Acta Oto-Laryngologica. 2014; Early Online, 1–9

ORIGINAL ARTICLE

Development and validation of a questionnaire for hearing implant users to self-assess their auditory abilities in everyday communication situations: the Hearing Implant Sound Quality Index (HISQUI$_{19}$)

EDDA AMANN & ILONA ANDERSON

Clinical Research Department, MED-EL, Innsbruck, Austria

Abstract

Conclusion: The Hearing Implant Sound Quality Index (HISQUI$_{19}$) seems to be a valid tool for quantifying the self-perceived level of auditory benefit that cochlear implant (CI) users experience in everyday listening situations. Additional research is, however, required. *Objectives:* To develop and validate a user-friendly instrument for quantifying the self-perceived level of auditory benefit that CI users experience in everyday listening situations. *Methods:* This was an explorative, uncontrolled, single-group, cross-sectional study. Items for the HISQUI$_{19}$ were decided upon using user input and verified by professionals. The HISQUI$_{19}$ was assessed on 75 CI users from hearing implant centres in Germany and Austria to determine the questions. *Results:* The HISQUI$_{19}$, consisting of 19 items scored on a 7-point Likert scale, was validated. Subjects older than 60 years at time of implantation did not have significantly higher mean values than subjects younger than 60 years. Gender and whether subjects are unilateral or bilateral implant CI users did not influence self-perceived functioning. Subjects with ≤20 years of hearing loss reported no significantly higher functioning than those with >20 years of hearing loss.

Keywords: *Cochlear implant, adults, auditory benefit*

Introduction

Cochlear implantation is a proven and effective treatment for people with severe and profound deafness. Cochlear implant (CI) users typically experience improved sound and speech perception and speech production ability [1]. Speech perception tests and various outcome analyses (e.g. audiometric testing, categorical loudness scaling) are currently the most commonly used assessment tools to evaluate benefit from implantation. While such objective outcomes provide specific information and results with high reliability, they fail to show individual CI user's performance and benefit in daily life [2]. Indeed, few studies have examined the subjective outcomes of cochlear implantation, perhaps because unlike physical signals, such as overall sound pressure level, the imprecise and complex nature of human perception cannot be objectively measured according to well-defined international standards. Different listeners perceive identical sounds differently; age, gender, nationality and many other factors affect perception [3].

To more accurately assess the auditory benefit CI users derive from implantation, it is beneficial to query the users themselves on the functional levels they experience in different everyday life situations. Surely this is a more robust marker of benefit than the results of objective tests conducted in the artificial setting of a clinic? Self-assessment tools have the advantage of being better able to explicitly demonstrate the difficulties faced by people with hearing loss [4].

The World Health Organization (WHO) [5] extended the definition of 'health' to include psychological and social domains. An increasing number of medical interventions, for an increasingly broad range of health domains, are being comprehensively

Correspondence: Edda Amann, Clinical Research Department, MED-EL Worldwide Headquarters, Fürstenweg 77a, Innsbruck 6020, Austria.
E-mail: edda.amann@medel.com

(Received 24 January 2014; accepted 18 March 2014)

ISSN 0001-6489 print/ISSN 1651-2251 online © 2014 Informa Healthcare
DOI: 10.3109/00016489.2014.909604

evaluated. The aim of the present study was to develop and validate a user-friendly questionnaire that will enable CI users to evaluate their own level of auditory benefit in everyday listening situations.

Material and methods

Steps of questionnaire development and validation

Identification of relevant studies. Although several instruments have been used to assess CI users' self-perceived auditory benefit after implantation, few have been psychometrically validated [2]. Many studies used generic quality of life (QoL) questionnaires, which are too comprehensive and not sensitive enough to examine the everyday hearing challenges that CI users experience [2]. Others tools were originally designed for hearing aid users but because of basic differences between hearing aid users and CI users (e.g. degree of hearing loss, costs of management), the factors that contribute to self-perceived benefit may be different.

