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Intelligence of Hearing-Impaired Children: An Evaluation Based on Demographic, Educational, and Audiological Characteristics

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Abstract

Studies to determine the intelligence level of children with special needs are performed by Guidance and Research Centers, university research centers, schools, and the relevant clinics of hospitals for a variety of reasons. International occupational organizations describe that gaining an understanding of the intelligence characteristics of hearing-impaired children in different cultures and societies is of critical importance to ensure that specialists and researchers performing intelligence tests can interpret their results correctly. Based on this consideration, the purpose of this study was to demonstrate the intelligence characteristics of hearing-impaired children through comparisons with children with typical development. In addition, I investigated the relationship of the intelligence quotient (IQ) score with basic demographic, educational, and audiological variables, and evaluated whether IQ scores differed according to these variables. The sample of the study consisted of 329 hearing-impaired children in different educational settings within the Eskişehir province. According to the results of the one sample *t*-test performed within the frame of the study's main purpose, the total IQ scores of the hearing-impaired children, as determined by the WISC-R performance sub-tests, were higher than the scores of the standardization sample of Turkey. Pearson correlation analysis indicated that the WISC-R performance sub-tests had a moderate correlation with one another, and a high correlation with IQ scores. Among the different demographic variables, the educational level of both the father and mother had a significant effect on total IQ scores, although the fathers' level of education showed a higher correlation with total IQ than the mothers'. In regards to the audiological variables, the degree of hearing loss did not have a significant correlation with total IQ. Based on the ANCOVA, in which the fathers' level of education as covariate, it was determined that with respect to the gender, male children had higher total IQ scores than female children; and that, with respect to the educational setting variable, children receiving education at the Education and Research Center for Hearing Impaired Children (İÇEM) and in inclusive settings had higher total IQ scores than children receiving education at the Ministry of National

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Education's (MoNE) Elementary Schools for the Hearing Impaired. No significant difference was identified in terms of IQ scores between children using hearing aids and children using cochlear implants. Higher IQ scores were observed for the standardization group during the comparison of Turkey's standardization sample with the hearing-impaired children sample. We believe that this may have been due to the fact that the test's standardization data were somewhat not actual. The study findings indicate that individuals performing intelligence assessments on hearing-impaired children should take into account the socio-economic level of these children's families, as well as the educational setting. Possible recommendations we can make to other researchers include determining the psychometric characteristics of the new version of this test and other non-verbal intelligence tests; conducting norm studies; testing the psychometric characteristics of intelligence tests with groups that have different special needs; and developing tests suitable for the Turkish culture.

Introduction

Although certain researchers claim that there are over 300 cognitive processes (Solso, Maclin & Maclin, 2007), the concept of "intelligence" is still the first concept to come to mind when discussing the subjects of cognitive processes, intellectual processes, cognitive functioning, or mental functioning (Maller, 2003; Maller & Braden, 2011). Intelligence assessments may be required for a variety of reasons in areas such as clinical psychology, educational psychology, developmental psychology, psychiatry, neurology, forensic science, social services and education (Braden, 2001; Flanagan & Harrison, 2012). The main educational environments in which intelligence assessments are performed include general education settings, and often special education settings. In general education settings, intelligence tests are mainly performed to the determine whether learning problems observed in students are related to underlying intelligence-related problems; to guide students identified as having low intelligence levels to special education programs; and to determine the relationship between intelligence tests and academic performance (Watkins, Lei, & Canivez, 2007; Yen, Konold, & McDermott, 2004). School psychologists in the United States apply approximately 1.8 million intelligence tests every year; this number becomes even higher when tests performed by clinical psychologists are also considered. It is claimed that over five million children have been directed towards special educational programs following the application of intelligence tests (Kamphaus, Petoskey & Rowe, 2000).

In a manner similar to general education, intelligence assessments for individuals with special needs are performed for purposes such as determining the eligibility of children to special education; for examining the children's developmental course during educational process; for determining the relationship of intelligence test results with other cognitive processes, academic and social skills, and demographic variables; for understanding the relationship between learning problems and intellectual capacity; for reflecting assessment results to educational programs; and for occupational guidance (Braden, 2001; Kauffman & Landrum, 2013). Groups with special needs where intelligence assessments are the most required include individuals with intellectual disabilities (Armstrong, Hangauer and Nadeu, 2012); individuals with autism spectrum disorder (Klinger, O'Kelley, Mussey, Goldstein & Devries, 2012); individuals who are gifted (McIntosh, Dixon and Pierson, 2012); individuals with learning disabilities (Soysal, Koçkar, Erdoğan, Şenol & Gücüyener, 2001); individuals with emotional-behavioral disorders (Kauffman and Landrum, 2013); and children with hearing-impairment (Maller & Braden, 2011).

Intelligence Studies in Hearing-Impaired Children: Past and Present

The most studied subject in the education of hearing-impaired individuals after literacy skills has been the cognitive processes involved in memory and intelligence (Marschark, Sapere, Convertino, Mayer, Wauters & Sarchet, 2009). The first intellectual assessment was developed in 1889 in the United States by Greenberger, who created this assessment tool in order to identify children with intellectual disabilities in schools for the deaf, as they were then known. However, it is reported that this tool was not standard, and that is more an informal tool reminiscent of intelligence tests (Ergenç, 1995). It is known that the first formal intelligence assessment was performed by Pintner and Patterson by using the Stanford-Binet Intelligence Scales (Vernon, 2005). Within the scope of her doctorate thesis on the subject of intelligence among hearing-impaired individuals, Tayrose (2011) recently screened all empirical articles and doctorate theses that have been published in peer-reviewed journals (screened by international indices) ever since standard intelligence tests were first used, and identified a total of 894 studies. When articles, postgraduate theses, unpublished project reports, and studies in national peer-reviewed journals published since 2011 are considered as well, it can be clearly observed that foreign researchers are highly interested in studies assessing intelligence among hearing-impaired children (Bakhiet, Barakat & Lynn, 2014; Philips, Wiley, Barnard & Meinzen-Derr, 2014).

