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Article

# Delays in receptive vocabulary and verbal IQ in deaf children and adolescents

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## ABSTRACT

**Background/Objectives:** Despite participating in early intervention programs, deaf children still present language delays. The purpose of this study is to examine the performance of deaf and hard of hearing (DHH) children and adolescents in two language-related aspects (receptive vocabulary and verbal intelligence) in comparison to a group of normal hearing (NH) peers, regarding different age groups (preschool, childhood, and adolescence). Gender differences are also assessed. **Method:** A total of 123 participants (68 DHH and 55 NH) are evaluated using the verbal subtest of the Kaufman Brief Intelligence Test (KBIT), and the Spanish version of the Peabody Picture Vocabulary Test (PPVT). **Results:** Overall, findings suggest verbal delays in deaf children when compared to a NH group, with these differences remaining in the three age groups. Deaf girls seem to have better receptive vocabulary performance than boys. **Conclusions:** Delays in verbal intelligence and receptive vocabulary are present in Spanish DHH children, through preschool age to adolescence. Gender differences seem to occur, with deaf girls performing better than boys.

## Déficits en vocabulario receptivo e inteligencia verbal en niños y adolescentes con hipoacusia

***Palabras clave:***
Hipoacusia
Lenguaje
Intervención Temprana
Vocabulario Receptivo
Inteligencia Verbal

## RESUMEN

**Antecedentes/Objetivos:** A pesar de participar en programas de intervención temprana, los niños con hipoacusia aún presentan dificultades en el lenguaje. El objetivo de este estudio es examinar el rendimiento de niños y adolescentes sordos en dos aspectos del lenguaje (vocabulario receptivo e inteligencia verbal) en comparación con un grupo de niños oyentes, teniendo en cuenta diferentes grupos de edad (prescolar, infancia y adolescencia). También se han analizado diferencias de género. **Método:** Un total de 123 participantes (68 sordos y 55 oyentes) son evaluados a través del subtest verbal de la prueba KBIT, test breve de inteligencia de Kaufman, y del Test de Vocabulario en Imágenes de Peabody (TVIP). **Resultados:** En general, se muestran dificultades verbales en los niños con hipoacusia, encontrándose estas dificultades en los tres grupos de edad. Las niñas sordas parecen mostrar un mejor rendimiento en vocabulario receptivo. **Conclusiones:** Pueden observarse dificultades en el vocabulario receptivo y en la inteligencia verbal de niños españoles con hipoacusia, tanto en edad prescolar como en la niñez y la adolescencia. Diferencias de género pueden observarse, con un mejor rendimiento en niñas que en niños con hipoacusia.

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## Introduction

The auditory input deprivation that subdues a hearing loss (HL) may conduct to significant delays in the children's neurodevelopment, including language skills, among others (American Speech-Language-Hearing Association, n.d.; Simon et al., 2020; Yoshinaga-Itano et al., 2008). Not only is auditory access important for the cognitive development of deaf children, but language access does also play a meaningful role (Hall et al., 2017). This lack of language experience that deaf children face during their early years/months, until they receive any intervention, may compromise their access to information, leading to poor early experiences in life that may affect their language development and access to knowledge (Lim & Simmer, 2005). Moreover, their academic performance might be affected as well, given this difficulty in accessing to communication, which may lead to difficulties or delays in learning processes, literacy skills, or even to school failure (Marco & Matéu, 2003; Hrastinski & Wilbur, 2016).

Early intervention programs have become a key component on the intervention with deaf children, their main purpose is to optimize the child's development and well-being. Thus, qualified professionals from different areas (e.g. audiologist, psychologist, speech therapist), with core knowledge and skills, will work hand in hand with the child and its family (Sandy & Bowen, 2016). These programs also aim to facilitate the acquisition of age-appropriate language skills to the deaf child (Wiggin et al., 2021). Despite following a stablished protocol, every intervention is personalized, since it depends on the individual characteristics of the child, such as degree of hearing loss, age at diagnosis, and more. The most common intervention in a deaf child, especially when the parents preferred communication mode is oral language, is the use of a hearing device, either if it consist in the use of hearing aids (HAs), cochlear implants (CIs), or bone-anchored hearing systems (BAHAs) (Niemensivu et al., 2018). When provided with a hearing device and an auditory-verbal therapy, deaf children develop comparable levels of speech and language (Dieleman et al., 2019).