Instruments that provide reliable assessments of adult CI users' self-perceived auditory benefit or quality of life do exist, namely the Nijmegen Cochlear Implant Questionnaire (NICQ) [6]; the Cochlear Implant Function Index (CIFI) [2]; and the Speech, Spatial and Qualities of Hearing Scale (SSQ49 [7] and SSQ12 [8]). The NCIQ, with 60 items, is a very comprehensive tool and measures 3 general domains: physical, psychological and social functioning. The CIFI evaluates CI users' functional level with and without the use of listening support (e.g. input microphone, written notes, oral interpreter, communication access real-time translation) in different situations, for example, at work, in different noise conditions, on the telephone, or in social groups. Recently, the SSQ12, a 12 question adaptation of the SSQ49, was developed and focuses on speech in noise, speech in multiple streams, localization and segregation.

Item generation. An expert group of audiologists, speech therapists, a psychologist, and a bio-statistician was involved in the questionnaire development. Specific standards were formulated for item development: (1) the questionnaire should contain items that show a range of speech understanding abilities in everyday listening situations, (2) the items should be phrased in a similar way, (3) responses to the items should be consistent, and (4) the items should be suitable for construction of Likert scales. The expert group then pooled items, several of which were extracted from established measures, and created a pilot version. This pilot questionnaire gave examples of everyday life situations and asked participants with a CI ($n = 14$) to define and describe the challenges they faced in these situations. The experts revised the item pool based on these results.

A preliminary version of the Hearing Implant Sound Quality Index (HISQUI$_{35}$), with 35 items, was developed and sent to cooperating health professionals who offered it to CI users. In addition to responding to the questionnaire, CI users could note if they had problems with the answer categories, the wording of the items, or the practicability of the questionnaire. We received 19 completed questionnaires. Responses to each item were scored in terms of percentage corresponding to the answer selected. Although the sample size was small, preliminary validation analyses (internal consistency with Cronbach's alpha, inter-item correlation statistics) were performed. One item with low inter-item correlation results was deleted ('In general, do you have problems understanding speech?').

From April 2010 to February 2011, responsible health professionals from investigation centres in Germany and Austria distributed the HISQUI$_{34}$, now with 34 items, to 72 CI users, all of whom had a MED-EL cochlear implant system (COMBI40+, PULSAR Ci^{100} or SONATA Ti^{100}). Subject inclusion criteria consisted of (1) wearing a MED-EL CI system and (2) being 18 years or older at the time of implantation. Potential subjects were informed about the purpose of the survey and how to complete the questionnaire. Subjects completed the questionnaire themselves and, together with the signed Subject Information and Declaration of Consent, returned it to the investigation centre in an enclosed self-addressed stamped envelope.

In all, 69.4% (56/72) CI users returned the questionnaire. The psychometric examination of the 34 items showed 5 items with a more narrow range of scores, more missing data compared with the other items, smaller inter-item correlation results and item discrimination results <0.5: 'Do you have problems, to effortlessly understand speech in a quiet environment?'; 'You are driving in a car and the passengers are having a conversation, do you have difficulties listening to the news on the radio?'; 'You are in a cinema or theatre and, for example, other people are whispering, rustling with a paper, or eating popcorn/chips, can you effortlessly understand the dialogue of the film/play?'; 'Can you effortlessly participate in a conversation (e.g. in meetings), when multiple people are talking simultaneously?'; 'When driving in a car and one or more windows are open, can you effortlessly listen to the conversation of passengers?'. These items were eliminated; the next version, the HISQUI$_{29}$, contained 29 items.

We received a further 32 completed questionnaires from eligible CI users from the same investigation centres and thus could do the validation of the HISQUI$_{29}$ with a larger sample. Of the 32, 18 respondents completed a second questionnaire version within 4 weeks to test the repeatability and consistency of the questionnaire across time.

For practical reasons, we decided to provide an abbreviated form (19 items), as with a limited subset of questions routine assessments in clinical practice could be managed more quickly. Items with a similar meaning were grouped together: (1) distinguishing between different voices/speakers, (2) identifying music sound, (3) sound localization, (4) talking on the phone, (5) watching TV and listening to the radio (speech in noise), (6) understanding speech in public situations (speech in noise), and (7) and participating in conversations (speech in noise) (Table I). As some items queried similar content, the expert group decided to keep those items that assessed more demanding but common everyday listening situations and items that produced a wider range of scores in the HISQUI$_{19}$ version. The deleted items are listed in Table II.

