

RESEARCH ARTICLE

Applied behavior analysis on inhibition, planning, and working memory of intellectually disabled children with hearing impairment

Farangis Demehri*, Mohsen Saeidmanesh, Fahimeh Dehghani Tezeng

Department of Psychology, School of Humanities, Science and Arts University, Yazd, Iran

Received: 29 Oct 2018, Revised: 7 Dec 2018, Accepted: 17 Dec 2018, Published: 15 Jul 2019

Abstract

Background and Aim: Children with intellectual disability have significant defects in the essential elements that constitute mental development. The purpose of this study was to investigate the effectiveness of applied behavior analysis on inhibition, planning, and working memory of intellectually disabled children with hearing impairment.

Methods: The study design was quasi-experimental with pretest, posttest and a group control. The study population comprised all intellectually disabled children with hearing impairment, referred to Yazd Rehabilitation Centers. A total of 30 students were selected from the hearing-impaired children with mild to moderate intellectual disability. Then, they were randomly assigned into control (n = 15) and experimental (n = 15) groups. The study instrument was the Behavior Rating Inventory of Executive Function (BRIEF) questionnaire. The program based on applied behavior analysis presented for experimental group and after that the posttest were administered for both groups. Analyses of covariance was used to analyze data.

Results: The study result indicate that group therapy based on applied behavior analysis has

significant effects on inhibition ($p < 0.01$) and planning ($p < 0.05$) of intellectually disabled children with hearing impairment, but cannot change their working memory ($p < 0.17$).

Conclusion: Applied behavior analysis can be used as a therapeutic method for improving executive functions in intellectually disabled children with hearing impairment.

Keywords: Applied behavior analysis; intellectual disability children; inhibition; working memory

Citation: Demehri F, Saeidmanesh M, Dehghani Tezeng F. Applied behavior analysis on inhibition, planning, and working memory of intellectually disabled children with hearing impairment. *Aud Vestib Res.* 2019;28(3):158-163.

Introduction

In DSM-V manual, mentally retarded term has been changed to intellectual development disorder (IDD). To determine intellectual disability, clinical judgment and a rigorous individualized assessment of the person's intellectual functioning are required to prove the presence of significant subaverage intellectual functioning and adaptive behavior. The generally accepted scientific definition of the term "significant subaverage" is performance that is at least two standard deviations below the average level

* **Corresponding author:** Department of Psychology, School of Humanities, Science and Arts University, Daneshjoo Blvd., Yazd, 13335-89167, Iran. Tel: 009835-38264090,
E-mail: m.saeidmanesh@yahoo.com

for the individual's peers [1]. The prevalence of intellectual development disorder has been reported as 1% to 3% [2]. These people have more problems in their physical activity, movement and health [3,4]. Some of these children have hearing impairment, so painting or physical movements are used to communicate with them. Tone of voice, face mode, eye contact and movement of head and hand are useful for communicating to children with hearing disability. Some research has shown that the deficiencies in intellectual development of children with hearing impairment in problem solving and verbal short-term memory are related to their executive functions [5]. Executive functions play an important role on adaptive functioning, social interaction, and academic achievement [6]. Executive functions are a specific area of abilities, including organization in space, selection restraint, preparation, environmental response, goal-orientation, planning and flexibility [7]. Executive functions as a general concept, involve planning and selecting a goal, organizing behaviors over time, flexibility, attention, work memory, and self-regulatory processes such as self-management [8]. Executive functions comprised response inhibition, fluency, working memory, cognitive flexibility, planning, shifting attention, organizing, and attention control. Based on development research, these functions start from the earliest stages of child growth and gradually develop. There is a very significant change when the child is two to five years. At about 12 years of age, the performance of the child in the field of executive functions is very much like the performance of adults [7]. According to some research studies, executive functions are two parts; cool executive functions that involve cognitive process like working memory and planning, and hot executive functions that involve emotion management like behavior inhibition and emotional control. The presence of hearing impairment in intellectually disabled children can be further expressed by their cognitive problems. Auditory problems affect the communication and social skills of children. It also affects the development of cognitive abilities in the areas of attention,

