Psicothema

Psicothema 2015, Vol. 27, No. 3, 229-234
doi: 10.7334/psicothema2014.269

ISSN 0214 - 9915 CODEN PSOTEG

www.psicothema.com

The influence of cochlear implants on behaviour problems in deaf children

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Abstract

Background: This study seeks to analyse the relationship between behaviour problems in deaf children and their auditory and communication development subsequent to cochlear implantation and to examine the incidence of these problems in comparison to their hearing peers. **Method:** This study uses an ex post facto prospective design with a sample of 208 Spanish children, of whom 104 were deaf subjects with cochlear implants. The first objective assesses the relationships between behaviour problems, auditory integration, and social and communication skills in the group of deaf children. The second compares the frequency and intensity of behaviour problems of the group of deaf children with their hearing peers. **Results:** The correlation analysis showed a significant association between the internal index of behaviour problems and auditory integration and communication skills, such that deaf children with greater auditory and communication development had no behaviour problems. When comparing behaviour problems in deaf children versus their hearing peers, behavioural disturbances are significantly more frequent in the former. **Conclusions:** According to these findings, cochlear implants may not guarantee adequate auditory and communicative development that would normalise the behaviour of deaf children.

Keywords: Behaviour problems; deaf children; cochlear implant; auditory-communication development.

Resumen

La influencia del implante coclear en los problemas de conducta de los niños sordos. **Antecedentes:** resulta importante la relación entre los problemas de conducta y el desarrollo auditivo posterior al implante coclear en niños sordos y la frecuencia de estos problemas respecto a los oyentes. **Método:** se trata de un diseño ex post facto prospectivo de 208 niños, de los cuales 104 eran sordos implantados. En primer lugar se evaluó la relación entre los problemas de comportamiento y la integración auditiva, habilidades sociales y de comunicación en el grupo de sordos. En segundo se comparó la frecuencia e intensidad de estos problemas de los sordos respecto a los oyentes. **Resultados:** se aprecia relación entre el índice interno de los problemas de comportamiento y las habilidades de integración y comunicación auditivas. De tal manera que los niños sordos con mayor desarrollo auditivo y de la comunicación no presentaron problemas de comportamiento. Al comparar los problemas de conducta en los niños sordos con sus compañeros oyentes, las alteraciones del comportamiento son significativamente más frecuentes en los primeros. **Conclusiones:** es posible que los implantes cocleares no garanticen un desarrollo auditivo y de la comunicación suficiente para normalizar el comportamiento de los niños sordos.

Palabras clave: problemas de conducta; niños sordos; implante coclear; desarrollo auditivo-comunicación.

Bilateral (both ears are impaired), severe/profound (speech sounds do not fall within the individual's hearing range), sensory neural (the impairment is located in the inner ear, specifically in the cochlea) or prelingual (congenital or occurring in the first years of life) hearing loss greatly hinders auditory integration and the acquisition of spoken language (Ramírez, 2007). These serious shortcomings in auditory perception and in the development of communication with the environment trigger a sequence of educational and psychological gaps that place children with this type of hearing loss in worsened conditions compared with hearing children (Acosta, 2006; World Health Organisation, 2001).

Received: November 30, 2014 • Accepted: May 17, 2015
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Regarding the treatments applied to this type of hearing loss, only cochlear implant (CI) enables the possibility of the auditory development and progress in oral skills for the deaf children we are considering. After the Food and Drug Administration (FDA) definitively approved the use of cochlear implants in children in June, 1990, these devices have brought about a true revolution in the treatment of severe-profound, bilateral, and cochlear hearing loss (prevalence 1-3/1000) (Alzina of Aguilar, 2005; Commission of Experts of the Spanish Committee of Audiophonology - Royal Board on Disability [Comisión de Expertos del Comité Español de Audiofonología - CEAF – Real Patronato sobre Discapacidad], 2005; Manrique & Huarte, 2002).

This device consists of internal and external components and is intended to artificially replace the transduction processes and bioelectric phenomena occurring in hair cells of the organ of Corti to transmit auditory afferents to the cochlear nerve when those cells are damaged (Loizou, 1998). Once auditory afferents towards the brain are established by the early use of CIs, the development of spoken language in deaf children follows the same stages as in children without auditory deficiencies (Chin & Pisoni, 2000). In many cases, it is possible to observe the first oral productions in response to interaction with hearing people 6 months after the device is implanted. These productions show the particular characteristics of younger hearing children, indicating a gap depending on the age at which the implant is inserted (Le Maner-Idrissi, Barbu, Bescond, & Godey, 2008).