Questionnaire validation. The items and the total score of the HISQUI$_{19}$ were validated according to the psychometric criteria of the classical test theory [9]. The steps of validation are described below.

Ethical considerations

Freiburger Ethik-Kommission International (FEKI) approved the study. Written informed consent was obtained from all subjects upon entering the study.

The final questionnaire

The Hearing Implant Sound Quality Index (HISQUI19) is a paper-based 19-item questionnaire to quantify the degree of self-perceived auditory benefit from implantation in various everyday listening situations. Items listed with regard to content can be seen in Table I. Each item is formulated as a statement on a seven-point Likert scale. Each answer option also includes a percentage value. This percentage value will help with answering the questions: for example, 'almost always' means that the statement is currently correct about 87% of the time for the participant. The seven response categories are as follows: always (99%), almost always (87%), frequently (75%), mostly (50%), occasionally (25%), rarely (12%) and never (1%).

Instructions on how to complete the questionnaire and an evaluation matrix to calculate the HISQUI$_{19}$ total score are provided in the questionnaire. The total score ranges from 19 to 133 points. Each response option corresponds to a numerical value (from never = 1 to always = 7). Missing data and the answer option 'not applicable' (N/A) are treated as 'missing values'. The maximum number of incomplete answers for the validation analyses was set at three items per subject; if this number was exceeded the subject was excluded.

Table I. Items listed with regard to content: distinguishing/allocating/understanding.

Domain	Item
Distinguishing between different voices/speakers	1, 10, 14
Identifying music sound	3, 6
Sound localization	5, 13, 16
Talking on the phone	2, 8
Watching TV, listening to the radio	7, 11
Understanding speech in public situations (speech in noise)	9, 12, 15
Participating in conversations (speech in noise)	4, 18, 19, 17

Table II. Items *not* included in the final HISQUI$_{19}$ version and listed according to their content.

Identifying music sound

Can you effortlessly distinguish specific rhythms in a familiar piece of music?

When listening to music, do you have difficulties distinguishing familiar pieces of music?

You are in a room together with other people and music is playing on the radio. When another person is talking, do you have difficulties distinguishing between the person's voice and the music?

Talking on the phone

When background noise is present, do you have difficulties talking on the phone?

When talking on the phone, can you effortlessly distinguish between female and male voices?

Watching TV, listening to the radio (speech in noise)

Provided that the volume is loud enough, can you effortlessly understand the news on the TV?

When driving in your car with your windows closed, can you effortlessly understand the news on the radio?

Understanding speech in public situations (speech in noise)

Can you effortlessly understand speech in background noise (e.g. on the street or in a restaurant)?

Participating in conversations (speech in noise)

When no background noise is present, can you effortlessly participate in conversations with friends or family members (e.g. after dinner)?

When no background noise is present, can you effortlessly participate in a conversation with multiple people?

The total score is obtained by adding the numerical values of the answers of all 19 questions. This total score can then be classified qualitatively on a five-point scale: very poor, poor, moderate, good and very good self-perceived auditory benefit (Table III). This score range was worked out based on the subjects' results. See Figure 1 for the distribution of the subjects' scoring.

Participants

13/88 (14.8%) subjects were excluded because they had more than 3 incomplete answers. Questionnaires from 75 subjects (38 men, 37 women) were included in the final validation. Mean age at time of implantation was 50 years (range 12–77 years). Mean duration of hearing loss was 25 years (range 2–73 years); 35 subjects (47.3%) were bilaterally implanted, 22 (29.7%) were implanted only in the right ear and 17 (23%) were implanted only in the left ear. Information was unavailable on the location of one subjects implant(s). See Table IV for subjects' self-reported aetiologies.

Statistical analysis

Descriptive statistics for the single items were computed, including the mean, median, standard deviation (SD) and percentage of responses at the floor and ceiling.

Item response analysis was used to look for missing or out-of-range data, which could indicate a response choice that was confusing or irrelevant, and questions where the full range of response options was not used. Furthermore, if a high proportion of respondents score at either the ceiling or the floor level, the questionnaire has a limited ability to quantify different sound quality perceptions.