In this context, it becomes necessary to answer the question, "Why are intelligence assessments important for specialists working on the education of hearing-impaired children?" The *first reason* for this is to perform comparisons between the intelligence levels of children with typical development and children with hearing-impairments, and to thereby obtain information regarding their intellectual functioning (Braden, 1985, 1994, 2001; Marschark, 2003, 2006). The *second reason* is because among children with typical development, intelligence is considered as the most important predictor of academic performance – in fact, it is sometimes claimed that the concepts of intelligence and academic performance are nearly synonymous (Watkins et al., 2007). Researchers are thus interested in discovering whether such a relationship between "intelligence and academic performance" is also applicable for hearing-impaired children (Karasu, 2011; Vernon, 2005). The *third reason* is based on the view that knowing the intellectual level of hearing-impaired children is important when developing individualized educational programs for them (Braden, 1991, 2001; Maller & Braden, 2011). Because preparation of all individualized educational programs are based on the performance and the learning speed of the child. The *fourth reason* is to allow intelligence test results to be used when making decisions concerning the placement of hearing-impaired children in different educational settings (Braden, 1994; Wood & Dockrell, 2010). The *fifth reason* is associated with the fact that intelligence tests are an important data source for the identification of additional disabilities and learning problems commonly observed among hearing-impaired children (Guardino, 2008; Soukup & Feinstein, 2007). The *sixth reason* is because intelligence tests are used as basic indicators of cognitive level during the suitability evaluations performed prior to surgeries for cochlear implants, which are also known as "bionic ears," and have become particularly widespread within the past 20 years. In addition, efforts to understand the role of cognitive factors in the developmental course observed following implantation also necessitates that an intelligence assessment is performed beforehand (Edwards, Frost & Witham, 2006). *Finally*, intelligence assessment can be useful in following and monitoring the general development of a hearing-impaired child (Remine, Brown, Care & Richards, 2007).

It is possible to state that these reasons for performing intelligence assessments are largely in parallel with the studies performed on hearing-impaired children to assess intelligence. One of the most commonly researched subjects in the literature is whether the intelligence level of hearing-impaired children is different from that of children with typical development (Braden, 1994; Vernon, 2005). It is generally described that studies on intelligence have passed through four stages since Pinter and Patterson's first studies in 1915 (Marschark, 2003, 2006). These four stages were associated with the following views about hearing-impaired children: (1) Their level of intelligence is behind that of normal-hearing children of the same age [1889 to 1965], (2) They think more concretely than children of the same age [1965 to mid-1980s], (3) They are not any different than children of the same age [second half of the 1980s to early 2000s], and (4) Being different from children of the same age is not a deficiency [2000 onwards]. Vernon (2005) previously performed a meta-analysis of 37 studies conducted between 1915 and 1965 to determine the level of intelligence of hearing-impaired children, and changed the general views that had been held until then. Vernon reported that while the intelligence level of hearing-impaired children was determined to be lower than that of normal-hearing children in all studies conducted between 1915 and 1928, a few of the studies conducted from 1928 to 1965 described no significant difference between the two groups. Vernon also noted that studies until 1965 commonly used verbal intelligence tests, and that hearing-impaired children were generally described as being 2 to 5 mental developmental years behind normal-hearing children of the same age. The most striking finding of Vernon's study was his observation that researchers regularly working with hearing-impaired children reported less of a difference between these two groups. At the time, other researchers interpreted such reports as an indication of "bias." During the 20 years between 1965 and the 1980s, the view that the IQ scores of hearing-impaired children were no different than that of children with typical development, and that hearing-impaired children have a more concrete way of thinking, gradually began to take hold and gain general acceptance (Maller, 2013; Maller & Braden, 2011). In the second half of the 1980s, with the influence of Braden's (1985a, 1985b, 1989, 1991, 1994, 2001) studies, the view that there are no differences between hearing-impaired children and normal hearing children of the same age began to be widely accepted. Studies performed during this period mainly used the performance sub-tests of the Wechsler scales, and reported no differences between hearing-impaired and normal hearing groups (Moores, 2001). After 2000, Braden & Marschark et al.'s views that there can be quantitative and qualitative differences between hearing-impaired children and children with typical development in terms of their intellectual processes, these differences are only natural, and that these differences do not necessarily reflect a deficiency began to gain general acceptance (Braden & Maller, 2011; Marschark, 2003, 2006; Marschark & Hauser, 2008).

Due to the heterogeneous nature of hearing-impaired children, the reasons for the differences in these children's intelligence levels began, over time, to be investigated in demographic variables such as gender, age, education level of parents, and whether the parents are also hearing-impaired (Phelps and Ensor, 1997; Slate and Fawcett, 1996); in educational variables such as the educational setting, and communication mode (Paquin & Braden, 1990); and in audiological variables such as the degree of hearing loss, and the type of technology used to aid hearing (Hashemi & Monshizadeh, 2012; Maller, 2003; Phelps & Ensor, 1997). In the study they conducted on 47 hearing-impaired children by using the Wechsler Performance Scales, Slate and Fawcett determined that the scores of male children were significantly higher compared to female children in four of the five subtests. On the other hand, in a study conducted on 106 participants using the same assessment tool, Phelps and Ensor observed no significant differences in intelligence scores with respect to gender. In a study they conducted on 142 children, Paquin and Braden observed that hearing-impaired children of lower socio-economic status who attend residential schools had lower scores than hearing-impaired children who attended day schools. Phelps and Ensor, on the other hand, reported no differences between the intelligence test scores of children attending residential schools and inclusive settings. The degree of hearing loss, which is one of the audiological variables, was reported to have no effects on intelligence test results (Maller & Braden, 2012). Furthermore, comparisons between hearing aids and cochlear implants – two types of technologies that assist hearing – have shown differences in favor of cochlear implants, although the difference between these two technologies was not statistically significant (Hashemi & Monshizadeh, 2012). In sum, studies have generally demonstrated that the degree of hearing loss has no effect on children performance IQ scores; that the parents' education level has a definite effect on IQ scores; and that additional studies are necessary before being able to make generalizable statements concerning the effects of other variables (Maller, 2003; Marschark, 2006).