For Thoutenhoofd et al. (2005), the results achieved by children with CI can be classified according to two parameters. The first relates to the order in which results appear once the CI begins to stimulate the cochlea. The second addresses the quantity and quality of empirical evidence in the various areas related to the use of this device in the child population. Following the first criterion, the results can be primary or secondary. Primary results appear first, when the child begins to use the implant, and involve changes in auditory reception and perception as well as the child's first oral productions. Secondary results occur as time progresses and include the development of spoken language, behavioural development, and basic learning. With regard to the second parameter, results can be well established at the scientific level, inconclusive-contradictory, or still barely researched. Child CI findings with sufficient scientific evidence include auditory performance and speech perception-production. Language and behaviour development in deaf children with cochlear implants represent secondary results because their development post CI is more notable some time after the device is implanted. Additionally, these secondary effects have been investigated to a lesser extent than the auditory response prior to use of the device.

The time between the implant connection and the appearance of both primary and secondary results varies considerably, especially among the child population, possibly illustrating that inter-subject variability is one of the characteristics with the most consensus in the scientific community (James, Rajput, Brinton, & Goswami, 2008; Sarant, Blamey, Dowell, Clark, & Gibson, 2001).

Studies prior to the use of cochlear implants in deaf children have demonstrated that behaviour problems are more frequent in deaf children than in their hearing peers. The many difficulties in speech acquisition and their logical consequences seem to be at the root of these maladaptive behaviours (Marchesi, 1987).

Is it possible to think, then, that the recognition of auditory sensations and the consequent enabling of spoken language through this intra-cochlear implant would positively affect aspects such as socialisation and behaviour? (Note that this is not considered restoration or rehabilitation, as in congenital or in early onset deafness: it is not about restoring something that began but rather about beginning something new).

To analyse the potential relationship between behaviour problems in deaf children and spoken language development through cochlear implantation, Barker et al. (2009) conducted a comparative study between a group of deaf children with cochlear implants (N = 116) and another group of hearing children (N = 69) with ages ranging from 18 months to 5 years. According to the results obtained by these authors, the indirect effects of auditory status (being deaf or hearing), assessed through spoken language level, suggest that deficits in communication contribute to an increased incidence of behaviour problems. Thus, deaf children with language levels similar to those of their hearing peers do not present differences in the externalisation and internalisation of behaviour problems or child negativity that were observed during interactions between parents and hearing children. Along the same lines, Barker et al. (2009) consider language to play a central role in social exchange, rule internalisation, and the development of behaviour control. Language deficits may contribute indirectly to the onset of behaviour problems through two processes: interference in understanding requests and the needs of others (interpersonal process), on the one hand, and difficulties in regulating emotions and behaviour (intrapersonal process), on the other.

Additionally, Edwards, Khan, Broxholme and Langdon (2006) suggest that increasing the ability to use verbal concepts and internalise thought seems to be linked to a decrease in behaviour problems, although they continue to be more frequent in deaf children than in hearing children.

With regard to the prevalence of behaviour problems in deaf children with implants in comparison to hearing children, Dammeyer (2010) studied a sample of 334 Danish children, deaf and hearing, 90 of whom were using cochlear implants. The results of the study showed that the prevalence of these problems was 3.7 times higher in deaf than in hearing children. According to the author, when the language level of deaf children is good, whether sign language or oral language, the frequency of psychosocial difficulties decreases. This study documents the importance of communication, regardless of modality, in the psychological and social welfare of children with hearing impairments.

Considering the scientific literature consulted, it should be noted that behaviour problems in deaf children who use implants and the relationship of these disorders with hearing and spoken language development remain poorly researched. Similarly, there is insufficient scientific evidence to claim that behaviour problems continue to appear more frequently in deaf children with cochlear implants than in hearing children.

For all these reasons, this study presents two objectives. The first aim is to examine the relationship between auditory integration, communication skills and behaviour problems in a group of deaf children with cochlear implants. The second aim is to compare the frequency and intensity of behaviour problems in the group of deaf children compared with the group of hearing children.

Method

Participants

A total of 208 Spanish children took part in the study, of whom 104 had prelingual, bilateral, sensorineural, and profound hearing loss and used CI as a hearing aid. A total of 104 were children with normal hearing, paired subject-to-subject with the aforementioned group according to gender, age, city of residence, school centre attended, and educational level. The mean age of the sample was 89.19 months (SD = 40.83), with ages ranging between 24 and 192 months (2 and 16 years). Regarding gender, 92 were girls (44.2%) and 116 were boys (55.8%). In all cases, deafness was not accompanied by associated disorders. The mean age at which deaf children received a cochlear implant was 33 months (range between 6 and 132 months).