Questionnaire validation

Item analysis. The difficulty and discrimination of each item and the item homogeneity were examined to select the best items for the final version of the questionnaire. A high difficulty index in this study means a higher self-perceived sound quality [10]. The more single items correlate with the corrected total score and the lower the variance of these coefficients, the higher the item homogeneity. These relationships are depicted using the item discrimination index [10].

Table III. Quantification of the total score (range 19–133 points).

Level of auditory benefit	Score range (%)
Very poor	<30 (22.6%)
Poor	≥30 to <60 (45.1%)
Moderate	≥60 to <90 (67.7%)
Good	≥90 to <110 (82.7%)
Very	≥110 to 133 (100%)

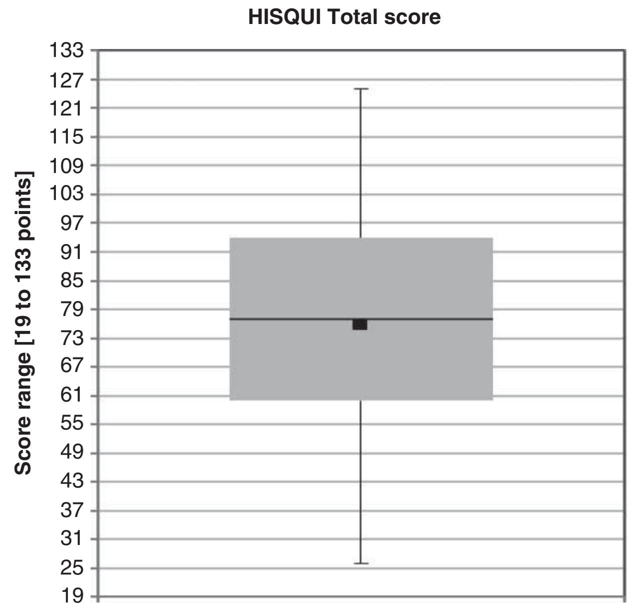

Figure 1. HISQUI total score distribution.

Table IV. Subjects' self-reported aetiologies.

Aetiology	*n*
Otosclerosis	31
Hereditary	14
Progressive	14
Scarlet fever	12
Sudden deafness	10
Since childhood	7
Otitis media	3
Measles	2
Ménière's disease	2
Noise-induced	2
Chemotherapy for breast cancer	1
Meningitis	1
Mumps	1
NF2 (neurofibromatosis type 2)	1
Progressive Alport syndrome	1
Sensorineural hearing loss	1
Trauma	1

Reliability. The scale's internal consistency was tested using Cronbach's alpha [11] and Guttman's split-half-coefficient, with the data split into odd and even numbered items. The repeatability and consistency of the measure across time was checked using test–retest reliability.

Construct validity. Construct validity was checked, applying exploratory factor analyses with a rotated orthogonal (varimax) factor solution. Factor loadings >0.40 in absolute value were considered significant and assigned to the appropriate factor. To test the suitability of the items for factor analyses, the Kaiser-Meyer-Olkin (KMO) [12] statistic and the Bartlett test of sphericity were performed. As an additional and more pragmatic approach, the inter-relationship between items was examined using Pearson correlation.

Relationship to age, gender, duration of hearing loss and unilateral vs bilateral CI use. Spearman's rho correlation was conducted to test the relationship between the HISQUI$_{19}$ total score and age at implantation. Additional age-stratified analyses using the Mann–Whitney U test were performed to see if subjects older than 60 years at implantation perceived sound quality with their CI differently than did subjects younger than 60 years old. The influence of gender on sound quality perception using the Mann–Whitney U test was examined. The Mann–Whitney U test was conducted to test if subjects with a duration of hearing loss of 20 years or less performed differently than subjects with a duration of hearing loss of more than 20 years. The same test was used to see if there is a difference in sound quality perception between unilateral and bilateral CI users.

Statistical significance was set to $p \leq 0.05$. IBM SPSS Statistics 19 (IBM, Armonik, New York, NY, USA) was used for all analyses. The Figure 1 was created in Microsoft Office Excel 2010 (http//www.microsoft.com).