Parallel to the results of the studies described above, there are also ongoing discussions regarding the procedural approaches that should be employed in studies assessing the intelligence of hearing-impaired children (for the details of these discussions, see Braden, 1994). Two of these discussions are particularly obvious, which can be summed with the following questions: (1) "Should the intelligence assessments make use of general norms or specific norms?" (2) "Should the intelligence assessments make use of verbal or non-verbal tools?" Regarding the first discussion, Braden (1984, 1985a, 1985b) previously suggested that tests performed on groups with typical development and hearing-impairment assessed the same cognitive structures, and that the intelligence tests applied to these groups generally have similar factor structures. Braden therefore argued that the most suitable approach for assessing intelligence is to utilize instruments with general norms, based on the sample of children displaying typical development (on condition that the instructions of these instruments are adjusted according to the level of hearing-impaired children during their use). Phelps and Branyan (1988), on the other hand, opposed Braden's view on grounds that, although tests developed for children with typical development generally assess the same structures, they also bear the risk of displaying the intellectual capabilities of hearing-impaired children as being deficient. Concerning the second area of discussion, it is possible to state that a consensus has generally been reached on this subject, minus a few exceptions. As an example of such an exception, it is held that the verbal sections of intelligence tests can be used when assessing the verbal skills of children with cochlear implants (Remine et al., 2007). Aside from such exceptions, since the main purpose of intelligence tests is to determine the general intellectual capacity rather than verbal skills, it is generally recommended that either non-verbal intelligence tests, or the performance sections of intelligence tests – which do not require verbal skills – should be used in order to avoid the problems and negative results associated with the language deficiency of hearing-impaired children (Braden, 2001; Braden & Athanasiou, 2005; Maller & Braden, 2012). Although there are numerous non-verbal tests for hearing-impaired children (Krivitsky, McIntosh, Rothlisberg & Finch, 2004) the most commonly used and researched one is the Wechsler Scale's performance sub-tests (Krouse & Braden, 2011; Zhu & Weiss, 2005).

As described above, the intelligence characteristics of hearing-impaired children, as well as the relationship of intelligence with demographics, educational, and audiological variables and academic skills, have been researched in the Western world, especially in the United States, for over 100 years (Tayrose, 2011). On the other hand, we identified no studies in Turkey directly investigating the intelligence characteristics of hearing-impaired children, or attempting to explain the relationship of intelligence with other variables. In the available national literature, we found that only a single study evaluated the predictive power of intelligence, along with many other variables, in predicting hearing-impaired children's ability to read (Karasu, 2011), while another study used intelligence scores as a control variable when comparing the temporary memory processes of hearing-impaired and normal-hearing children (Doğan, Tüfekçioğlu & Er, 2013).

Purpose of the Study

The intelligence level of children with special neEds are assessed by Guidance and Research Centers, university research centers, schools, and the relevant clinics of hospitals for a variety of reasons. For specialists performing such assessments, having knowledge of the intelligence characteristics of children in different cultures and societies could be an important step in preventing these specialists from viewing the tests results solely as a numerical value, and to thereby make incorrect decisions by interpreting them erroneously (American Educational Research Association [AERA], American Psychological Association [APA], and National Council on Measurement in Education [NCME], 1999). Thus, it is possible to state that services that will be provided to hearing-impaired children must be based on assessments that that properly reflect the real level and characteristics of these students. In this context, the purpose of this study was to demonstrate the intelligence characteristics of hearing-impaired children through comparisons with children with typical development. In addition, the study also aimed to determine the relationship of the IQ score with basic demographic, educational, and audiological variables, and to evaluate whether IQ scores differed according to these variables. The study sought to answer the following questions:

1. When the scores of the children with hearing impairments were compared to the scores of children exhibiting typical development who constituted the standardization sample, were there any significant differences between the groups with regards to their intelligence levels as measured by the Wechsler Intelligence Scale for Children-Revised [WISC-R] performance sub-tests?
2. Was the WISC-R performance sub-test scores of hearing-impaired children correlated with the total IQ scores and the demographic, audiological, and educational variables?
3. When the education level of the parents was statistically controlled; did the intelligence levels of the hearing-impaired children as measured by the WISC-R Performance sub-tests differ according to demographic, audiological, and educational variables (gender, educational setting, and hearing assistive technology)?

Methods

Study Design

This study was conducted based on the quantitative study design, which involves comparisons between groups when considered based on the study conditions, and a factorial design when considered based on to the number of independent variables whose effects on the dependent variable were examined (Büyüköztürk, 2010). As the second research question focused on the relationship between the variables, it did not have any associated dependent or independent variables. For the first research question, the independent variable was the hearing status (data from the hearing-impaired children and standardization sample); for the third question – where the education level of the parents were also examined – the independent variables were gender, educational setting, and hearing assistive technology. The dependent variable was the intelligence level. Since it is known to conceptually and empirically have important effects on intelligence (Maller & Braden, 2011), the level of education of the parents was considered as a covariate. As emphasized in the standardization data as well (Savaşır & Şahin, 1995), the education level of the father has a stronger correlation with intelligence (see Table 3).

Participants

The participants included a total of 329 hearing-impaired students attending the Anadolu University Research Center for Hearing Impaired Children (İÇEM, n = 177), schools applying the inclusive education (n = 103), and the MoNE-Elementary School for the Hearing Impaired (n = 48). Detailed information regarding the participations are shown in Table 1.

As shown in Table 1, 53.8% of the participants attended İÇEM, 31.3% attended inclusive schools, and 14.4% attended elementary school for the hearing impaired, which are affiliated with the MoNE. The gender distribution of the participants appeared to be balanced, with 46.8% of the participants being female, while 53.2% were male. The ratio of students using hearing aids was higher than the ratio using cochlear implants. More than half of the participants had profound hearing loss; in terms of frequency, profound hearing loss was followed by severe and moderate hearing loss. Most of the parent had elementary, middle, and high school level education, with fathers generally having higher education than the mothers. The age average of the children ranged between 6 years and 16 years 6 months, with the mean age being 10 years 10 months (SD = 2.7). The mean level of hearing in the good hear was 96.23 (SD = 18.07) dB.

