Psychopathology in hearing-impaired children

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CHAPTER 5

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Behavioral problems in school-aged hearing-impaired children: the influence of sociodemographic, linguistic, and medical factors

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ABSTRACT

Objective

The purpose of this study was to examine several behavioral problems in school-aged hearing-impaired children with hearing aids or cochlear implants, compared to normally hearing children. Additionally, we wanted to investigate which sociodemographic, linguistic, and medical factors contributed to the level of behavioral problems, to pinpoint where targeted interventions can take place.

Methods

This large, retrospective study included a sample of 261 school-aged children (mean age = 11.8 yrs, *SD* = 1.6), that consisted of three age- and gender-matched subgroups: 75 with hearing aids, 57 with cochlear implants, and 129 normally hearing controls. Self- and parent-reports concerning reactive and proactive aggression, delinquency, and symptoms of psychopathy, attention deficit hyperactivity disorder, oppositional defiant disorder, and conduct disorder were used. In addition, several language and intelligence tests were administered.

Results

Hearing-impaired children showed significantly more proactive aggression, symptoms of psychopathy, attention deficit hyperactivity disorder, oppositional defiant disorder, and conduct disorder than their normally hearing peers. More behavioral problems were associated with special schools for the deaf, sign (-supported) language, hearing aids (in contrast to cochlear implants), higher age, male gender, lower socioeconomic status, lower intelligence, and delayed language development.

Conclusion

Hearing-impaired children face multiple problems regarding their behavior. The outcomes implicate that professionals should be aware of the higher risk of developing behavioral problems, in order to screen, detect, and treat in time. Furthermore, the associated risk and protective factors emphasize that clinicians must always consider the heterogeneity of the group of hearing-impaired children, in order to help and support the individual patient.

INTRODUCTION

Cochlear implants (CI) and hearing aids help hearing-impaired (HI) individuals to improve their auditory input, resulting in a more active participation in a society where spoken language is the most commonly used mode of communication. In terms of improvement, direct outcomes of these medical interventions are usually measured, such as sound and speech perception. Hence, most literature focuses on the direct results of amplification, although gradually this scope is expanding to other non-auditory fields, including social and emotional functioning [1]. Except for age-appropriate speech and language, the ultimate outcome for HI children is the development of adequate social and emotional behavior resembling the behavior of their normally hearing (NH) peers.

Nevertheless, the lives of HI individuals are known to be affected by their hearing loss, because they have less or no access to the social world. This can impede communication, not only because it is hard for a HI individual to understand speech without visual cues, but also because hearing loss can have a detrimental impact on speech and language development. Often a developmental gap is noticed, because HI children have had sustained auditory deprivation since birth. In fact, early detection of hearing loss has been associated with better developmental outcomes, because the period of deprivation has been shortened considerably [2, 3]. When the hearing loss is detected later in addition to other environmental effects (i.e., speech-in-noise), HI children do not experience a normal acoustic environment and can come across wide-ranging difficulties in making adjustments to the hearing world. For example, HI children feel less socially accepted, have more problems at school, experience more depression, and demonstrate more difficulties with social interactions [4-8]. Concluding, communication problems and incomplete access to interactions make social and emotional learning complicated for HI children and therefore, they are more likely to exhibit difficulties in their social and emotional functioning, with possible consequences for their behavior [9, 10].

Behavioral problems are manifested in outward, negative, and poorly controlled behavior, ranging from aggressive and/or hyperactive to oppositional. In this paper we examined reactive and proactive aggression, delinquency, psychopathy, and symptoms of Attention Deficit Hyperactivity Disorder (ADHD), Oppositional Defiant Disorder (ODD), and Conduct Disorder (CD) (see Table 1 for descriptions of the specific behavioral problems). We chose these specific behavioral problems because they destructively impact on the well-being of the child and can have life-long consequences resulting in substantial disabilities.