Results

Item analysis

Nineteen items were included in the final validation of the questionnaire. The distribution of the responses indicated that subjects used the full range of answer options. Item means ranged from 3.6 to 4.5, with an average mean deviation of 1.9. Overall, no floor and ceiling effects were detected. The percentage of responses at the floor ranged from 2.7% to 20%, and the percentage of responses at the ceiling ranged from 5.3% to 17.3% (Table V). Item characteristics, such as difficulty index ($p = 0.3$ to $p = 0.9$) and discrimination index (>0.5), were satisfactory (Table VI, column 2).

Reliability

The questionnaire reached a good reliability with high internal consistency (Cronbach's α, 0.949; Guttman's split-half-coefficient, 0.940). The result of the test–retest reliability analyses was high and very significant ($r = 0.926$; $p < 0.001$), showing a trend of repeatability and consistency of the measure across time.

Construct validity

Support for conducting exploratory factor analysis was provided by the KMO test, with a value of 0.888, which is 'meritorious' according to Kaiser and Rice [12]. The Bartlett test of sphericity ($\chi^2 = 1262.32$, df = 171, $p < 0.001$) indicated that there was a significant correlation between the items; thus the null hypothesis could be declined with a probability of error of 0.00%. The items loaded on two factors: distinguishing between different voices/ speakers and sound localization on the first factor, and identifying music sound, talking on the phone,

Table V. Descriptive statistics of the 19 individual HISQUI items.

Item no.	Mean	Median	SD	% Floor effect	% Ceiling effect
1	3.6	3	2.2	20.0	14.7
2	3.8	4	2.0	17.3	9.3
3	3.8	4	1.8	13.3	6.7
4	4.1	4	1.7	5.3	9.3
5	3.9	4	2.1	16.0	17.3
6	3.9	4	1.8	9.3	8.0
7	4.2	4	1.8	6.7	9.3
8	4.1	4	1.9	9.3	10.7
9	4.1	4	1.7	5.3	6.7
10	3.9	4	1.9	10.7	8.0
11	4.2	4	1.9	5.3	14.7
12	4.5	5	1.7	2.7	14.7
13	3.8	4	2.2	20.0	16.0
14	3.9	4	2.0	16.0	10.7
15	4.3	4	1.6	4.0	9.3
16	3.8	4	2.0	17.3	12.0
17	4.1	4	1.8	8.0	5.3
18	4.3	4	1.7	4.0	9.3
19	4.1	4	1.8	6.7	13.3

Higher mean/median values imply higher perceived auditory benefit (range 1–7 points).

Table VI. Reliability analyses of the 19 HISQUI items.

Item no.	Corrected item-scale-correlation (item discrimination index)	Cronbachs α, if item deleted
1	0.539	0.950
2	0.836	0.944
3	0.808	0.945
4	0.705	0.946
5	0.624	0.948
6	0.759	0.945
7	0.640	0.947
8	0.744	0.946
9	0.695	0.947
10	0.722	0.946
11	0.537	0.949
12	0.539	0.949
13	0.586	0.949
14	0.796	0.945
15	0.748	0.946
16	0.724	0.946
17	0.798	0.945
18	0.652	0.947
19	0.685	0.947

watching TV and listening to the radio, understanding speech in public situations, and participating in conversations on the second factor (Table VII). The factors explained 78.1% of the total variance.

Almost all items were positively and significantly intercorrelated ($p < 0.001$ to $p = 0.049$). The strongest relationship was typically among items belonging to the same group. The items on understanding the news on the radio when others are talking (item 11) and understanding an announcement in a public situation (item 12) seem to be less related to items of other groups. Thus, item 11 was not significantly correlated with items 1, 5, 13 and 16. Item 12 was not significantly correlated with items 1, 5, 10, 13 and 16.

Calculation of the total score

See Figure 1 for the distribution of the HISQUI_{19} total score. The achieved mean total score of 75.7 points (56.9%) suggests moderate auditory benefit for the subjects in their everyday listening situations. Three subjects reported very poor auditory benefit (<30 points), 15 subjects reported poor auditory benefit (≥30 to <60 points), 32 subjects reported moderate auditory benefit (≥60 to <90 points), 19 subjects reported good auditory benefit (≥90 to <110 points) and 6 subjects reported very good auditory benefit (≥110 to 133 points).