All of the study participants met the following inclusion criteria: (a) Having at least mild hearing loss, such that they can be considered as being hearing-impaired (the hearing-impaired children included into the study had at least moderate hearing loss), (b) In the presence of additional disabilities or problems in the child, the hearing-loss should represent the primary disability, with the child attending a formal education institution providing education for hearing-impaired children (Krouse & Braden, 2011), (c) Being between the ages of 6 years and 16 years 6 months – the age range for the WISC-R, and (d) Visual or movement-related difficulties independent intellectual functioning that might affect the participant's test performance.

Table 1. Participant Characteristics (*N* = 329)

Categorical Variables		
Characteristics	***n***	**%**
Gender		
Male	154	46.8
Female	175	53.2
Educational setting		
İÇEM	177	53.8
Inclusion	103	31.3
MoNE-School for the Deaf	48	14.6
Assistive device		
Haring aid	225	68.4
Cochlear implant	102	31.0
Unknown	2	0.6
Degree of hearing loss		
Moderate [41-70 dBHL]	39	11.9
Severe [71-95 dBHL]	86	26.1
Profound [96+ dBHL]	196	59.6
Unknown	8	2.4
Education levels of parents*		
No formal education	19/2	6.7/0.7
Primary school	146/95	44.4/28.9
Secondary school	22/35	6.7/10.6
High school	80/98	24.3/29.8
University	16/53	4.9/16.1
Unknown	46/46	14/14
Continuous Variables		
Characteristics	***M***	***SD***
Age (years; months)	10;10	2;7
Hearing level-better ear (dBHL)	96.23	18.07
Mothers' education (years; months)	7;3	3;7
Fathers' education (years; months)	9;10	3;8

Note. İÇEM = Education and Research Center for Hearing-Impaired Children, dBHL = decibel Hearing Level,
*First number in the rows is for the mothers, second is for the fathers.

Data Collection Tools

Participant Information Form: With this form consisting of 15 items, the researcher determined and recorded the characteristics of the study participants, including their demographic (age, gender, mother's education level, father's education level, and income level of the family), educational (formal education institution attended and current grade), and audiological (hearing assistive technology used, level of hearing in both ears, and degree of hearing loss) characteristics. When completing the Participant Information Form, the researcher made use of the parent meetings performed before applying the study tests; the meetings performed with the children; the demographic and educational information written on the WISC-R forms; and the school and audiological dossiers of the students.

WISC-R: To date, four versions of the Wechsler Intelligence Scale for Children (WISC-R) have been developed: the WISC (1949), WISC-R (1974), WISC-III (1991), and WISC-IV (2003) (Prifitera, Saklofske, Weiss & Rolphus, 2005). The WISC-R used in this study is the second version of this series. It is the most commonly used and studied intelligence scale for individuals between the ages of 6 years and 16 years 6 months (Zhu & Weiss, 2005). The WISC-R consists of two sections: verbal and performance. Each section has six sub-tests, with one of these sub-tests being optional. The scale thus has a total of 12 sub-tests. The verbal section of the scale has the General Knowledge, Similarities, Arithmetic, Vocabulary, Comprehension, Digit Span, and Letter-Number Sequencing (optional) sub-tests. Performance subscales and their contents are as follows: *Picture Completion* (focusing, visual vigilance, differentiating the needed from unneeded, attention to details, memory), *Picture Arrangement* (interpretation of social situations, planning skills, perceptual organization, reasoning, prediction of social processes), *Block Design* (perceptual organization, synthesizing, visual-motor coordination, trial and error learning, three dimensional thinking), *Object Assembly* (perceptual organization, piece-whole patterns, trial and error learning, insight, intuition), *Coding* (visual-motor coordination, speed of cognitive processing, adaptation to novel situations, short term memory, fine motor skills) and Mazes (optional). The mean of the WISC-R total IQ score is 100, while its standard deviation is 15. The mean for the sub-test scores is 10, while their standard deviation is 3 (Anastasi and Urbina, 1997). The adaptation and standardization studies of the scale for Turkish culture was performed with 1639 children. Although the standardization data were collected in 1980, the standardization analyses and the preparation of the handbooks was completed in 1995. The researchers describe that the psychometric characteristics of the WISC-R Turkey standardization are, in certain respects, even stronger than the original scale. The reliability coefficient of the total intelligence quotient point is 0.98. The reliability coefficient calculated using the split-half method was 0.98 for the verbal quotient, 0.96 for the performance quotient, and 0.98 for the total intelligence quotient (IQ). For the sub-tests, the reliability coefficients based on the split-half method was 0.88 for picture completion, 0.86 for picture arrangement, 0.92 for block design, 0.77 for object assembly. The reliability coefficient for the coding sub-test could not be calculated (Savaşır & Şahin, 1995). Based on the performance sub-tests, it is possible to calculate the performance IQ score and the total IQ score. The sub-tests in the performance section evaluate different intellectual characteristics of intelligence (Anastasi & Urbina, 1997; Braden, 1994; Savaşır & Şahin, 1995).

In this study, the reasons for using the WISC-R Performance Section can be listed as follows: (a) the test is the most commonly used and studied assessment instrument both for children with typical development and hearing-impaired children (Braden, 2001; Zhu and Weiss, 2005); (b) the test's reliability and validity characteristics are fairly strong, and its factor structure is similar to that of the standardization sample (Braden, 1984); (c) at the time this study was performed, this test is the only widely used and comprehensive intelligence scale whose sample standardization had already been performed on a sample in Turkey (Savaşır & Şahin, 1995); and (d) the sub-tests of the WISC-R Performance Section do not require verbal skills.

Application

The data of this study were obtained from the results of WISC-R scales routinely administered between 2002-2014 to children applying for formal education at İÇEM; to children receiving education at İÇEM (as part of their routine assessments); and to children being evaluated for suitability for cochlear implant surgery. In addition, we have also used the results of tests applied to students at the MoNE Elementary School for the Hearing Impaired. Informed consent was obtained from the children's parents after they were informed that the test results would be used solely for research purposes, and that individual test results would remain confidential under all circumstances. The administration of the WISC-R performance sub-tests lasted between 30 to 60 minutes. The scale were administered in a room with as little stimuli as possible. Vernon (2005) describes that those administering intelligence tests to hearing-impaired children must have prior experiences with these children, and that otherwise the validity of these assessments would be questionable. In the current study, all tests were administered by the article's author, who has 15 years of working experience with hearing-impaired children, as well as a WISC-R Administration and Interpretation Certificate.