Although there is a considerable body of literature involving behavioral problems in HI children, only very few studies looked more in-depth into different types of behavioral problems. Furthermore, these studies showed divergent results. That is, some studies reported more aggressive and delinquent behaviors in HI than in NH children [11, 12], while others reported similar levels [13, 14]. For ADHD, findings also were inconsistent: one study demonstrated ADHD in 5.6% of HI children [15], which is lower than in the NH population, whereas another study detected ADHD in 12% of the HI children, which is considerable higher than in NH children [16]. Furthermore, only one study worldwide examined symptoms of ODD in HI children and observed these symptoms in 8% [16], also higher than in NH

children [17]. To the best of our knowledge, information involving the two other problems we investigated in this study (symptoms of psychopathy and Conduct Disorder) is lacking. Moreover, no study for any of the behavioral problems was performed in which a differentiation between children with CIs or with hearing aids was made.

Table 1 Behavioral problems or disorders

	Short description [18]
Reactive aggression	Instant and immediate aggression to a threatening situation
Proactive aggression	Planned and instrumental aggression in order to dominate or intimidate others
Delinquency	Crime or illegal behavior
Psychopathy	Deficits in the affective and interpersonal functioning and highly associated with ODD and CD
Attention deficit hyperactivity disorder (ADHD)	Disorder with symptoms of hyperactivity, impulsivity, and/or inattention
Oppositional defiant disorder (ODD)	Mental disorder characterized by a pattern of negativistic, hostile, and defiant behavior and can develop in CD
Conduct disorder (CD)	Mental disorder characterized by aggressiveness, destructiveness, threatening, cruelty, and deceitfulness

The present study

To get a more complete understanding of behavioral problems in school-aged HI children, we examined several different types. The present study provides an opportunity to investigate this in a large sample of HI children with CIs or hearing aids. In literature, many researchers stress the fact that studies involving psychosocial development are definitely needed and appear to be a crucial step in improving outcomes for HI individuals [1]. Extensive study of this development will increase our understanding and will lead to focused counseling and treatment in the future [10, 12, 19-21]. Therefore, the aim of this study was three-fold: I. to compare the levels of behavioral problems between HI and NH school-aged children by means of both self- and parent-reports; II. to examine the influence of type of device (CI or hearing aid), type of school (regular or special), and degree of hearing loss (moderate, severe, or profound); III. to identify which other risk or protective variables contribute to the level of problems. The following variables known to affect performance were taken into account: socioeconomic status (SES), intelligence, language, age at onset of hearing loss, mode of communication, and (specifically for CI recipients) age at implantation, duration of CI use, and being uni- or bilaterally implanted [7, 11, 12, 22-25]. The Medical Ethics Committee of the Leiden University Medical Center granted permission for the study.

MATERIALS AND METHODS

Procedure

To collect the complete spectrum of HI children, they were recruited from Speech and Hearing centers, hospitals, and primary and secondary schools (both special schools for the deaf and regular schools). The children were in schools that supported development of auditory and oral skills, with or without the use of signs. The controls were recruited from primary and secondary mainstream schools throughout the country, resulting in a sociodemographically diverse group.

Parental consent was obtained for all children. Before the individual assessment started, children were guaranteed that their answers would be processed anonymously. Instructions were provided clearly and simply, in their preferred mode of communication to ensure children's understanding. HI children could choose between two versions: a written version or a version in which each item was presented in written text and sign language simultaneously. Backtranslation of the sign language showed good convergence between the original and translated items. The written version was chosen by 105 children and 27 children chose the simultaneous version. The parents received their questionnaires via mail or by a secured Internet site. More than 70 % of the parents returned the questionnaires.

Materials

To assess aggressive behavior the *Self Report Instrument for Reactive and Proactive Aggression* was used (36 items) [26, 27]. Children were presented with six forms of aggressive behavior (three physical forms: kicking, pushing, hitting; and three relational forms: name calling, arguing, and gossiping). Based on the functions of aggressive behavior, a distinction between reactive and proactive aggression was made. Participants had to report how often they performed this behavior in the last four weeks on a 3-point scale from 1 (*never)* to 3 *(often)* for reasons related to Reactive aggression (e.g., "I was bullied") and reasons related to Proactive aggression (e.g., "I wanted to be mean"). Data of five children were missing due to time constraints.