Instruments

Inventory for Client and Agency Planning (ICAP) (Bruininks et al., 1986). This questionnaire was adapted from the original by Bruininks, Hill, Weatherman and Woodcock (1986) and validated for the Spanish population by Montero (1996). The inventory provides internal, external and asocial indexes of behaviour problems as well as a scale that assesses social and communicative skills. The mean reliability of the adapted test gives a Cronbach's alpha of .93.

Meaningful Auditory Integration Scale [MAIS]) (Robbins, Renshax, & Berry, 1991). The scale assesses children's use of implants, the trust they place in the implant and in hearing, and the increase in the ability to associate sounds with meaning. This test can be applied to children of all ages. Standardised interviews were used to avoid influence by parents' responses. Similarly, a strict system was developed to ensure consistency between examiners in scoring parents' responses, resulting in a high degree of reliability (Cronbach's alpha of .90) (Robbins et al., 1991).

Ad-hoc Questionnaire. The questionnaire was designed to elicit all the data required by the study. Before drawing up the final version of the questionnaire, 25 trial tests were conducted to verify its suitability, especially to develop exclusive and exhaustive questions. This instrument was used to collect information related to children's age, gender, city of residence, school, educational level, hearing loss and cochlear implant process.

The information provided by parents on development subsequent to their children's CI in several studies prior to this one was regarded as highly valuable, appropriate, realistic and consistent in offering objective confirmation (Lin et al., 2007). Loy, Warner-Czyz, Tong, Tobey & Roland (2010) studied the results provided by 188 deaf children with CI in relation to spoken language and auditory skills measured through different instruments and also evaluated by the perceptions of their parents. These authors concluded that such perceptions coincided with the results of diagnostic tests. Similarly, Percy-Smith (2010) cross-referenced the data provided by parents of 168 deaf children with cochlear implants with the assessments made by the specialists and audiologists who followed with those same children. The information collected by both parents and specialists was related to hearing ability, speech intelligibility, and the structure of spoken language among children with CI. The authors found that the parents had adequately assessed all these aspects.

Process design

The data required for the study were collected via telephone to parents. Various procedures were used to contact a good number of families. The Federation of Cochlear Implant User Associations in Spain (Federación de Asociaciones de Implantados Cocleares de España - AICE) organises annual meetings for families to exchange experiences and receive information. It was feasible to approach families during their leisure time to invite them to participate in this research. In addition, the quarterly magazine "Integración" (Integration), edited by AICE, offers a listing of professionals from all over Spain who work on language development in children after implantation. These professionals were the link between researchers and families. Spanish educational centres known to the author of this study (judgemental or purposive sampling), recognised for their extensive experience in deaf children's education and currently attended by children with implants, were of great use as well. The school administrations met with parents to determine whether they wished to participate in the research.

Once contacts were made, a group 116 deaf children was arranged. Their families provided contact information for a hearing child of similar characteristics to gather the hearing peer group.

The data below present the information obtained via phone interviews, lasting 45 minutes each, with the families who agreed to participate in the study. In each of these telephone contacts the information was collected to complete the ICAP Inventory, the MAIS scale and the ad-hoc questionnaire.

The collection procedure prevented data loss. The reliability of the data collected via questionnaire was guaranteed by a sampling of 25-30 questions administered to 25% of the sample by a second interviewer, which resulted in an inter-evaluator agreement above 85% (agreements/agreements + disagreements).

This study uses a prospective ex post facto design (a single group for the first objective and a control group for the second). The first group (G1) consisted of 104 deaf Spanish children who were implanted at an early age. The second group (G2) included the same number of hearing Spanish children. Children in both groups were paired according to gender, chronological age, socio-economic status, place of residence, educational centre, and classroom. It is necessary to note that, in terms of age, 15 children in the deaf group were in a course below their chronological age at school; therefore, they exceeded the age of the hearing children they were paired with. In 5 cases, both deaf children and their hearing peers were below the chronological age at school, which means that they were the same age.