Data Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS 20.00). The first type error probability used in the analyses was $p \leq .05$. While this acceptance ratio was considered as the upper level of the error probability, significance levels of $p \leq .01$ were also considered with regard to lower error probabilities. Within the frame of the general study purpose, for the first study question, the one sample *t*-test was performed in order to compare the intelligence levels of hearing-impaired children and the standardization samples. For the second study question, the Pearson Product-Moment Correlation coefficient was calculated in order to determine the relationships between the main variables of the study. For the third study question, the one-way analysis of covariance (ANCOVA) was used in order to determine whether basic demographic, educational and audiological variables (gender, education level, and hearing assistive technologies) had any effects on the level of intelligence. In this analysis, the education level of the father was considered as a covariate. In all analyses, the total IQ score obtained from the standard points of the sub-tests in the WISC-R performance was considered as the indication of intelligence level. The effect size was calculated in all intergroup comparisons.

Results

Preliminary Analysis

At this stage, we determined whether the data control and analyses satisfied the assumptions. We first verified whether the data had been entered correctly into the statistics program, by visually examining the data files and reviewing the basic descriptive statistics. As a result of this evaluation, erroneously coded data were corrected, and all values outside the series were removed. Lost values were identified, and their reasons were evaluated. As none of the participants has a missing data greater than 5%, none of the participants were removed from the analysis (Tabachnick & Fidell, 2001).

In the second stage, we test the assumptions of the analyses. As satisfying the ANCOVA's assumptions also satisfied the assumptions of the *t*-test and Pearson's correlation analysis (Field, 2005), only the ANCOVA's assumptions were tested. These assumptions were: (1) the dependent variable and covariate have a linear correlation in all groups; (2) the equality of regression slopes; and (3) the group scores have normal distribution and equal variance (Büyüköztürk, 2010). In this study, a positive correlation was observed between total IQ scores and the father's level of education (a covariate in all groups) (between $r = 0.20$ and 0.32, $p < .05$), while the appearance of the scatter graphs showed that the relationship between the covariate and dependent variable was linear. To evaluate the assumption concerning the equality of regression slopes, the interaction of the dependent variables (which include the educational setting, gender, and hearing assistive technologies) with the covariate (the father's level of education) was assessed, and it was determined that the interaction between these was significant under all circumstances [$F_{edu..setting}$ (1. 277) = 1.65, F_{gender} (1.279) = 0.79; $F_{hear.asst.tech.}$(1.278) = 2.74; $p > .05$ for all comparisons]. Therefore, the assumption concerning the equality of the regression slops was satisfied. Finally, the kurtosis-skewness values in all groups was between -1 and +1, which indicated that the data has normal distribution. In addition, the results of the Levene test were not significant, which indicated that the variances were not homogenous (Field, 2005). It was thus determined that the data satisfied all assumptions, and were ready for analysis.

Comparison of Hearing-Impaired Children with the Standardization Sample

For the first study question, the single sample *t*-test was applied to compare the WISC-R total IQ scores of the hearing-impaired children and the standardization sample. The descriptive values of the WISC-R total IQ scores and the *t*-test results are shown in Table 2.

Table 2. Descriptive statistics for WISC-R total IQ scores by groups and *t*-test results

Sample	*N*	*M*	*SD*	Mode	Median	*df*	*t*	Cohen's *d*
Turkish standardization [a]	1639	100	15	100	100	328	7.54**	.45
Hearing-Impaired (this study's sample)	329	107	16	107	108			

Note. [a] Values of Turkish standardization sample were derived from Savaşır and Şahin (1995). $^{**}p < .01$.

As shown in Table 2, the WISC-R total IQ scores displayed a small size of effect and significant differences between the groups [t (328) = 7.54, $p < .01$, Cohen d = 0.45]. As such, the IQ scores of hearing-impaired children (M = 107) was higher than that of the standardization sample for Turkey (M = 100). According to the Cohen's *d* value, the difference was approximately 1/2 SD.

The Relationship of the WISC-R Total IQ Scores with the Demographic and Audiological Variables

Within the frame of the second study question, we investigated the correlation of the hearing-impaired children's WISC-R performance sub-test scores with one another and the total IQ scores, as well as the correlation of these scores with the basic demographic, audiological, and educational variables. The values calculated using the Pearson's product-moment correlation coefficient are provided in Table 3.

As shown in Table 3, the correlation between the WISC-R Performance sub-tests was significant, ranging between 0.35 and 0.58 ($p < .01$). The correlation of all sub-tests with the performance IQ and total IQ was between 0.72 and 0.78 ($p < .01$), which was considerably high. Of the important demographic variables, age had a negative correlation will all sub-tests except for coding (r = -0.16 to -0.22, $p < .01$). The education level of the mother and father were highly correlated (r = 0.55, $p < .01$). The WISC-R total score showed higher correlation with the father's education level (r = 0.31, $p < .01$) than with the mother's education level (r = 0.19, $p < .01$).

Table 3. Correlations of WISC-R 34total IQ with performance subtests scores and demographic and audiological variables

Variables	*N*	*M*	*SD*	2	3	4	5	6	7	8	9	10	11
1 Age	329	10;10	2;7	-.04	-.16**	-.11	-.16**	-.24**	-.17**	-.17**	-.10	-.22**	-.22**
2 Hearing level [dB]	321	96.23	18.07		.15*	.06	.09	.13*	.05	.11*	.08	.13*	.13*
3 Mothers' educ.	284	7;3	3;7			.55**	.18**	.15*	.13*	.21*	.08	.18**	.19**
4 Fathers' educ.	284	9;10	3;8				.24**	.22**	.25**	.27**	.22**	.29**	.31**
5 PC-Subtest	329	11.63	2.63					.58**	.49**	.54**	.35**	.72**	.75**
6 PA-Subtest	323	10.28	2.86						.43**	.51**	.35**	.72**	.73**
7 BD-Subtest	329	11.00	3.12							.57**	.46**	.75**	.78**
8 OA-Subtest	329	11.41	2.56								.43**	.75**	.78**
9 Coding-Subtest	329	10.37	3.55									.72**	.72**
10 Performance IQ	329	54.41	11.60										.97**
11 Total IQ	329	107	16										

Not. dB = decibel, PC = Picture Completition, PA = Picture Arrangement, BD = Block Design, OA = Object Assembly, $^{*}p < .05$, $^{**}p < .01$.