Additionally, a frequent way to acknowledge an individual's verbal ability may be through the application of a verbal IQ scale (e.g., Weschler scales), from which information about language content can be retrieved (Lange, 2011). This verbal IQ "represents the ability to access and apply acquired word knowledge, involving verbal concept formation, reasoning and expression" (Ribeiro de Oliveira et al., 2020). Also, in the process of language acquisition, the development of receptive language skills antecedes the expressive language development (Dada et al., 2020; Duncan & Mathews, 2018).

Nevertheless, even after the improvements that early intervention can produce, language development still supposes a challenge for deaf or hard of hearing (DHH) children (Välimaa et al., 2022). Some authors mention the existence of developmental sensitive periods, related to environmental experiences, although it is difficult to determine the exact time where the development of a certain function is at its pike (Gabard-Durnam & McLaughlin, 2020; Gariépy et al., 2019). Regarding language development, as a complex system as it is, there appears to be a high likelihood of not just one sensitive period, but multiple interrelated periods with increasing levels of complexity (Gariépy et al., 2019). As mentioned before, hearing intervention may suppose the use of a hearing device, especially CIs. For this, it seems to exist a sensitive period when the implantation is recommended so that the individual may obtain as much benefit as possible from it (Heman-Ackah et al., 2012; Kim et al., 2010).

In this study we analyze the performance of a group of DHH children and adolescents in comparison to a group of normal hearing (NH) peers. Afterwards, we stablish three different age groups following the different periods in life and in relation to the sensitive periods in development (Gariépy et al., 2019). In this regard, since gender differences have been observed between DHH children when studying empathy (Netten et al., 2015), we explore, as well, the performance of girls and boys, separately. Therefore, two main purposes are stablished: the first one is to determine if DHH children differ from NH peers regarding their verbal intelligence and receptive language skills in three different age periods. Whereas the second aim is to study the possible existence of gender differences between deaf and NH children.

## Method

### Participants

The data presented here has been collected from a broader cross-sectional study, which aims to analyze the neuropsychological performance of Spanish DHH children and adolescents. Participants for this study were 123 children and adolescents, from 3 to 18 years ($M$ = 11.1, $SD$ = 51.79). Two groups were formed regarding participants' auditory status: the DHH group formed by 68 participants, 30 boys and 38 girls, with a mean age of 11 ($SD$ = 50.88); and a control group formed by 55 NH children (32 boys and 23 girls) with a mean age of 11.2 ($SD$ = 53.36). On Table 1 are presented their main characteristics. Every participant was enrolled on a mainstream educational setting. No statistically significant differences were found between DHH children and their NH peers on age ($p$ = .429) or gender ($p$ = .121).

**Table 1.**
*Characteristics of the deaf and hard of hearing group.*

| Characteristics | Subcategories | N (%) |
|---|---|---|
| Gender | Male | 30 (44.1%) |
| | Female | 38 (55.9%) |
| Age | Mean = 11 years | |
| | Range (3.1-18.2) | |
| Date of Diagnosis | Perinatal | 37 (54.4%) |
| | Postnatal | 28 (41.2%) |
| | Missing | 3 (4.4%) |
| Type of Hearing Loss | Bilateral | 47 (69.1%) |
| | Unilateral | 18 (26.5%) |
| | Missing | 3 (4.4%) |
| Hearing Device | Yes | 57 (83.8%) |
| | Bimodal | 14 (20.6%) |
| | Hearing Aid | 37 (54.4%) |
| | Cochlear Implant | 6 (8.8%) |
| | No | 10 (14.7%) |
| | Missing | 1 (1.5%) |
| Etiology | Genetic | 14 (20.6%) |
| | Illness | 21 (30.9%) |
| | Unknown | 18 (26.5%) |
| | Congenital | 9 (13.2%) |
| | Missing | 6 (8.8%) |

Participants from the DHH group were recruited through the 'Fundación Vinjoy', where they attend or attended for early intervention services, meanwhile participants in the NH group enrolled in the study through their school or sport center. To be included in this study, children with any degree of hearing loss were considered, meanwhile the exclusion criteria was the presence of any other disability or syndrome that could affect their performance such as cerebral palsy, Down syndrome, Attention Deficit-Hyperactivity Disorder, among others.

### Measure instruments

To assess verbal intelligence, we used the verbal subtest of the Kaufman – Brief Intelligence Test (K-BIT) (Spanish edition) (Kaufman & Kaufman, 2011)– Designed to measure verbal and nonverbal intelligence. This tool offers scaled scores that are comparable to those obtained in the Weschler Scales. The verbal subtest is a measure of verbal skills such as language knowledge, verbal concept formation, and flow of information. The reported internal consistency of this subtest was excellent, $\alpha = .98$ (Kaufman & Kaufman, 2011).