The variables considered for the first objective involved internal, external and asocial indexes regarding behaviour problems, according to the results of the ICAP Inventory, auditory integration according to the results of the MAIS Scale and social and communicative skills of the ICAP Inventory. The internal index refers to the frequency and severity of self-injurious behaviours, repetitive and atypical habits, withdrawal or inattention (values in this index can be positive or negative, from +35 to -35, including the value zero). The external index rates the frequency and severity with which a subject presents hetero-aggressiveness, destruction of objects, and disruptive behaviour (values in this index can be positive or negative from +35 to -35, including the zero value). Finally, the asocial index assesses the frequency and severity with which a subject presents offensive social behaviour and uncollaborative behaviour (values in this index can be positive or negative, from +35 to -35, including the value zero). Auditory integration was measured through the MAIS scale and refers to the overall auditory perception and understanding developed by a deaf child after cochlear implantation (auditory integration values range between 0 and 100). Social and communicative skills included in the ICAP are defined as those skills involved in social interaction in different environments, in oral comprehension and production (values of the social and communicative skills range between 0 and 500).

In relation to the second objective, the dependent variable was: internal (DV_1), external (DV_2) and asocial (DV_3) index, according to the results of the ICAP inventory. The independent or grouping variable was the hearing condition of the subject (IV_2), with two levels: Level 1: deaf child with implant, Level 2: hearing child.

Data analysis

Version 18.0 of the Statistical Package for Social Sciences (SPSS) was used for statistical analysis. First, a descriptive analysis of all variables was conducted, using means for quantitative variables and distributions for categorical variables. Later, a bivariate analysis allowed us to find significant relationships between variables of G1 and G2, and the Pearson product-moment correlation coefficient

(r) was used to find relationships between continuous variables. Finally, the quantitative variables in G1 and G2 were compared through Student's t-test for the comparison of means.

Results

In relation to the objectives:

1. *Relationship between behaviour problems and auditory, social and communicative development subsequent to CI in the group of deaf children*

The results obtained for G1 (deaf children) in the internal index of behaviour problems, achieved with ICAP Inventory, were as follows: M = -.92, Md = 3, SD = 7.26; the maximum and minimum values were 3 and -30. The percentage of scores below -11 in the internal index, indicating behaviour problems according to the ICAP evaluation scales, was 9.6%. The results of the external index of behaviour problems were as follows: M = -.21, Md = 2, SD = 4.03; the maximum and minimum values were 2 and -11. The percentage of scores lower than -11 was 1%. The social index data were as follows: M = 1.1, Md = 1, SD = 2.47; the maximum and minimum values were 2 and -17. The percentage of scores lower than -11 was 2%.

Table 1 shows the results obtained after implementation of the Pearson product-moment correlation coefficient in the internal, external and asocial indexes of behaviour problems (ICAP Inventory), auditory integration (MAIS Scale), and social and communicative skills (ICAP Inventory). The data presented a positive linear relationship in all cases except for the relationship between the external index of behaviour problems and social and communicative skills, where there was a negative relationship. The correlations between the internal rate of behaviour problems and auditory integration and social and communicative skills were statistically significant.

Table 1
Correlation values (Pearson product-moment correlation coefficient r) among the following variables: internal, external and asocial indexes of behaviour problems (ICAP), auditory integration (MAIS) and social and communicative skills (ICAP)

		Auditory Integration (MAIS)	**Social and communicative skills (ICAP)**
Internal Index (ICAP)	**r**	.283**	.212*
	Sig. (bilateral)	.004	.031
	Covariance	39.64	20.80
	N	104	104
External Index (ICAP)	**r**	.022	.070
	Sig. (bilateral)	.824	.481
	Covariance	1.05	2.33
	N	104	104
Asocial index (ICAP)	**r**	.006	-.050
	Sig. (bilateral)	.950	.613
	Covariance	.483	-2.73
	N	104	104

** The correlation is significant at the .01 level.
* The correlation is significant at the .05 level

2. *Comparison of scores obtained by G1 and G2 in behaviour problem indexes (internal, external and asocial)*

According to the descriptive analysis, the results obtained by G1 (deaf children) in the behaviour problem index (ICAP Inventory) were as follows: internal index: M = -0.59, SD = 6.59; asocial index: M = 1.1, SD = 2.47; external index: M = -0.23, SD = 4.07. The results obtained by G2 (hearing children) are as follows: internal index: M = 2.7, SD = 1.43; asocial index: M = 1.2, SD = 2.06; external index: M = 1.66, SD = 1.06

The results in Table 2 show the comparative analysis between G1 and G2. The differences between G1 and G2 in the external and internal indexes of behaviour problems were statistically significant, which was not the case for the asocial index.