Relationship to age, gender, duration of hearing loss and unilateral vs bilateral CI use

A small and non-significant relationship was found between the HISQUI_{19} total score and age at implantation (Spearman's rho, $r = -0.124$; $p = 0.295$). Stratified analyses showed that subjects older than 60 years ($n = 23$) at time of implantation had slightly but not significantly (Mann–Whitney U test, $p = 0.653$) higher mean values than those younger than 60 years ($n = 51$) at implantation. Gender did not influence self-perceived auditory benefit (Mann–Whitney U test, $p = 0.730$). Subjects with shorter duration of hearing loss (≤20 years) indicated slightly but not significantly higher (Mann–Whitney U test, $p = 0.412$) self-perceived auditory benefit than those with longer duration of hearing loss (>20 years). No significant difference in self-perceived functioning was found between unilateral and bilateral CI users (Mann–Whitney U test, $p = 0.432$) (Table VIII).

Discussion

The goal of the present study was to provide clinical practice and research with a user-friendly questionnaire, based on established psychometric standards, to quantify CI users' self-perceived auditory benefit in everyday listening situations. This goal has been realized: the HISQUI_{19} seems to be a valid tool, assessing speech understanding in demanding listening situations, to query hearing implant users' ability to use a telephone, distinguish between different speakers, identify music sounds and localize sound.

With only 19 items and the ease of scoring (7-point Likert scaling), the HISQUI_{19} is quick to complete; it usually takes 10 min. The strong spread of the total score results demonstrates that the HISQUI_{19} is sensitive enough to reveal common everyday hearing challenges of CI users. The questionnaire had a good reliability with high internal consistency and repeatability.

In our cross-sectional evaluation, subjects younger than 60 years at implantation had slightly and not significantly higher mean values than those older than 60 years. Several authors have reported that between 35% and 42% of those aged 65 years and older are already hearing impaired (e.g. Hertzel and Smith [13]). According to Coelho et al. [2], older CI users, when they are not at work, tend to avoid challenging hearing situations and experience more difficulty when communicating with family members. Cohen et al. [14] also found a significant inverse

Table VII. Factor pattern matrix for the HISQUI$_{19}$* (items listed according to their content).

Item no.	Item description	Factor 1	Factor 2
	Distinguishing between different voices/speakers		
1	Can you effortlessly distinguish between a male and a female voice?		0.912
10	Can you effortlessly distinguish between a female voice and a child's voice (6–10 years of age)?		0.847
14	You are listening to friends or family members talking to each other in quiet surroundings. Can you effortlessly identify the talker?		0.847
	Identifying music sound		
3	When listening to music, can you effortlessly distinguish whether one or multiple instruments are being played simultaneously?	0.617	0.565
6	Can you effortlessly distinguish single instruments in a familiar piece of music?	0.703	0.412
	Sound localization		
5	Can you effortlessly hear noises such as falling keys, the beeping of the microwave or the purring of a cat?		0.897
13	Can you effortlessly hear the ringing of the phone?		0.874
16	Can you effortlessly allocate background noise to a specific sound source (e.g. toilet flushing or vacuum cleaner) using acoustic help only?		0.883
	Talking on the phone		
2	When talking on the phone, can you effortlessly understand the voices of familiar people?	0.508	
8	When talking on the phone, can you effortlessly understand the voices of unfamiliar people?	0.854	
	Watching TV, listening to the radio (speech in noise)		
7	You are watching a movie on TV and music is playing in the background. Provided that the volume of the TV is loud enough, can you effortlessly understand the movie's text?	0.778	
11	At home when other family members are having a conversation and you are listening to the news on the radio, can you effortlessly understand the news?	0.860	
	Understanding speech in public situations (speech in noise)		
9	Can you effortlessly understand a speech/lecture in a hall (e.g. lecture hall, church)?	0.756	
12	Can you effortlessly understand the announcement in a bus terminal, a train station or an airport?	0.777	
15	You are seated on the back seat of a car and the driver in the front is talking to you. Can you effortlessly understand the driver?	0.852	
	Participating in conversations (speech in noise)		
4	When background noise is present (e.g. at a party/in a restaurant), can you effortlessly participate in a conversation with friends or family members?	0.682	
18	When background noise is present (e.g. in the office, printer, copier, air conditioning, fan, traffic noise, in busy restaurants, at parties, noisy children), can you effortlessly participate in a conversation with multiple people?	0.897	
19	When multiple people are talking simultaneously, can you effortlessly follow discussions of friends and family members?	0.785	
17	When other people in your close surrounding are having a conversation (e.g. talking to a salesperson, a bank clerk at the counter or a waiter in a busy restaurant), can you effortlessly talk to another person?	0.613	0.561