The Spanish adaptation (*Test de Vocabulario en Imágenes de Peabody* [TVIP]; Dunn et al., 2006) of the Peabody Picture Vocabulary Test – Revised (Dunn & Dunn, 1997), was used to measure receptive language abilities, by assessing receptive vocabulary. The Peabody Picture Vocabulary Test consists in 192 elements of increasing difficulty, with each element being formed by 4 black-and-white illustrations, as the examiner gives a word (orally) the examinee needs to choose the illustration that better represents the word given. Following Rasch's model, the internal consistency was excellent, $\alpha = .91$.

### Procedure

DHH children's families were contacted to participate on a broader study which aims to neuropsychologically assess DHH children to analyze their cognitive, social, and behavioral performance. If parents agreed to participate, a date was set to perform the neuropsychological assessment with the child/adolescent. The assessment was carried out on an adapted room in the 'Fundación Vinjoy', which is a familiar place for DHH participants as they used to go there for early intervention sessions and check-ups. The assessment of the control group was carried out at a familiar place for those children as well, whether it was their school or sports center, depending on the institution through which their families were contacted. Every child/adolescent went through the same assessment and tests were applied in the same order. It is noteworthy that parents/caregivers of every participant signed an informed consent and were aware that they could refuse to participate, or even stop their participation, at any moment of the process. They also received a report with the results of the child's performance.

### Data analysis

Statistical analysis was conducted using the SPSS version 29.0. Firstly, descriptive analysis were conducted for sociodemographic and clinical variables. Since not all the variables analyzed meet the parameters stablished (follow a normal distribution and homoscedasticity) *t*-test and Mann-Whitney test were used to examine the differences in standard scores based on participant's hearing status. The Pearson correlation coefficient was used to examine whether there was a significant association between the participant's hearing status and the outcome variables (verbal measures). A significance level of $\alpha$ .05 was used for all statistical analyses, being the confidence intervals in the parameter estimates of 95%.

## Results

### General outcomes

DHH children differed from NH peers on verbal IQ (KBIT) ($U$ =2988, $p < .001$; $r = .513$) as well as on receptive vocabulary (TVIP) ($U$ = 2648.5, $p < .001$, $r = .374$). On the KBIT, DHH children performed 16.4 points below their NH peers ($M$ = 104.5, $SD$ = 18,57) and $M$ = 120.9, $SD$ =8,45, respectively). Similarly, on the TVIP, DHH children scored 13.5 points below the NH group (with means 92 ($SD$ = 19.77) and 105.5 ($SD$ = 10.33), respectively) (see Figure 1). A strong association was found between both verbal measures in both groups, $p < .001$ (.526) for DHH group and $p < .001$ (.570) for NH group.

### Age differences

As mentioned before, three different age groups were stablished: preschool (ages 3 to 6) childhood (7 to 12), and adolescence (13 to 18 years), to observe whether DHH children's performance differs from that of their NH peers. Indeed, differences were found in both tasks (see tables 2 and 3). Specifically, DHH children perform in 1 *SD* below NH children's performance on both tasks at any age group. Additionally, the performance of the preschool DHH children on the KBIT falls to more than 2 *SD*s below the NH preschool children performance.

Moreover, strong correlations were also found between KBIT and Peabody scores in both groups (DHH and NH) in the childhood and adolescents ages, with $p < .001$ on both, regardless of DHH or NH children, except from the preschool NH children where no associations were found.

**Figure 1.**
*Scatter plot regarding the scores obtained by deaf (DHH) and hearing (NH) participants. The significant differences between the participants in both tasks, verbal IQ (KBIT) and receptive vocabulary (Peabody) can be observed.*

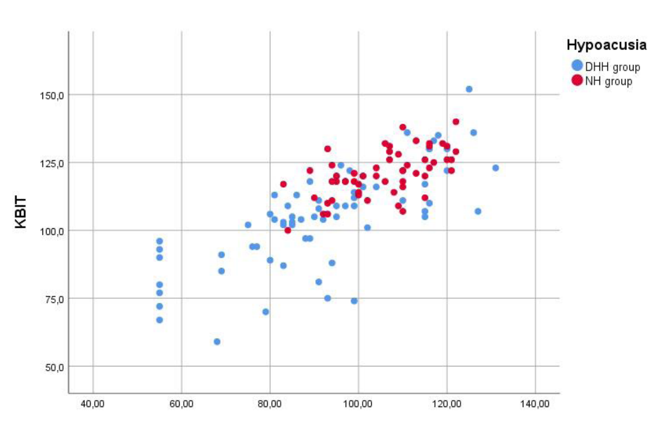

**Table 2.**
*Differences between DHH and NH children in the KBIT test.*

| Age group (years) | U Mann-Whitney | p (sig.) | r (effect size) |
|---|---|---|---|
| 3-6 | 153 | <.001 | .817 |
| 7-12 | 372,5 | .003 | .447 |
| 13-18 | 517 | .003 | .409 |