The Effect of Gender, Educational Setting, and Hearing Assistive Technologies on Intelligence Level

Within the frame of the third study question, we separately applied the ANCOVA to each dependent variable in order to determine whether the WISC-R total IQ score varied according to gender, educational setting, and the type of hearing assistive aid being used. The father's education level – an important factor in hearing-impaired children's intelligence level – was considered as a covariate in these analyses. The effect of size was not calculated for the dependent variables, for reason that the number of participants was not sufficient in some of the sub-groups (for example, there were no students using cochlear implants in the MoNE Elementary Schools for the Hearing Impaired). The descriptive statistics of the IQ scores with respect to the independent variables are shown in Table 4, while the ANCOVA results are shown in Table 5.

Table 4. Descriptive statistics for WISC-R total IQ scores by groups

Independent variable	Group	*N*	*M*	*SD*	Corrected Mean	Stand. error
Gender	Male	135	103.64	16.12	104	1.27
	Female	148	108.15	15.16	108	1.21
Educ. settings	İÇEM	172	109.45	14.89	108.59	1.25
	Insclusion	94	106.76	13.72	106.26	1.52
	School for the Deaf	47	95.80	18.09	99.39	2.31
Assistive devices	Hearing aid	196	105.03	16.15	105.44	1.06
	Cochlear implant	86	109.23	14.73	108.28	1.61

Not. İÇEM = Education and Research Center for Hearing-Impaired Children

Table 5. ANCOVA of WISC-R total IQ scores for the groups of gender, educational settings, and assistive devices

Independent Variable	Source	*df*	SS	MSS	*F*	Partial η²	Power
Gender	Fathers' educ.	1	7214	7214	32.87**	.10	1.00
	Gender	1	1351	1351	6.15*	.03	.70
	Error	280	61437	219			
	Total	283	3267871				
Educ. settings	Fathers' educ.	1	3579	3579	16.56**	.06	.98
	Educ. setting	2	2508	1254	5.80**	.04	.87
	Error	279	60280	216			
	Total	283	3267871				
Assistive devices	Fathers' educ.	1	7225	7225	32.43**	.10	1.00
	Assistive devices	1	475	475	2.13	.01	.30
	Error	279	62153	222			
	Total	282	3257670				

Note. SS = Sum of Squares, MSS = Mean Sum of Squares. *$p < .05$, **$p < .01$.

The fathers' education level, which is a covariate, was found to have a moderately-effect sized and significant relationship with all of the dependent variables [F_{gender} (1.280) = 32.87, $p < .01$, partial η^2 = 0.10; $F_{edu.setting}$ (1.279) = 16.56, $p < .01$, partial η^2 = .06; $F_{hear.asst.tech.}$ (1.279) = 32.43, $p < .01$, partial η^2 = 0.10].

The ANCOVA results are described below for each dependent variable:

Gender. When the education level of the father was taken into account, the difference between the IQ score of female children and male children was significant with a low size of effect [F (2, 280) = 6.15, $p < .05$, partial η^2 = .03]. As such, in the corrected mean and standard deviation values formed by taking into account the father's education level and shown in Table 5; male children had significantly higher IQ scores (corrected mean = 108) than female children (corrected mean = 104).

Educational Setting. When the education level of the father was taken into account, the difference between educational settings with respect to total IQ scores was found to be significant with a small size of effect [$F(2.279) = 5.80$, $p < .01$, partial $\eta^2 = .04$]. According to Bonferroni test results based on the mean and standard deviation values corrected by taking the father's education level into account (see Table 5); the difference for the two comparisons was significant. As such, the IQ scores of both the İÇEM students (corrected mean = 108.59) and the Inclusion students (corrected mean = 106.26) was significantly higher than that of the students at the MONE Elementary Schools for the Hearing Impaired (corrected mean = 99.39). However, the difference in student IQ scores between the first two of these educational settings (İÇEM and the inclusive settings) was not significant.

Type of Hearing Assistive Technology. When the education level of the father was as covariate, no significant difference was identified in terms of total IQ scores between children using hearing aids and children using cochlear implants [$F(2.279) = 2.13$, $p > .05$, partial $\eta^2 = .01$].

In sum, the ANCOVA results indicated that, with regards to the gender and educational settings, and when the father's education level was controlled and taken into account, male students had higher total IQ scores than female students, while children receiving education at İÇEM and inclusive settings had higher total IQ scores than children receiving education at MoNE Elementary Schools for the Hearing Impaired. No significant difference was identified between children using hearing aids and children using cochlear implants with respect to IQ scores.

Discussion

The purpose of this study was to demonstrate the intelligence characteristics of hearing-impaired children through comparisons with children exhibiting typical development, and also to investigate the relationship of the intelligence quotient (IQ) score with basic demographic, educational and audiological variables, and whether IQ scores differed according to these variables. According to the obtained results, the hearing-impaired children constituting the study sample had a higher intelligence level as measured by the WISC-R performance sub-tests ($M = 107$, $SD = 16$) than this test's standardization sample for Turkey ($M = 100$, $SD = 15$). This finding appears to be in agreement with the results of a previous study performed by Remine et al. (2007) on a small sample of hearing-impaired children in Australia. The researchers divided 37 hearing-impaired children into two groups as those with suitable language development ($n = 18$) and those with delayed language development ($n = 19$), and reported that the mean WISC-III score for the former groups was 116, while the score for the latter group was 97; in the same study, the mean score for the general sample was 106. The study hence determined that the mean score of the hearing-impaired children was higher than that of the standardization sample. The most important difference of the present study from that of Remine et al. was the study sample size. The similarity between these two studies is that they did not use the latest version of the Wechsler scale. When tested with different versions of the Wechsler scale, hearing-impaired children tend to have higher scores in the older versions. For example, Slate and Fawcett (1995) administered the WISC-R as well as the 1991 versions of the scale to 47 hearing-impaired children, and observed that the children's mean WISC-R scores were 3.8 points higher.