The *Delinquency Questionnaire* is a self-report that reflects delinquent offences (e.g., shoplifting or stealing from parents) children might have committed, adapted from Baerveldt and colleagues [28]. The original version of this questionnaire consisted of 19 delinquent behaviors, but due to very low incidence of 9 items in a previous pilot study (with almost 600 participants) only the 10 most frequently reported items were selected. Children were asked to state how many times they had perpetrated each of the offences in the past year (*never, once or twice,* or *three times or more*).

In order to examine Psychopathy, the parent-completed *Psychopathy Screening Device* was used [29]. The questionnaire, consisting of 20 items, involves psychopathic behaviors of the child (e.g., "Keeps his/her promises"). Parents were asked to rate the behavior on a 3-point scale (*totally not true, sometimes true, true*).

The *Child Symptom Inventories – version 4* (CSI-4) are parent-reported rating scales measuring symptoms of emotional and behavioral disorders described by the *Diagnostic*

and Statistical Manual of Mental Disorders [18, 30]. The scales assessing attention deficit hyperactivity disorder (ADHD, 17 items) (e.g., "Has difficulty paying attention to tasks or play activities"), oppositional defiant disorder (ODD, 8 items) (e.g., "Is angry and resentful"), and conduct disorder (CD, 15 items) (e.g., "Has run away from home overnight") were used. Each item could be scored with the answers *never, sometimes, often,* or *very often*.

The nonverbal intelligence of the participants was assessed with two (sub)tests of the *Wechsler Intelligence Scale for Children - Third Edition:* Block Design (copying geometric designs with cubes) and Picture Arrangement (sequencing pictures to make logical stories) [31, 32]. A random sampling (n = 23) across HI children who were assessed with a complete intelligence test earlier (either the Snijders-Oomen Nonverbal Intelligence Test [33] or the WISC) showed a high correlation between the scores of our study and the nonverbal IQ, r = .79, p < .001. All raw scores were converted into age equivalent norm scores based on Dutch standards (10 = average). To 8 HI and 17 NH children IQ tasks were not administered due to time constraints.

Two types of language skills were assessed; a *Sentence comprehension task* and a *Story comprehension task*. HI children using spoken language and NH controls received two subtests of the Dutch version of the *Clinical Evaluation of Language Fundamentals® - Fourth Edition* (CELF®) [34, 35]. HI children who use sign (-supported) language received subtests of the *Assessment Instrument for Sign Language of the Netherlands* [36]. All original scores were transformed to norm scores and these were corrected for chronological age. When clinical or school records already contained CELF scores, these age-corrected scores were used instead. To 9 HI and 16 NH controls the Sentence comprehension task was not administered and to 5 HI and 16 controls the Story comprehension task was not administered.

The *Children's Communication Checklist version 2* was used to identify communication problems [37]. This 70-item questionnaire, filled out by parents, has been predominantly designed for assessing social and pragmatic language of children aged 4 to 16, although it also assesses other qualitative aspect of language. Each item can be scored from 0 (*never or less than 1 time a week*) to 3 (*several times a day or always*). The checklist consists of eight scales: a. speech production, b. syntax, c. semantics, d. coherence, e. inappropriate initiation, f. stereotyped conversation, g. use of context, and h. non-verbal communication. Two composite scores are obtained from these scales: the General Communication Composite (GCC; scales a to h) and the Pragmatic Composite (PC; scales e to h).

Participants

The total cohort consisted of 261 school-aged children. Eligibility criteria were: living in the Netherlands or Dutch speaking part of Belgium and having performal intelligence of at least 80 quotients. The inclusion criteria for the HI children (n = 132) were: having moderate, severe, or profound (pre- or perilingual) hearing loss in the better ear and no other comorbidities, such as visual impairment or mental retardation. Including children with other disabilities would make the sample too heterogeneous. Table 2 shows characteristics of the group and Table 3 shows them for CI recipients specifically. Age,

gender, SES, and IQ were comparable for the HI and NH groups, but language skills were lower in the HI children when compared to the NH children (Story Comprehension, $t(224) = 2.23$, $p = .027$, General Communication Composite, $t(177) = -6.95$, $p < .001$, and Pragmatic Composite, $t(186) = -8.32$, $p < .001$, respectively).