*Note.* DHH: Deaf or Hard of Hearing. NH: Normal Hearing. KBIT: Kaufman's Brief Intelligence Test.

**Table 3.**
*Differences between DHH and NH children in the TVIP test.*

| Age group (years) | U Mann-Whitney | p (sig.) | r (effect size) |
|---|---|---|---|
| 3-6 | 113,5 | .014 | .490 |
| 7-12 | 341 | .023 | .338 |
| 13-18 | 505 | .006 | .379 |

*Note.* DHH: Deaf or Hard of Hearing. NH: Normal Hearing. TVIP: Test de Vocabulario en Imágenes.

**Table 4.**
*Associations between age-equivalent scores and both verbal tasks, regarding different age groups.*

| Age group | Type of hearing group | Tests | Pearson Coefficient | Sig. |
|---|---|---|---|---|
| 3-6 years | DHH | AES-KBIT | 498 | .084 |
| | | AES-TVIP | .552 | .063 |
| | NH | AES-KBIT | .211 | .510 |
| | | AES-TVIP | .483 | .112 |
| 7-12 years | DHH | AES-KBIT | .737 | <.001 |
| | | AES-TVIP | .757 | <.001 |
| | NH | AES-KBIT | .149 | .554 |
| | | AES-TVIP | .587 | .010 |
| 13-18 years | DHH | AES-KBIT | .773 | <.001 |
| | | AES-TVIP | .914 | <.001 |
| | NH | AES-KBIT | .401 | .047 |
| | | AES-TVIP | .627 | <.001 |

*Note.* DHH: Deaf or Hard of Hearing. NH: Normal Hearing. AES: Age-equivalent score. KBIT: Kaufman's Brief Intelligence Test. TVI: Test de Vocabulario en Imágenes.

**Table 5.**
*Associations between KBIT and TVIP in DHH and NH children regarding gender.*

| Type of hearing group | Gender | Pearson Coefficient | P (sig.) |
|---|---|---|---|
| DHH | Male | .687 | <.001 |
| | Female | .844 | <.001 |
| NH | Male | .566 | <.001 |
| | Female | .535 | .008 |

*Note.* DHH: Deaf or Hard of Hearing. NH: Normal Hearing. KBIT: Kaufman's Brief Intelligence Test. TVIP: Test de Vocabulario en Imágenes.

### Chronological age *vs.* equivalent developmental age

Since the Peabody test provides with an "age equivalent" score, we analyzed this variable in relation to the chronological age of the participants. No significant differences were found between DHH and NH children regarding their chronological age ($p$ = .429), However, these children differ on their equivalent age ($U$ = 2270, $p$ = .042, $r$ = .183). In relation to the mean chronological age of each hearing group, a mean of 11 month less equivalent age is indicated for the DHH group, whilst a mean 6 month more equivalent age is indicated for the NH group. DHH children present a mean equivalent age of 121 months old (*SD* =52,08) while the equivalent age for the NH group is about 140 months old (*SD* = 49.55). This is in contrast with the chronological mean age of both groups; 132 months for the DHH group (*SD* = 50,87) and 134 for the NH group (*SD* = 53.36).

Regarding the three different age groups mentioned before, positive strong correlations were found between the age equivalent score (AES) and the KBIT and PPVT tasks (see Table 4.) in the adolescence group. However, no associations were found in the preschool children group in any verbal tasks, as well as in the NH childhood group as to the AES and KBIT.

### Gender differences

Although no sex differences were found between DHH girls and boys (KBIT: $p$ = .084; TVIP: $p$ = .122) and between NH girls and boys (KBIT: $p$ = .056; TVIP: $p$ = .070), DHH boys' performance differed from that of their NH peers on both tasks, (KBIT: $U$ = 866, $p$ <.001, $r$ = .691; and TVIP: $U$ = 740, $p$ < .001, $r$ = .506). However, DHH girls only differed with NH girls on the verbal IQ task ($U$ = 593.5, $p$ = .020, $r$ = .298). On the other hand, strong associations were also found between both clinical variables in both groups (DHH and NH) independently of the participant's gender (see Table 5).