The scores obtained using the WISC-R performance sub-tests serve as an indication of children's non-verbal intellectual skills (Braden, 1994, 2005; Ortiz, Ochoa & Dynda, 2012). The findings described above might initially suggest that "the non-verbal, visual-based skills of hearing-impaired children is more developed than those of normal-hearing individuals." However, in a previously conducted detailed study, Bavelier, Dye and Hauser (2006) claimed that this view, which has limited scientific support, will remain open to argument for a long time. Since 1974, the year the WISC-R was developed in the United States, various studies have demonstrated that normally developing children and hearing-impaired children displayed similar performance with regards to their non-verbal intellectual skills (Braden, 1994; Vernon, 2005). Therefore, attempting to interpret the findings above as "the non-verbal intellectual skills of hearing-impaired students is better than those of children displaying typical development" would be erroneous and inadequate. The WISC-R is the second version of the Wechsler Intelligence Scale, which is currently in its fourth version in the Western world (Prifitera et al., 2005). It is also the only comprehensive intelligence test for which standardization has been performed in Turkey. The standardization data of the test were collected in 1980 (Savaşır & Şahin, 1995). According the phenomenon known as the "Flynn effect," whose validity has been researched in many cultures, the intelligence test scores obtained by individuals gradually increase over the years by a certain level (by 3 points every 10 years.) (Flynn, 2013). Whether this effect is also applicable for hearing-impaired children has only been studied in Saudi Arabia with a large sample (N = 302); this study reported an annual 0.31 annual increase in the intelligence scores of hearing-impaired children (Bakhiet, Barakat & Lynn, 2014). We identified no studies in Turkey evaluating whether intelligence test scores increase over the years among children displaying typical development and hearing-impaired children. However, if the Flynn effect reported by Flynn for typical children and by Bakhiet et al. (2014) for hearing-impaired children was valid for children in Turkey, it could then have been expected that the children displaying typical development would have had a score average of approximately 109 at the time of the test. This might have removed the difference currently observed between the two groups. Until the time when study results demonstrating the Flynn effect for children in Turkey are published, it would be best to approach this interpretation cautiously. In other words, it is very possible that had the children displaying typical development – with which the hearing-impaired children were compared – not been based on the standardization sample data obtained in 1980, but instead on samples and data collected today, there might have been no differences between the hearing-impaired and typical development groups of our study.

Within the frame of the second study question, we investigated the correlations between the basic variables. Based on our analysis results, we determined that, as expected, the correlation between the WISC-R performance sub-tests with one another, with the total performance IQ score and the total IQ score was significant. These results supported the validity of the test for the evaluated sample. This finding is in agreement with the results of all studies evaluating the psychometric characteristics of Wechsler scales (Braden, 1984, 1985a, 1989; Krouse & Braden, 2011; Phelps & Branyan, 1988; Slate & Fawcett, 1995; Sullivan & Montoya, 1997). It was determined that age, which is one of the demographic variables, had a significant negative correlation with all of the WISC-R performance sub-tests with the exception of "coding." This finding, which is somewhat interesting, appears to support Flynn's (2013) view that the scores obtained in intelligence tests tend to increase over the years. If we can assume that older students are closer to the time when the standardization data were collected, while younger students are more distant; and that, as claimed by Flynn, the scores obtained in intelligence tests tend to increase as we approach present times; we can then state that the study data appears to support Flynn. However, making such generalizations without sufficient study findings would be too hasty and somewhat baseless. The absence of a correlation between age and the coding sub-test might have been associated with the characteristics assessed by this sub-test. One of the most important cognitive skills assessed by the coding sub-test is short-term memory (Anastasi & Urbina, 1997). It is described that the development of short-term memory, and especially of short-term visual memory, takes place at an earlier age than the other cognitive processes (Gathercole, Pickering, Ambridge and Wearing 2004). The sample of this study consisted of children between the ages of 6 and 16, and did not include children of small age; this might have been the cause of the lack of correlation between age and the coding sub-tests that assesses short-term memory.

In this study, the educational levels of the mother and father were, as expected, found to be highly inter-correlated. However, when the relationship of each one of these parameters with the total IQ score was evaluated, it was determined that the father's education level showed a greater correlation with the total IQ score than the mother's education level. This finding is in agreement with the results of the standardization study. For this reason, during the standardization study, the father's education level, rather than the mother's level of education, was taken into account as the indicator of socio-economic level (SES). The SES based on the father's education level had a considerable effect on the IQ scores, such that, for example, 10-year-old children of upper SES, middle SES, and lower SES had a scores of 108, 105, and 94, respectively (Savaşır & Şahin, 1995). This serves to explain why the father's education level was controlled and taken into account in this study when evaluating the changes in IQ scores with respect to gender, educational setting and the type of hearing assistive technology being used. One the other hand, it appears that the mothers' level education had a limited relationship with intelligence scores because many of the mothers had lower levels of education; thus, the mothers were not distributed in an equal and balanced way between different levels of education.

Within the frame of the third and final study question, we investigated whether the total IQ scores differed according to gender, educational setting, and the type of hearing assistive technology being used, by also taking into account the father's education level. When the two genders were compared, it was observed that male children had higher scores (*mean* = 108) than the female children (*mean* = 104); this difference was significant. Slate and Fawcett (1996) previously administered the WISC-R and WISC-III to 47 hearing-impaired children, and reported that, in both tests, male children received an approximately 1 SD (15 points) higher score than the female children. Sullivan and Montoya (1997), on the other hand, applied only the WISC-III, and reported that the score of the hearing impaired children (*n* = 106) did not vary according to gender. It is possible to say that the present study is somewhat in between the findings of these two previous studies. In a manner similar to Slate and Fawcett's study, the present study also identified a difference in favor of male children; however, this difference was approximately 1/4 SD, and hence much lower than the value they identified in their study. The present study thus appears to support the view that, in general population samples, male children perform better in non-verbal cognitive skills than female children (Slate and Fawcett, 1996); however, as the difference observed in our study was fairly small, and due to the limited number of studies on hearing-impaired children, we believe that further systematic studies are required before making generalizations on this subject.