learning, and memory. According to the research, children with Down syndrome have various strength and weakness in the field of executive functions [8,6]. Children with Down syndrome are strong in emotional control and shifting attention from the field of executive performance and have poor performance in metacognitive and cognitive fields such as working memory and ability to plan and organize [9]. According to parents' report, behavioral inhibition is one of the most important problems of children with mental disabilities [6]. Behavioral studies of executive functions also confirm that the weaknesses in working memory [10] planning, problem solving, and inhibition [11] are related to rational age therefore intellectual disability children according to their level of intelligence, they show different functions.

In 2 to 5 years old children with intellectual disability, poor performance is observed in the planning and behavioral inhibition of their executive functions, but in the age group of 6 to 18 years old, weakness is more seen in the shift of attention, work memory, the initiation of activity and planning [6]. Thus, attention to intervention in improving the executive functions of intellectually disabled children is of great importance. According to another study, the growth of executive functions in hearing impaired children could have a two-year delay. One of the reasons for this delay is the relationship between the language system and the symbolic system of children with hearing impairment; also children with hearing impairment have problems in naming and labeling, as well as the mechanism of attention [12].

In applied behavior analysis, tasks are divided into smaller components, and whenever the tasks are correctly done, the child's behavior will be reinforced to motivate him or her to repeat the behavior. The underlying principle of this approach is that the likelihood and frequency of behaviors that are encouraged is increased and behaviors that are not addressed may be eliminated [13,14]. Applied behavior analysis is a set of concepts and principles used to make behavior change meaningful and applied in a person so that he or she can have an

independent and constructive life as a member of the community. The objectives of each intervention using applied behavior analysis principles are to 1) increase positive behaviors, 2) reduce negative behaviors, 3) teach new skills, and 4) generalize and maintain significant skills and principles that manage applied behavior [15].

Most interventions on executive functions focus on children with attention deficit hyperactivity disorder (ADHD) and learning disabilities. The results approved the effectiveness of cognitive training and cognitive-behavioral therapies on improving functional performance in children with ADHD and children with autism spectrum [16,17]. However, few studies have been conducted on interventions that have an impact on the executive functions of children with intellectual disorders with hearing impairment. Therefore, the purpose of this study was to investigate the effectiveness of applied behavior analysis on inhibition, planning and working memory of children with mild and moderate intellectual disability with hearing impairment.

Methods

Participants

The research method is a quasi-experimental, pretest and posttest with the control group. The statistical population included all children with mild and moderate intellectual disability with mild and moderate hearing impairment in Exceptional Children's schools, Yazd, central Iran. The study sample comprised 30 children who were selected by convenience sampling method. The inclusion criteria were the children diagnosed with mild and moderate mental disabilities and hearing impairment at mild to moderate levels after referring to schools and their examination. In the next step, the absence of physical and emotional disabilities, and chronic physical illness, were studied in the children. Then the selected children were randomly divided into two groups: experimental and control. The experimental group consisted of 8 girls and 7 boys with the mean age of 9 years and IQ of 61. The control group comprised 9 girls and 6 boys with an average age of 9 years and IQ of

58. The ethical considerations were the confidentiality of information, the consent of parents to participate voluntarily in the research. The follow-up program for applied behavior analysis was conducted on the experimental group and not the control group. A summary of the treatment plan is provided.

Questionnaire measures

The Behavior Rating Inventory of Executive Function (BRIEF): This questionnaire was developed for parents and teachers to measure executive functions at home and in the school environment. The questionnaire is designed for children aged 5 to 18 years. There are two forms of parenting and teacher reporting that each has 86 questions. The list evaluates 8 subscale of executive functions, including inhibition, shifting attention, emotional control, initiation, working memory, planning, organization and control. The test-retest reliability of the questionnaire was 0.81 for the parents' form and 0.86 for the teachers' form. BRIEF's content validity is good because all questions have been selected from parent interviews and executive functions. In this study, parents' report form was used to measure inhibition, planning and working memory of the subjects [18].