Statistical analyses

T-tests and Analysis Of Variance (ANOVA) were used to compare the HI and NH groups and the HI subgroups. All (sub)groups were similar regarding age and gender. The relations between risk or protective variables and behavioral problems were established by means of Pearson's correlations. The program *Statistical Packages for the Social Sciences* version 19.0 was used. When a score was not available, the participant was excluded from the analysis concerned. The internal consistencies of all questionnaires were sufficient to good, except for the CD scale due to floor effects (i.e., Cronbach's Alpha of .35 for controls and .58 for the HI sample).

RESULTS

Level of behavioral problems in HI children compared to NH controls

First, we compared the complete sample of HI children to children without hearing loss (Figure 1). HI children had higher scores for proactive aggression, symptoms of psychopathy, ADHD, ODD, and CD than NH controls ($t(254) = -3.26$, $p = .001$; $t(186) = -2.20$, $p = .029$; $t(192) = -2.84$, $p = .005$; $t(192) = -2.65$, $p = .009$, and $t(192) = -3.30$, $p = .001$, respectively).

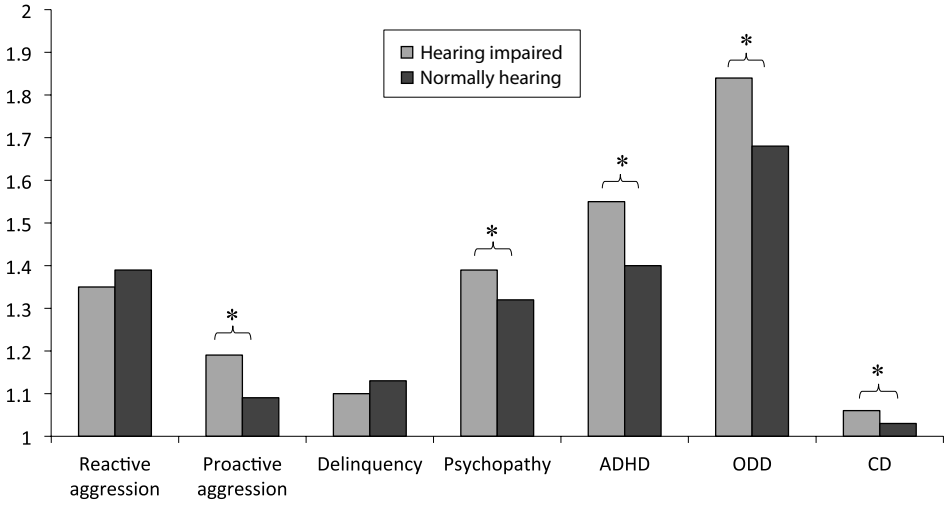

Figure 1 Mean scores of all HI and NH children.
*$p < .05$.

