sisters, brothers and teachers give importance to the interaction of deaf children. By changing the educational plan of the deaf children, the shortcomings of the theory of mind and their education are considered. Based on the results of the study, some plans are considered for training and directing the deaf children for having skills in communication with other people including the deaf and hearing children. Based on the results of the study, the necessity of the importance of the deaf children parents and authorities to cochlear implant to improve the hearing of totally deaf people is felt. Using technology like subtitle of TV programs and movies and internet, applied use of the associations of the deaf can help these people to improve the communicative skills.

## References

1. Khanjani Z, The theory of mind of changes and approaches. *Scientific Journal of Tabriz University*, **4(16)**, 1-10 (2011)
2. Baron-Cohen S, Does the autistic child have a theory of mind?, *Cognition*, **21(1)**, 37-46 (1985)
3. Leslie. A.M., Pretence and Representation : The Orgins of Theory of Mind, *Psychological Review*, **94(4)**, 12-426 (1988)
4. Mashhadi A and Mohseni N, The investigation of the comparison of the empowerment of the theory of mind and maintenance of number, *Scientific-Research Journal*, **10(2)**, 1-10 (2006)
5. Isolde A, Translated by Sepide Khalili, The behavioral

- problems of child, Peidayesh Chap publications (2005)
6. Hindley P, Child and adolescent Psychiatry in: Mental Health and Deafness (Edsp. Hindley and N. kitson), Whurr Publishers, London, 42-74 (2000)
  7. Barkley Russell, Executive Functioning and ADHD, Nature and Assessment, Courses For Mental Health Professionals (2011)
  8. Alizade H, The executive functions with and without development disorder, *The new theories in cognitive sciences*, 6(3), 1-10 (2004)
  9. Alizade H, The theoretical determination of attention deficit, hyper activity : Behavioral inhibition model and self-control nature, *Research in Exceptional Children field*, 5(3), 1-10 (2005)
  10. Zelazo P.D., The Development of Conscious Control In Children Trends in Cognitive Sciences, *Trends in Cognitive Sciences*, 8, 12-17 (2004)
  11. Hughes C, Executive function in Preschoolers : Links With Theory of mind and verbal ability, *British Journal of Development Psychology*, 16, 155-233 (1998)
  12. Alizade H, The relation between executive functions neural-cognitive with development disorder, *New theories in cognitive sciences*, (2006)
  13. Delavar A, The theoretical and practical basics of the study in humanistic and social sciences, Roshd Publications, (2009)
  14. Jaroelahi F, The early diagnosis of hearing impairment and prevention of hearing problem side effects, Online journal of ENT (ear, nose, throat) specialist, (2012)
  15. Ghamrani A, Alborzi S.H. and Khayer M, The validity and reliability investigation of the theory of mind test, *Psychology Journal*, (2006)
  16. Qorbani M, Malekpour M, Neshatdust H, Molavi H and Kazemi H, The executive functions among the patients with paranoid schizophrenia compared to normal people, *The new theories of cognitive sciences*, (2007)
  17. Hassanzade Afruz, The cognitive change of the deaf children based on mind theory, *Research in exceptional children field*, (2007)
  18. Russel D.J., The Development of Theory of Mind, *Journal of Child Psychology*, 39(6), 1-10 (1998)
  19. Ruffman T., Lance S., Rowlandson K., Rumsey C. and Garnham A, How language relates to belief, desire, and emotion understanding., *Cognitive Development*, 113, 1-20 (2002)
  20. Zelazo P.D., The Development of Executive Function in Deaf Children: Comparing With Normal Children, *Advances in Neurology*, 77, 149-165 (1995)
  21. Edwards L. and Langdon D, Executive Function and Language in Deaf Children, *J Deaf Stud Deaf Educ.*, 13(3), 362-377 (2008)
  22. Christopher M, and David B, Pisoni, Executive Function, Cognitive Control and Sequence Learning in Deaf Children With Cochlear Implants, *Dev Sci*. Author manuscript, available in PMC, (2012)
  23. Figueras B, Executive function and Language in Deaf Children, *Journal of Deaf Studies and Deaf Education*, 13(3), 362-368(2013)
  24. Mitchell T.V. and Quittner A, A.L. Multi Method Study of Attention and Behavior Problems in Hearing Impaired children, *Journal of Clinical Child Psychology*, 25, 83-96 (2000)
  25. Devilliers P.A., Devilliers J.G., Schick B., and Hoffmeister R, theory of Mind Development in Signing And Nonsigning Deaf Children : The Impact if Sign Language On Social Cognition, Paper Presented at The Conference of Theoretical Issues in Sign Language Research, *Amsterdam*, (2000)
  26. Carlson S.M. and Moses L.J., Inhibitory Control and Children's Theory of Mind, *Child Development*, 12, 1032-1053(2001)
  27. Adam P, link Between Theory of mind and Executive Function : Towards a More Comprehensive Model, Institute of Psychology, University, Poznan, (2010)
  28. Bayhan Pinar, Firat Sipal and Rafet, Do Deaf Children Delay in Their Executive Function Due to Their Delayed Language Abilities? Department if Child Development, Hacettepe, Ankara, Turkey, (2011)