In this research, after the implementation of pretest on both experimental and control groups, 10 sessions of intervention training were performed for the subjects of the experimental group using behavioral behavior analysis. A summary of the issues worked in each session is presented in Table 1. After completing the training sessions, post-test was administered to both the experimental and control groups.

The obtained data were analyzed by descriptive statistics (mean and standard deviation) and inferential statistics (analysis of covariance, Levene's test). The normality of data was confirmed by Kolmogorov-Smirnov test. All analyses were performed in SPSS 21.

Results

Table 2 presents descriptive information on the efficacy of behavioral analysis applied to inhibition, planning and working memory of

Table 1. Applied behavior analysis program

Session	Explanation
One	Performing pretest, establishing medical communication and behavioral registration in relation to executive functions
Two	Cognitive and rehabilitation training
Three	Cognitive and rehabilitation training
Four	Shifting attention training
Five	Working memory training
Six	Working memory training
Seven	Planning training
Eight	Planning training
Nine	Teaching organization
Ten	Performing post test

intellectually disabled children with hearing impairment along with the results of analysis of covariance. The results of analysis of covariance with the elimination of the pretest effect indicate significant difference between the experimental group and the control group in planning ($F(1, 27) = 14.33, p = 0.04$) and inhibition ($F(1, 27) = 22.23, p = 0.01$), but no significant difference in the working memory ($F(1, 27) = 5.65, p = 0.17$).

Discussion

In this research, the effectiveness of applied behavior analysis was investigated on the executive functions of inhibition, planning and working memory of intellectually disabled students with hearing impairment. In this quasi-experimental study, 30 hearing impaired mentally retarded children aged 8 to 11 years were selected and assigned to two groups of experimental and control. After the treatment program, the pretest and posttest results were compared between the two groups. According to the study findings, the application of behavioral analysis method was effective and could improve behavior inhibition of children with mild and moderate mental disabilities that has hearing impairment. Behavior inhibition is one of the most important variables

in executive functions and is a neurological variable that coordinate thoughts, actions and feelings. We have cognitive and behavioral inhibition that children with intellectual disorder show weakness in the field of behavioral inhibition. [19]. In the method of applied behavior analysis, the tasks are presented to the child in consecutive stages, and if the child correctly passes one stage, he or she is directed to the next stage. Thus, mentally retarded children can associate between the posture and interacting behaviors in carrying out a relational task. Since the subjects had hearing impairment, verbal cues were also used for behavioral control and reinforcement of behavioral inhibition.

When the child first ignores other intervening stimuli in the environment by an external stimulus (therapist's voice) and then by an internal stimulus (inner speech), then he or she can approach the behavioral goal earlier and receive reinforcement, then child use more cognitive process of inhibition [16]. Findings indicate that applied behavior analysis can be useful for planning of children with intellectual disorder with hearing impairment. This finding is consistent with a research that showed that behavioral programs are effective in improving social skills and children's executive functions of the autism spectrum and intellectual disorder [17]. The ability to plan requires the conceptualization of changes in the current environment, moving forward based on identifying the various choices, selecting, and realizing the plans [19]. In this problem, all behavioral and cognitive exercises are given step by step to the children therefore they have better predictions and better planning through repetitions of specified exercises and understanding of the predetermined stimulus activities. On the other hand, planning is one of the components of executive functions related to the cognitive and behavioral inhibition. Therefore, when a mentally retarded child demonstrates progress in inhibiting, one can expect to see progress in planning, which is a cognitive component. According to the findings, there was no significant positive change in the working memory of mentally retarded children with the applied

Table 2. Mean (standard deviation) scores of the behavior rating inventory of executive function in the experimental and control group with the results of covariance analysis