## Discussion

The overall aim of this study is to provide an overview on the performance of Spanish DHH children and adolescents regarding their verbal intelligence and receptive vocabulary skills. Although there is a vast literature on language performance of DHH children, this is, to our knowledge, the first study that puts together verbal IQ and receptive vocabulary on Spanish population. It also is important to mention that, in our sample, we include DHH children that are not only CI users but HAs users or have a bimodal hearing adaptation (CI + HA).

In general, our findings suggest lower verbal IQ and receptive vocabulary in the DHH group. This finding is supported by a very recent study where Busch et al. (2022) aimed to understand the receptive vocabulary abilities of a group of 3 to 16 years old DHH children with CIs. They found that these children presented general poorer receptive vocabulary when compared to a matched NH group, also with their scores falling below the normative range. Another study that supports this finding was carried out by Hayes et al. (2009), they found a vocabulary delay of DHH children with CIs in comparison to their hearing peers.

Similarly, the differences between DHH and NH children on our study remain, even when studying different age groups.

Significant differences were found between DHH and NH children in each age group and in both verbal tasks. Although DHH children performance falls under a standard deviation of the mean score, these differences may be due to the high performance of the NH group. In addition to the receptive vocabulary score obtained in the TVIP test, it provides with a developmental equivalent age (EA), based on the participant's receptive vocabulary. In comparison to their chronological age (CA), DHH children included in the preschool and adolescence groups showed significant differences in relation to their EA. These were small differences in the preschool group (4 months apart) meanwhile in the adolescence group, the mean EA of DHH children was of almost 2 years; in other words, DHH adolescents lag not only behind their hearing peers, but also behind the norm.

Furthermore, the preschool group also scored below hearing peers and the norm. Meanwhile, the childhood group seems to perform age appropriately, even though they still differ from their NH peers.

A possible explanation for these differences can indeed be related to the early intervention that DHH children have received (Ching, 2015). Nowadays, children get screened and diagnose quite early in life which is of great importance to begin with an intervention program, especially if the chosen communication mode is oral language, which is a common thing since most of the DHH children are born from hearing parents, so that the child would be fitted with the most appropriate hearing device. The perfect time to fit a DHH child with a CI is before 2.5 years old, and it is usual that before getting implanted the child uses a HA, to minimize as possible the lack of access to language (de Giacomo et al., 2013; Hayes et al., 2009; Lund, 2016). Adolescents of our sample might not have had this opportunity and the intervention in other cognitive areas may have not been enough, hence their performance. Meanwhile, the preschool children may still be adapting to their new hearing situation after implantation or HA use, as well as receiving speech therapy sessions.

In relation to our second aim, no gender differences were found in the DHH group nor in the NH group. Nevertheless, DHH boys differed from NH boys on both verbal tasks, whilst DHH girls only differed from NH girls in the receptive vocabulary task. The number of NH girl participants may be the reason for these results, since it is smaller than the DHH girl group.

Still, several limitations must be addressed. First, our results must be taken carefully for two main reasons: a) the small sample, especially with the NH group being smaller than the DHH group; and b) given the high performance of the NH group on both verbal tasks. Furthermore, these results cannot be generalized to talk about the language performance of a DHH group since we only assessed certain aspects of the whole language domain. We have demonstrated differences on DHH children that are not only CI users, thereby, further research is needed to specify possible differences between DHH children that use HAs or bimodal adaptation. Likewise, it might be interesting to acknowledge other verbal aspects such as expressive vocabulary, or other language-related areas (e.g., reading comprehension).

## Conclusions

This study provides an overview on the performance of Spanish deaf or hard of hearing children, whether if they use cochlear implants, hearing aids, or a bimodal adaptation, in two verbal tasks that assess verbal IQ and receptive vocabulary. Our study adds support to the literature with our findings of deaf or hard of hearing children presenting delays in certain verbal aspects, in comparison with normal hearing peers. Moreover, these differences remain through childhood and adolescence, although they are more noticeable in the latter period. Gender differences were also assessed, with deaf girls seemingly performing better than deaf boys regarding receptive vocabulary. These results provide with useful information for future research, since they open the search to gender differences on deaf children, as well as demonstrate that, despite using augmentative technology, this is still not enough to achieve an age-appropriate verbal performance.

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