Table 2 Sociodemographic, linguistic, and medical profile of all participants

	Total sample (N = 261)		**HI sample (*n* = 132)**	
	HI	**Controls**	**CI**	**Hearing aid**
Number of children - *n*	132	129	57	75
Age mean in years (*SD*)	11.9 (1.8)	11.6 (1.3)	11.8 (2.0)	12.0 (1.7)
Age range (in years)	8.3 - 16.5	8.3 - 14.8	8.3 - 16.5	9.2 - 15.7
Gender - *n* (%)				
Male	66 (50%)	58 (45%)	27 (47%)	39 (52%)
Female	66 (50%)	71 (55%)	30 (53%)	36 (48%)
Socioeconomic status mean (*SD*) [a]	11.5 (2.3)	12.1 (2.4)	11.7 (2.3)	11.3 (2.4)
Socioeconomic score range	4 - 15	5.3 - 15	7.3 - 15	4 - 15
Nonverbal IQ				
IQ norm score Picture arrangement (*SD*)	10.1 (3.6)	10.6 (3.4)	10.0 (3.5)	10.2 (3.7)
IQ norm score Block design (*SD*)	10.5 (3.1)	10.6 (3.0)	10.3 (2.8)	10.6 (3.4)
Spoken language skills [b]				
Sentence comprehension (*SD*)	6.6 (3.1)	7.1 (2.3)	6.7 (3.1)	6.6 (3.1)
Story comprehension (*SD*)	6.2 (2.8)	7.0 (2.5)	5.6 (2.9)	6.7 (2.6)
Sign language skills [b]				
Sentence comprehension (*SD*)	2.6 (0.7)	-	2.8 (0.8)	2.5 (0.6)
Story comprehension (*SD*)	2.3 (0.9)	-	2.1 (0.9)	2.3 (1.0)
Children's Communication Checklist [c]				
General Communication Composite (*SD*)	93.2 (18.9)	73.9 (18.2)	93.4 (18.7)	93.1 (19.2)
Pragmatic Composite (*SD*)	47.1 (8.9)	36.2 (9.1)	47.6 (9.0)	46.7 (8.9)
Degree of hearing loss - *n* (%) [d]				
Moderate (40 - 60 dB)	31 (23.5%)	-	0 (0%)	31 (41.3%)
Severe (61 - 90 dB)	27 (20.5%)	-	2 (4%)	25 (33.3%)
Profound (> 90 dB)	65 (49%)	-	52 (91%)	13 (17.3%)
Unknown	9 (7%)	-	3 (5%)	6 (8%)
Preferred mode of communication - *n* (%)				
Oral language only	102 (77%)	-	44 (77%)	58 (77%)
Sign-supported language	28 (21%)	-	13 (23%)	15 (20%)
Sign language only	2 (2%)	-	0 (0%)	2 (3%)
Type of education - *n* (%)				
Regular education	79 (60%)	-	34 (60%)	45 (60%)
Special education	53 (40%)	-	23 (40%)	30 (40%)
Mean age at detection of hearing loss in years (*SD*)	1.6 (1.3)	-	1.3 (0.9)	2.0 (1.5)
Age at detection of hearing loss range (in years)	0 - 5.5	-	0 - 5	0 - 5.5

Table 2 continued

Age at onset of hearing loss - *n* (%)				
Prelingual	112 (85%)	-	53 (93%)	59 (79%)
Perilingual	13 (10%)	-	2 (3.5%)	11 (15%)
Unknown	7 (5%)	-	2 (3.5%)	5 (6%)
Mean age of 1st hearing aid in years (*SD*)	2.1 (1.4)	-	1.5 (0.9)	2.6 (1.5)

[a] Socioeconomic status score was measured by parental education, job, and net income. (Unfortunately, due to privacy reasons, half of the parents did not fill out the question concerning the net income, so these were not taken into account.)

[b] Spoken language skills were derived from the Clinical Evaluation of Language Fundamentals® and Sign language skills were derived from the Assessment Instrument for Sign Language of the Netherlands; please see Materials section for more information.

[c] The higher the composite, the more (social) language problems were present.

[d] Degree of hearing loss was calculated by using the Fletcher Index (averaging unaided hearing thresholds at 500, 1,000, and 2,000 Hertz).

Table 3 Characteristics of participants with *CI* (*n* = 57)

Mean age at implantation in years (*SD*)	3.8 (2.9)
Age at implantation range in years	0.9 - 10.8
Mean duration of CI in years (*SD*)	8.1 (2.8)
Duration of CI range in years	0.8 - 13
Unilateral : bilateral implants - *n* (%)	43 (75%) : 14 (25%)
Sequentially : simultaneously implanted - *n* (%)	57 (100%) : 0 (0%)

Level of behavioral problems by Type of device and Type of school

Second, the HI sample was inspected by investigating the influence of Type of school (Regular or Special schools for the deaf) and Type of device (conventional hearing aid or CI). Two-way ANOVAs with interaction effects were carried out (Table 4). For reactive aggression, proactive aggression, and delinquency, significant interactions were identified. Post-hoc *t*-tests revealed that children with hearing aids attending special schools, scored significantly higher than the three other groups. Furthermore, irrespective of the type of device, higher psychopathy scores were found for children attending specials schools than for children attending regular schools.