Component	Groups	Before	After	F	p
		Mean (SD)	Mean (SD)		
Inhibition	Experimental	14.12 (3.64)	9.11 (3.23)	22.23	0.01
	Control	13.45 (2.24)	12.87 (2.98)		
Planning	Experimental	11.12 (2.45)	8.69 (2.36)	14.03	0.04
	Control	13.12 (2.41)	12.65 (3.12)		
Working memory	Experimental	15.43 (4.14)	11.56 (3.34)	5.65	0.17
	Control	14.12 (2.76)	13.65 (3.34)		

behavior analysis program. This finding is not consistent with the research by Baltruschat et al. whose results suggest that behavioral intervention and use of boosters improve the working memory of children with the autism spectrum [20]. Working memory is the ability to maintain information in an information processing position. In order for working memory to work well, it is necessary for the data to be logged in continuously, then processed and stored, so that they can finally be reminded well. Thus remembering needs significant organization and process of information [19]. The working memory system can be affected by brain damages of mentally retarded children, for example, seizures that are uncontrolled, can affect the work memory. Therefore, the damages done to parts of the brain of mentally retarded children in the field of work memory can affect the program of applied behavioral analysis, which should be further investigated in future research. This study has some limitations, for example, the cause of brain damage in a mild to moderate mentally retarded child was out of control, and so the generalization of results is limited. It is suggested that in future research, the impact of applied behavior analysis programs on cognitive components and executive functions of a specific group of mentally retarded children be

investigated.

Conclusion

According to the research findings, the intervention program of the behavioral analysis can improve inhibition and planning executive functions of intellectually disabled children, but it does not affect the working memory of the experimental group. Therefore, an applied behavior analysis program can be used to improve the cognitive status of mild to moderate mentally retarded children in the areas of inhibition and planning.

Acknowledgements

This paper is extracted from Dissertation of F. Demehri with the Ethics Code No. IR.SSU.REC.1398.006 that submitted to Science and Arts University, Yazd, Iran.

We would like to thanks to Mr Amin Mohammadi, the manager of the Rehabilitation Center and the Rehabilitation expert of the Yazd Welfare Organization

Conflict of interest

The authors declared no conflicts of interest.