*The two-factor solution was obtained by principal component analyses with the varimax rotation method.

relationship between self-perceived benefit score and age at intervention for CI users. According to Ryugo and Limb [15], diminished plasticity in older adults may be an influencing factor towards achieving less success with the CI. A possible explanation is provided by Skevington et al. [16], who found that increasing age has in itself a deteriorating effect on the overall QoL benefit. Vermeire et al. [17], however, found no significant difference in benefit outcomes between the geriatric group (≥70 years) and younger age groups for the Hearing Handicap Inventory for Adults ($p = 0.411$) and for the Glasgow Benefit Inventory ($p = 0.886$). Gender did not influence self-perceived auditory benefit, which was also reported by Coelho et al. [2] and Cohen et al. [14].

In the present study, subjects with a shorter duration of hearing problems reported slightly but not significantly better self-perceived auditory benefit in

Table VIII. Mean values (± standard deviation, SD) of total score for stratified groups.

Parameter	Mean (± SD)
Age at time of implantation	
<60 years (n = 51)	74.6 (27.42)
≥60 years (n = 23)	77.8 (21.33)
Duration of hearing loss	
≤20 years (n = 26)	76.4 (25.06)
>20 years (n = 36)	70.4 (26.42)
Unilateral vs bilateral CI users	
Unilateral (n = 39)	77.6 (23.75)
Bilateral (n = 35)	73.9 (27.70)

everyday life than did subjects with a longer duration of hearing loss. Coelho et al. [2], who also reported no significant effects on hearing function with duration of deafness, believed that the majority of respondents who judged themselves in high-level function categories may have skewed the data. They also believed that respondents who lost their hearing in adulthood have established effective adaptive strategies for their everyday life settings. Cohen et al. [14] also did not find a significant association between QoL benefit and length of hearing loss.

Correlational analyses to test external validity with objective measures can also be performed with the total score. According to some authors, only low to moderate correlations exist between traditional audiometric measures and questionnaire data (e.g. Hinderink et al. [6]). Cohen et al. [14] found that improvements in overall QoL scores correlated with increases in sound-only sentence recognition scores. But according to Hinderink et al. [6], users' subjective perception of benefits due to CI is not directly linked to the objective performance level. A CI's effect on user's QoL may not be commensurate with his/her scores on speech perception or objective measures tests, for example, the extent to which a CI user believes they benefit from their device may not be commensurate with his/her objective performed scores (e.g. a user's self-perceived auditory benefit may increase dramatically with only a slight increase in objective hearing ability). Coelho et al. [2] suggest that respondents may unrealistically assess their own functional level. Moreover, the relationship between audiometric data and self-reported data can be different for different questionnaires, probably due to the wording of the items [18]. Sometimes CI users have difficulty responding to a particular item because they have never experienced the specific situation described [19]. The differences across studies may also be the result of sampling effects and measurement error [20] and might not only reflect underlying differences in the questionnaires.

The present study is not without limitations. A self-selection bias could have occurred, making the subjects a non-representative sample. CI users who are satisfied with the benefit of their implant are often more motivated to participate in a survey than those less satisfied. Future studies should evaluate the criterion/convergent validity of the HISQUI_{19} by comparing results gathered from the HISQUI_{19} with those from established instruments. Although there are only low to moderate correlations between traditional audiometric measures and questionnaire data as reported in the literature, the external validity should be evaluated by correlating HISQUI_{19} results with objective measures of hearing performance.