Level of behavioral problems by Degree of hearing loss

An ANOVA was performed to compare outcomes of HI children with moderate, severe, or profound hearing losses and did not demonstrate any significant differences. Secondly, the children with profound losses only were scrutinized, because this group contained children with hearing aids that are more comparable to CI recipients than children who experience moderate to severe losses. CI recipients (*n* = 52) reported significantly lower scores for reactive aggression ($t(62) = 2.54$, $p = .014$) and proactive aggression ($t(62) = 3.32$, $p = .036$) than children with profound losses who received hearing aids (*n* = 13) (Figure 2).

Table 4 Mean scores of HI sample, divided by Type of device and Type of school

	Mean *(SD)*				*F*		
	CI		**Hearing aid**		**Main effect CI vs. Hearing aid**	**Main effect Regular vs. Special**	**Inter-action effect**
	Regular school (*n* = 34)	**Special school (*n* = 23)**	**Regular school (*n* = 45)**	**Special school (*n* = 30)**			
Self-reports							
Reactive aggression	1.23 (.23) [a]	1.33 (.32) [a]	1.27 (.34) [a]	1.65 (.47) [b]	7.81**	14.63***	5.19*
Proactive aggression	1.13 (.18) [a]	1.20 (.25) [a]	1.10 (.20) [a]	1.39 (.38) [b]	3.16	15.15***	5.50*
Delinquency	1.09 (.15) [a]	1.04 (.09) [a]	1.07 (.12) [a]	1.21 (.24) [b]	7.44**	2.53	10.45**
Parent-reports							
Psychopathy	1.38 (.21)	1.44 (.20)	1.33 (.23)	1.47 (.20)	.03	5.37*	.72
ADHD (CSI)	1.51 (.37)	1.71 (.35)	1.51 (.33)	1.59 (.34)	.74	3.58	.66
ODD (CSI)	1.91 (.46)	1.90 (.51)	1.74 (.43)	1.92 (.41)	.67	.95	1.16
CD (CSI)	1.07 (.10)	1.05 (.10)	1.06 (.09)	1.07 (.08)	.02	.02	.31

Note. In case of a significant interaction, post hoc t-tests were performed and letter-superscripts indicate differences at $p < .05$. *$p < .05$; ** $p < .01$; *** $p < .001$.

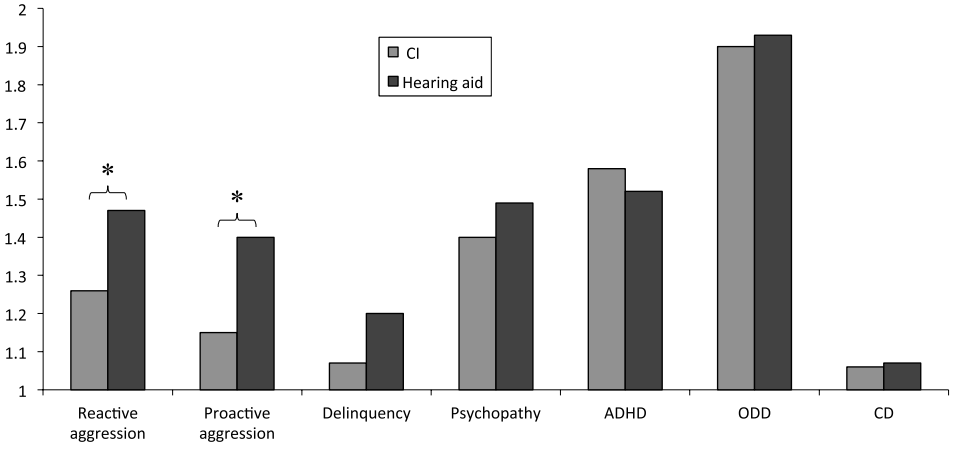

Figure 2 Mean scores of HI children with profound (> 90 dB) losses only, divided by type of device. *$p < .05$.