References

1. American Psychiatric Association. Diagnostic and

- statistical manual of mental disorders (DSM-5®). 5th ed. Washington, DC: American Psychiatric Association; 2013.
2. Maulik PK, Mascarenhas MN, Mathers CD, Dua T, Saxena S. Prevalence of intellectual disability: a meta-analysis of population-based studies. *Res Dev Disabil.* 2011;32(2):419-36. doi: [10.1016/j.ridd.2010.12.018](https://doi.org/10.1016/j.ridd.2010.12.018)
 3. Heslop P, Blair PS, Fleming P, Hoghton M, Marriott A, Russ L. The Confidential Inquiry into premature deaths of people with intellectual disabilities in the UK: a population-based study. *Lancet.* 2014;383(9920):889-95. doi: [10.1016/S0140-6736\(13\)62026-7](https://doi.org/10.1016/S0140-6736(13)62026-7)
 4. Tyrer F, McGrother C. Cause-specific mortality and death certificate reporting in adults with moderate to profound intellectual disability. *J Intellect Disabil Res.* 2009;53(11):898-904. doi: [10.1111/j.1365-2788.2009.01201.x](https://doi.org/10.1111/j.1365-2788.2009.01201.x)
 5. Lee NR, Anand P, Will E, Adeyemi EI4, Clasen LS, Blumenthal JD, et al. Everyday executive functions in Down syndrome from early childhood to young adulthood: evidence for both unique and shared characteristics compared to youth with sex chromosome trisomy (XXX and XXY). *Front Behav Neurosci.* 2015;9:264. doi: [10.3389/fnbeh.2015.00264](https://doi.org/10.3389/fnbeh.2015.00264)
 6. Loveall SJ, Conners FA, Tungate AS, Hahn LJ, Osso TD. A cross-sectional analysis of executive function in Down syndrome from 2 to 35 years. *Journal of Intellectual Disability Res.* 2017; 61(9):877-87. doi: [10.1111/jir.12396](https://doi.org/10.1111/jir.12396)
 7. Carlson SM. Developmentally sensitive measures of executive function in preschool children. *Dev Neuropsychol.* 2005;28(2):595-616. doi: [10.1207/s15326942dn2802_3](https://doi.org/10.1207/s15326942dn2802_3)
 8. Memisevic H, Sinanovic O. Executive function in children with intellectual disability--the effects of sex, level and aetiology of intellectual disability. *J Intellect Disabil Res.* 2014;58(9):830-7. doi: [10.1111/jir.12098](https://doi.org/10.1111/jir.12098)
 9. Pritchard AE, Kalback S, McCurdy M, Capone GT. Executive functions among youth with Down Syndrome and co-existing neurobehavioral disorders. *J Intellect Disabil Res.* 2015;59(12):1130-41. doi: [10.1111/jir.12217](https://doi.org/10.1111/jir.12217)
 10. Jarrold C, Baddeley AD. Short-term memory in Down syndrome: applying the working memory model. *Downs Syndr Res Pract.* 2001;7(1):17-23.
 11. Lanfranchi S, Jerman O, Dal Pont E, Alberti A, Vianello R. Executive function in adolescents with Down syndrome. *J Intellect Disabil Res.* 2010;54(4):308-19. doi: [10.1111/j.1365-2788.2010.01262.x](https://doi.org/10.1111/j.1365-2788.2010.01262.x)
 12. LI Y, WU R, HU X, LI H, Zelazo P D .The development of executive function in deaf children: comparing with normal children]. *Acta Psychology Sinica.* 2006; 38(3):356-64. Chinese.
 13. Willems M, Hilgenkamp TI, Havik E, Waninge A, Melville CA. Use of behaviour change techniques in lifestyle change interventions for people with intellectual disabilities: A systematic review. *Res Dev Disabil.* 2017;60:256-68. doi: [10.1016/j.ridd.2016.10.008](https://doi.org/10.1016/j.ridd.2016.10.008)
 14. Christy Hicks S, Rivera CJ, Patterson DR. Simple steps for teaching prepositions to students with autism and other developmental disabilities. *Interv Sch Clin.* 2016; 51(3):163-9. doi: [10.1177/1053451215585807](https://doi.org/10.1177/1053451215585807)
 15. Sambandam, E, Rangaswami K, Thamizharasan S. Efficacy of ABA programme for children with autism to improve general development, language and adaptive behaviour. *Indian J Posit Psychol.* 2014;5(2):192-5.
 16. Noorani Jurjاده SR, Mashhadi A, Tabibi Z, Kheirkhah F. [Effectiveness of executive functions training based on daily life on executive functioning in children with attention deficit/hyperactivity disorder]. *Advances in Cognitive Science.* 2016;18(1):68-78. Persian.
 17. Madani SS, Alizadeh H, Farrokhi NA, Hakimi Rad E. [Development of an executive functions (response inhibition, updating, sustained attention) program and examining its effectiveness on symptoms amelioration in children with attention deficit/hyperactivity disorder]. *Psychology of Exceptional Individuals.* 2017;7(26):1-25. Persian. doi: [10.22054/JPE.2017.24627.1622](https://doi.org/10.22054/JPE.2017.24627.1622)
 18. Gioia AG, Isguith PK, Guy SC, Kenvorth L. Test review behavior rating inventory of executive function. *Child Neuropsychology.* 2000;6(3):235-8. doi: [10.1076/chin.6.3.235.3152](https://doi.org/10.1076/chin.6.3.235.3152)
 19. Barkley RA. Behavioral inhibition, sustained attention, and executive functions: constructing a unifying theory of ADHD. *Psychol Bull.* 1997;121(1):65-94. doi: [10.1037/0033-2909.121.1.65](https://doi.org/10.1037/0033-2909.121.1.65)
 20. Baltruschat L, Hasselhorn M, Tarbox J, Dixon DR, Najdowski AC, Mullins RD, et al. Further analysis of the effects of positive reinforcement on working memory in children with autism. *Res Autism Spectr Disord.* 2011;5(2):855-63. doi: [10.1016/j.rasd.2010.09.015](https://doi.org/10.1016/j.rasd.2010.09.015)