Based on the comparison of educational settings, no differences were observed between children attending İÇEM and inclusive education in terms of their IQ scores, while the IQ scores of children in these educational settings was higher than that of children attending MoNE Elementary Schools for the Hearing Impaired. The lack of difference in terms of IQ scores between children at İÇEM and children in inclusive settings was, as expected, parallel to the study of Sullivan and Montoya (1997). The higher scores for these educational settings suggest that the education they provide support the intellectual skills and development of children. However, the applicability of this generalization is limited by the fact that no comparisons were performed between the characteristics of the education provided in these schools and other schools. Paquin and Braden (1990) described that hearing-impaired children attending residential schools exhibited lower intellectual performance possibly because of the lack of inadequacy of social interactions. In the current study, half of the students attending the MoNE Elementary Schools for the Hearing Impaired were residential school students. Therefore, the observed difference can be partly explained by the characteristics of these schools. However, we believe that other factors might also play a role. Although the effect of the father' education level was statistically controlled and taken into account in this study, we do not believe that it is the sole factor that needs to be taken into account within the context of daily life (Field, 2005). While correcting the means by controlling and taking into account the father's level of education did not lead to significant differences in the other groups, such corrections increased the scores of students attending the MoNE Elementary Schools for the Hearing Impaired from 95 to 99, indicating that this group is considerably affected by socio-economic factors. In addition, it is important to bear in mind that students applying for admission to İÇEM, as well as students wishing to begin their education in inclusive settings, join their respective educational institutions after successfully passing various assessments; this might also partly account for the differences in scores. Another possibility is that, as described by Maller and Braden (2011), children attending Elementary Schools for the Hearing Impaired (or School for the Deaf, as they were once called) might have a higher ratio of additional disabilities, which have the potential of further negatively affecting the intellectual performance of these children.

Conclusion and Recommendations

In conclusion, the intelligence level – as measured by the WISC-R performance sub-test scores of the hearing-impaired children constituting the study sample was higher than that of the standardization sample. However, it should be emphasized that this finding should be interpreted cautiously. It appears highly probable that had the data for the two samples been collected concurrently, there might not have been any differences between the two groups. Other important findings of the study were the observations that, as an indicator of socio-economic status (SES), the father's education level had a strong relationship with the children's intelligence level, and that the children's intelligence score differed according to their educational setting. In Turkey, the WISC-R is one of the most commonly used intelligence tests by the Guidance and Research Center, schools, university research centers, and clinics for assessing children displaying typical development, and also for identifying and evaluating children with special needs. In this context, the results described above appear to be important for both those administering this scale and for researchers. We provide below a list of recommendations for researchers, as well as those using the scale, based on an analysis and synthesis of the study results and limitations.

As the present study represents the first to evaluate the intelligence characteristics of hearing-impaired children, we can recommend researchers and the users of this scale not to take into consideration the difference which, currently, appears to be in the favor of the hearing-impaired children. This is because there is, at this stage, a need for further studies that would support our findings. In addition, the fact that the norm values used in the intelligence tests are not up-to-date also complicates the interpretations of the results and findings by researchers using the scale. In this respect, in general, we can recommend researchers (a) to determine the psychometric characteristics of the new versions of same test, (b) to determine the psychometric characteristics of other non-verbal intelligence tests, and (c) to conduct further norm studies, and to develop tests suitable for the Turkish culture.

By the side of the children with hearing loss, in the United States, it is described that the factor structure of the WISC-R performance sub-tests in hearing-impaired children is similar/overlapping with those of normal-hearing children, and that the test assesses the same cognitive structure in both groups. For this reason, it is suggested that a separate norm study for hearing-impaired children is not required (Braden, 1984, 1985a, 1985b). On the other hand, Phelps and Branyan (1988) describe that tests developed for children with typical development bear the risk of evaluating hearing-impaired children erroneously, and that norm studies may consequently be required. Whether separate norm studies are necessary for the groups is another issue that needs to be investigated and considered for children in Turkey.

For those performing assessments with intelligence tests, interpreting results for children who, based on their scores, can be clearly ranked as having an intellectual disability, as being gifted, or as having typical development is not an important issue. Because if the child's intellectual disability, giftedness or typical development is stable, mostly the results of these observations are supported by intelligence test results. At this point, what is important is how children whose scores are at the "borderline," and/or who represent "exceptions," should be interpreted. For example, if a hearing-impaired child has an IQ score of 130, the limit for high intelligence, should this child be considered as being "normal" or "highly intelligent"? What kind of a procedure should the professional follow? Of course there is no direct answers to these questions that will allow the solution totally.

In such aforementioned cases of uncertainty and ambiguity, the professionals using the test can take the SES variable into account (or at least the father's education level), which has been demonstrated to be a very important and influential parameter. In such a case, a child with an IQ score of 130 is more likely to have high intelligence actually if he/she comes from a low SES, and less likely to have high intelligence if he/she comes from a high SES. Of course, such decisions will also require a consideration of all assessment criteria. The second recommendation for the professionals could be to review all the test results up to date, it may be not in a scientific way but in an experiential way roughly. If the test results which applied till the moment indicate a tendency greater than mean of the standardization sample (M = 100), there can be a possibility of Flynn effect in the test they administered. In this case, the professionals should take into consideration the other assessment criteria, namely adaptive behaviors, and the professional experiences for final decision. The last recommendation is to administer another intelligence test to the child and take a decision by using two test results together in condition that if there is an uncertainty even applying all the assessment criteria.

Finally, the present study was conducted with a sample that was relatively large compared to those described in the international literature on hearing-impaired children. On the other hand, all of the study participants consisted of children living in the province of Eskişehir; for this reason, the study's ability to represent the Turkish population might be limited. Planning and conducting future studies encompassing the other provinces of Turkey might reduce this problem regarding the representation of the general Turkish population.

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