Variables associated with behavioral problems

Third, Pearson's correlations were carried out to see which sociodemographic, linguistic, and medical variables were related to behavioral problems (Table 5). First, higher age was associated with more delinquency and male gender was related to more delinquency and ADHD. A higher socioeconomic status contributed to less reactive aggression, psychopathy, and ADHD. Higher intelligence was associated with less proactive aggression. Next, better spoken language and communication skills were related to less proactive aggression, psychopathy, ADHD, ODD, and CD. Sign (-supported) language correlated to more reactive and proactive aggression, and more psychopathy. Finally, longer duration of having CIs was associated with less delinquency. Yet, when this correlation was corrected for age, the significance disappeared (p = .059).

Table 5 Pearson's correlations between behavioral problems and variables of HI participants

	Reactive aggression	Proactive aggression	Delin-quency	Psycho-pathy	ADHD	ODD	CD
Age	-.07	-.14	.21*	.07	-.02	-.10	.15
Gender [a]	-.04	-.01	-.18*	-.05	-.21*	-.00	-.06
Socioeconomic status	-.30*	-.01	.11	-.25*	-.24*	-.17	-.23
Nonverbal IQ							
IQ norm score Picture arrangement	-.15	-.22*	-.11	.00	-.03	-.06	-.06
IQ norm score Block design	-.17	-.34***	-.03	-.10	-.06	-.06	.05
Spoken language skills							
Sentence comprehension	-.14	-.31**	-.17	-.14	-.03	-.03	.02
Story comprehension	-.10	-.30**	-.11	-.21*	-.06	-.14	-.02
Sign language skills							
Sentence comprehension	-.05	-.31	-.07	-.08	-.04	-.06	-.17
Story comprehension	-.08	-.46	.18	.11	.03	.16	-.23
Children's Communication Checklist							
General Communication Composite	.07	.23*	.08	.45***	.39***	.29**	.32**
Pragmatic Composite	.07	.16	-.04	.48***	.43***	.32**	.38***
Degree of hearing loss	-.13	.05	-.08	.07	-.01	.14	-.02
Aided degree of hearing loss	.01	.19	.14	-.04	-.20	-.15	-.12
Mode of Communication [b]	-.23*	-.42***	-.15	-.19*	-.08	-.10	.02
Age at detection of hearing loss	.03	.15	.08	.01	-.06	-.10	-.11
CI characteristics							
Age at CI implantation	.16	.11	.02	.27	.20	.14	.13
Duration of CI use	-.10	-.23	.40**	-.16	-.10	-.17	.06
Uni- or bi laterality	.03	.01	-.20	-.01	-.00	-.01	.03

[a] Male is 0; female is 1.

[b] Sign (-supported) language is 0; spoken language is 1.

*p < .05; ** p < .01; *** p < .001.

All correlational analyses were repeated for NH children and this revealed one major difference in pattern: (most) language and communicational skills were not longer related to behavioral problems, while for HI children better skills resulted in less behavioral problems.

DISCUSSION

This study is, to our knowledge, one of the first studies that investigated several behavioral problems and their risk and protective factors in a large and representative sample of HI and NH school-aged children. Many researchers already postulated that there is really a need for this type of studies, which extends knowledge on psychosocial outcomes [1, 10, 12, 19-21]. The main finding was that, despite receiving amplification, counseling, and continuous support, more behavioral problems occurred in HI than in NH children. That is, higher levels of proactive aggression, symptoms of psychopathy, ADHD, ODD, and CD were experienced by HI children when compared to NH children. Moreover, HI children with hearing aids and attending special schools for the deaf were even more at risk of behavioral problems, including reactive and proactive aggression, and delinquency. Additionally, the following variables were associated with higher levels of behavioral problems: higher age, male gender, lower SES, lower IQ, less language and communication skills, and sign (-supported) language.