Discussion

According to the data obtained with respect to the first objective, the subjects of the sample who scored higher in auditory integration (according to MAIS Scale) and social and communicative skills (according to ICAP Inventory) were the subjects without behaviour problems. In other words, the best results in auditory perception and listening, in social interaction skills in various environments, and in the comprehension and production of spoken language are related to lower frequency and severity of self-injurious behaviours, repetitive and atypical habits, withdrawal or inattention. These results concur with the findings of Barker et al. (2009) and Edward et al. (2006). We see that the early use of cochlear implants increases children's ability to understand auditory information from their surroundings and produce intelligible oral messages, thus increasing the possibility of establishing healthier and more appropriate relationships with the environment and reducing behaviour problems.

No significant relationships were found in the case of external and asocial indexes of the ICAP Inventory. Positive or negative auditory and communicative results after CI are not related to the frequency and intensity of hetero-aggressiveness, destruction of objects and disruptive behaviour (external index), and offensive and uncollaborative behaviour (asocial index).

The poorest auditory and communicative findings do not relate to problems of antisocial behaviour and outwardly oriented maladjustment; rather, they are related to internalised behaviour problems, including withdrawal or inattention. Unsurprisingly, when the language or communication system is not shared with others, withdrawal and attention problems are a logical consequence. One does not pay attention when it is not possible to understand what the environment offers.

Table 2
Student's t-test for the comparison of means of the scores obtained by G1 (deaf children) and G2 (hearing children) in the Dependent variables: Internal (DV_1), External (DV_2) and Asocial (DV_3) behaviour problems indexes (ICAP Inventory)

Indexes	**Group**	**N**	**M**	**SD**	**t**	**Sig. Bil.**
Internal (DV_1)	G1	104	-.59	6.6	-4,972	.000
	G2	104	2.71	1.5		
External (DV_2)	G1	104	-.23	4.1	-4,591	.000
	G2	104	1.7	1.1		
Asocial (DV_3)	G1	104	1.1	2.5	-.304	.762
	G2	104	1.2	2.1		

The second objective analysed whether the scores in the behaviour problem index among deaf children differed significantly from the scores of hearing children with similar characteristics, or whether the influence of the implant would have changed this trend.

According to the results, the group of deaf children presents significantly different values from the group of hearing peers regarding internal and external indexes of behavioural problems. Therefore, it can be said that, in the study sample, the frequency and severity of self-injurious behaviours, repetitive and atypical habits, withdrawal or inattention as well as the frequency and severity of hetero-aggressive behaviours, destruction of objects and disruptive behaviour are significantly higher in deaf children. We observe that the greater trend towards behavioural problems in deaf children over hearing children continues even after CI implantation. These results are consistent with the findings presented by Dammeyer (2010). With regard to hetero-aggressive behaviour, destruction of objects and disruptive behaviour, there is no difference between the two groups.

Reflecting on the data obtained, and with the necessary caution required by topics influenced by a myriad of factors, it is possible to state that the use of cochlear implants in the infant population may not ensure, in all cases, the development of the auditory perception and spoken language necessary to establish a relationship with the environment similar to hearing children. This situation is likely to cause behaviour problems. Consequently, continuing with the study of secondary results of cochlear implants in infant population remains an essential and necessary task, without undermining the relevance of primary results.

Likewise, the idea that inserting an implant in a deaf child entails auditory comprehension similar to that of a hearing child is very risky. These considerations should be taken into account by the health teams that monitor these children, the local teams that tend to them, and the teachers who educate them on a daily basis in educational centres.

Deaf children implanted in their early years of life are different from deaf children with no access to hearing and speaking less than 20 years ago; nonetheless, it is important to bear in mind that the former are still different from the hearing children who sit next to them in the classroom and who play with them in the park. Implanted deaf children can continue to have difficulties in comprehending what they hear, learning to read and write and integrating into the environment. For these reasons, they may continue to require adjustments in the educational response they give to access of information, learning, and life on equal terms. This report is only a wake-up call to families and professionals in the fields of health, education, speech therapy, and other relevant areas so that we avoid placing excessive trust in cochlear implants and neglecting the fact that implanted children remain deaf.

In sum, within the group of deaf children, internal behaviour problems, especially self-injurious behaviours, repetitive and atypical habits, withdrawal or inattention, are more frequent than in hearing children. Behaviour problems were less frequent among deaf children who had developed higher levels of auditory integration and communication with the environment. Child CI may not ensure, by itself, sufficient auditory perception and spoken language development to allow children to establish a relationship with the environment on an equal footing with their hearing peers. This situation is likely to cause behaviour problems. Therefore, to consider that inserting an implant in a deaf child entails auditory comprehension similar to hearing children is very risky. These considerations should be taken into account by the health teams that monitor these children, as well as the local teams that tend to them and the teachers who educate them on a daily basis in educational centres.

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