Conclusion

The HISQUI_{19} seems to be valid and reliable for detecting German-speaking CI users' self-perceived auditory benefit in everyday listening situations. Its good internal consistency and ease of administration and scoring suggest that the HISQUI_{19} is a useful instrument for evaluating the subjective outcomes of cochlear implantation. Additional research is required to confirm this.

The HISQUI_{19} questionnaire can be downloaded from the MED-EL homepage: http://www.medel.com/int/media-gallery-print-materials-rehab/

Acknowledgments

The authors would like to thank all of the clinics and audiological professionals for their data and their support and Michael Todd (MED-EL) for his medical writing assistance.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

[1] Lorens A, Polak M, Piotrowska A, Skarzynski H. Outcomes of treatment of partial deafness with cochlear implantation: a DUET Study. Laryngoscope 2008;118:288–94.

[2] Coelho DH, Hammerschlag PE, Bat-Chava Y, Kohan D. Psychometric validity of the Cochlear Implant Function Index (CIFI): a quality of life assessment tool for adult cochlear implant users. Cochlear Implants Int 2009;10: 70–83.

[3] Fastl H. The psychoacoustics of sound-quality evaluation. Acta Acustica 1997;83:754–64.

[4] Noble W. Bilateral hearing aids: a review of self-reports of benefit in comparison with unilateral fitting. Int J Audiol 2006;45:63–71.
[5] The World Health Organization Quality of life assessment (WHOQOL): position paper from the World Health Organization. Soc Sci Med 1995;41:1403–9.
[6] Hinderink JB, Krabbe PF, Van Den Broek P. Development and application of a health-related quality-of-life instrument for adults with cochlear implants: the Nijmegen cochlear implant questionnaire. Otolaryngol Head Neck Surg 2000; 123:756–65.
[7] Gatehouse S, Noble W. The speech, spatial and qualities of hearing scale (SSQ). Int J Audiol 2004;43:85–99.
[8] Noble W, Jensen NS, Taylor G, Bhullar N, Akeroyd MA. A short form of the speech, spatial and qualities of hearing scale suitable for clinical use: the SSQ12. Int J Audiol 2013; 52:409–12.
[9] Allen MJ, Yen WM. Introduction to measurement theory. Long Grove, IL: Waveland Press. 2002.
[10] Wood DA. Test construction: development and interpretation of achievement tests. Columbus, OH: Charles E. Merrill Books, Inc. 1960.
[11] Cronbach LJ. Coefficient alpha and the internal structure of tests. Psychometrika 1951;16:297–334.
[12] Kaiser HF, Rice J. Little Jiffy, Mark IV. Educ Psychol Meas 1974;34:111–17.
[13] Hertzel L, Smith A. The 65 years and over population: 2000. Washington DC: US Census Bureau. 2001.
[14] Cohen SM, Labadie RF, Dietrich MS, Haynes DS. Quality of life in hearing-impaired adults: the role of cochlear implants and hearing aids. Otolaryngol Head Neck Surg 2004;131:413–22.
[15] Ryugo DK, Limb CJ. Brain plasticity: the impact of the environment on the brain as it relates to hearing and deafness. In Niparko JK, Kirk KI, Robbins AM, Mellon NK, Tucci DL, Wilson BS, editors. Cochlear implants: principles & practices. Philadelphia: Lippincott, Williams & Wilkins. 2000.
[16] Skevington SM, Lotfy M, O'Connell KA. The World Health Organization's WHOQOL-BREF quality of life assessment: psychometric properties and results of the international field trial. A report from the WHOQOL group. Qual Life Res 2004;13:299–310.
[17] Vermeire K, Brokx JP, Wuyts FL, Cochet E, Hofkens A, van de Heyning PH. Quality-of-life benefit from cochlear implantation in the elderly. Otol Neurotol 2005;26: 188–95.
[18] Koike KJ, Hurst MK, Wetmore SJ. Correlation between the American Academy of Otolaryngology-Hearing and Neck Surgery five-minute hearing test and standard audiologic data. Otolaryngol Head Neck Surg 1994;111:625–32.
[19] Cox RM. Administration and application of the APHAB. Hear J 1997;50:32–48.
[20] Cox RM, Gilmore C. Development of the Profile of Hearing Aid Performance (PHAP). J Speech Hear Res 1990;33: 343–57.