When comparing our results to the literature, the higher scores for aggression, ADHD, and ODD in the HI population were confirmed by others [11, 12, 16]. For the other problems we investigated (symptoms of psychopathy and CD) no literature was available until this paper. The reason why HI youngsters are more prone to developing behavioral problems is not exactly clear. In the first place, the frequently noted delays in speech and language development have been postulated to negatively affect behavior [10, 12] and these language problems were also found in our sample. The problems restrict the child's ability to communicate and, therefore, they may not achieve an understanding of the refinements of social language [38, 39]. In addition, HI children have difficulties with affective prosody, pitches, and discriminating tones, while expressing emotions and using social language tend to require these kinds of acoustic properties. Furthermore, previous research demonstrated that HI children often express their anger more bluntly [40]. It could also be that, because of the higher level of internalizing problems in HI children, such as depression or loneliness [8, 11, 41], they develop more behavioral problems, since research in NH children shows that internalizing and behavioral problems have been linked. For example, internalizing problems co-occur with ADHD (detected in children aged 6 to 17) and with ODD or CD (reported in children aged 4 to 21) [42, 43]. Moreover, it is plausible that HI children become victims of stigmatization or discrimination [44]. Alternatively, an often underestimated effect is the message for parents that their child experiences hearing impairment. This traumatic event can result in suboptimal bonding between parent and child, which in turn can lead to psychosocial difficulties [1].

Another explanation of the higher proportion of behavioral problems in HI children can be given when the other findings of our study are taken into consideration. Particularly type of school and type of device appeared to be very relevant, with children attending special schools and having hearing aids being most at risk. The influence of type of device has not been studied earlier in this respect, but the finding that type of school is related to behavioral problems in general is consistent with other literature [11, 25, 45]. Caution is warranted when interpreting these findings, because presumably, HI children with disturbing behaviors are already more likely to be referred to specials schools.

None of the behavioral problems were attributable to the degree of hearing loss or the aided hearing threshold. Although no other literature is available for aided hearing threshold, the outcome for degree of hearing loss is in line with other well-replicated research findings [13, 16]. Other factors than degree of hearing loss are actually more important for the development of behavioral problems, such as communication skills, mode of communication, type of school, or socioeconomic status [12, 16, 22, 46, 47]. Yet, it is still an interesting finding because this outcome implies that HI children with profound losses function at the same behavioral level as children with moderate to severe losses. Of course we have to bear in mind that children with profound losses have often received CIs. Nonetheless, our results show that CI recipients had lower levels of behavioral problems than hearing aided children with similar losses on several problems. The hypothesis could be formulated that, beyond the positive effects of the CI itself by restoring auditory input, these children receive more counseling as provided by CI rehabilitation programs in contrast to hearing aided children [48].

Finally, we have to keep in mind that this is a cross-sectional study in which no statements concerning causality can be made. The best way of clarifying potential confounders would be to investigate this longitudinally. Yet, we tried to measure the pure effect of hearing loss in several ways. First of all, we tested different subsamples of the HI group and we analyzed many different risk and protective variables. This was possible because the group was relatively large and in terms of size, comparable to other relevant research, such as the studies of Wake et al. (2004) and Geers et al. (2011) [21, 49]. Secondly, HI children with additional difficulties were excluded from the study, to focus on the direct effect of hearing loss. Finally, the assessment of the HI participants was done in either spoken or sign (-supported) language, so that we did not underestimate the behavioral problems due to communication barriers.

In summary, a large heterogeneity typifies the HI sample and demonstrates the necessity of individualized treatment. Hearing impairment solely does not contribute to the genesis of behavioral problems, but other factors, such as type of school, type of device, and language skills, influence the risk of developing these problems as well. This knowledge is essential in order to reveal which child may be at higher risk for developing behavioral problems, so that targeted counseling programs can take place, helping each HI child in reaching his/her full potential.

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