Measuring Cochlear Implant Satisfaction in Postlingually Deafened Adults with the SADL Inventory

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Abstract

Background: Cochlear implants (CI) have become widely used for the management of profound sensorineural hearing loss. However, data relative to satisfaction in CI users are not so readily available. No standard outcome inventory for CI users has been developed. The Satisfaction with Amplification in Daily Life (SADL) inventory was originally developed for hearing aid users by Cox and Alexander (1999). Because the SADL inventory has been shown to have good psychometric properties for use within hearing aid users, the present study adapted the SADL for CI use and assessed the validity and reliability of the adapted version.

Purpose: (1) To explore the factor structure (i.e., subscales), validity, and reliability of the SADL inventory applied to CI users and compare the resulting factor structure to that reported by Cox and Alexander (1999) for hearing aid users; and (2) to evaluate the satisfaction level of CI users as measured by the SADL inventory and compare the satisfaction level of unilateral CI users (CI-only) to that of users of a CI and hearing aid in opposite ears (CIHA).

Research Design: A cross-sectional survey. All CIHA users in this study voluntarily elected to wear their hearing aids in conjunction with their CIs.

Study Sample: The satisfaction level of postlingually deafened adult CI users was assessed for 100 CI-only and 35 CIHA users using the SADL inventory.

Data Collection and Analysis: The psychometric properties of the adapted SADL following administration to CI-only and CIHA users were examined through a factor analysis.

Results: A similar factor structure was found for CI-only users compared to the original published SADL data. The differences were primarily related to one particular factor. CI users have a moderately high satisfaction level. No significant differences were found between the CI-only and CIHA groups except for hearing aid feedback.

Conclusions: It is concluded that the SADL is appropriate for clinical use with CI users.

Key Words: Cochlear implant, hearing aids, SADL, satisfaction

Abbreviations: CFA = confirmatory factor analysis; CI = cochlear implant; CIHA = cochlear implant in one ear with hearing aid in the opposite ear; EFA = exploratory factor analysis; SADL = Satisfaction with Amplification in Daily Life (SADL) inventory

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Sumario

Antecedentes: Los implantes cocleares (CI) han sido ampliamente usados para el manejo de pérdidas auditivas sensorineurales profundas. Sin embargo, los datos relativos a la satisfacción en los usuarios de un CI no están tan disponibles. No se ha desarrollado un inventario estándar de resultados para usuarios de CI. El Inventario de Satisfacción con la Amplificación en la Vida Diaria (SADL) fue desarrollado originalmente para usuarios de auxiliares auditivos por Cox y Alexander (1999). Dado que el inventario SADL ha mostrado tener buenas propiedades psicométricas para su utilización entre usuarios de auxiliares auditivos, el presente estudio adaptó el SADL para el uso de CI y evaluó la validez y confiabilidad de la versión adaptada.

Propósito: (1) Explorar la estructura de factores (p.e., las sub-escalas), la validez, y la confiabilidad del inventario SADL aplicado a usuarios de CI y comparar la estructura de factores resultante con la reportada por Cox y Alexander (1999) para usuarios de auxiliares auditivos; y (2) evaluar el nivel de satisfacción de los usuarios de CI por medio del inventario de SADL y comparar el nivel de satisfacción de usuarios de CI unilateral (CI-sólo) con el de usuarios de un CI y de un auxiliar auditivo en oídos opuestos (CIHA).

Diseño de la Investigación: Es una encuesta transversal. Todos los usuarios CIHA eligieron voluntariamente utilizar sus auxiliares auditivos en conjunto con su CI.

Muestra del Estudio: Se evaluó el nivel de satisfacción de adultos ensordecidos post-lingüísticamente con CI en 100 usuarios CI-sólo y 35 usuarios CIHA utilizando el inventario SADL.

Colección y Análisis de Datos: Se examinaron las propiedades psicométricas del SADL adaptado a usuarios de CI-sólo y de CIHA a través de un análisis factorial.

Resultados: Se encontró una estructura de factores similar para los usuarios de CI-sólo comparada con los datos de SADL originalmente publicados. Las diferencias fueron primariamente relacionadas con un factor particular. Los usuarios de CI tienen un nivel moderadamente alto de satisfacción. No se encontraron diferencias significativas entre los grupos de CI-sólo y los de CIHA, excepto por la retroalimentación del auxiliar auditivo.

Conclusiones: Se concluye que el SADL es apropiado para su uso clínico con usuarios de CI.

Palabras Clave: Implante coclear, auxiliar auditivo, SADL, satisfacción

Abreviaturas: CFA = análisis confirmatorio de factores; CI = implante coclear; CIHA = implante coclear en un oído con auxiiliar auditivo en el oído opuesto; EFA = análisis exploratorio de factores; SADL = Inventario de Satisfacción con Amplificación en la Vida Diaria

As part of overall consumer care, audiologists, researchers, and manufacturers are increasingly interested in the overall satisfaction of hearing device consumers (e.g., Dillon et al, 1997; Cox and Alexander, 1999; Humes, 1999; Kochkin, 2000a; 2005; Humes et al, 2001; Vestergaard, 2006). Satisfaction has been defined in many ways, but in hearing device outcomes the term is typically used to reflect the individual's overall contentment with his or her hearing experience, as well as the competence of service providers, ease of access to services, and comfort of the devices (Wong et al, 2003). It is noted that device retention can be affected by satisfaction because a satisfied consumer is usually a continuous hearing aid user (Kochkin, 2000b; Wong et al, 2003).

In order to understand the nature of hearing device satisfaction, a tool specifically designed to assess this outcome domain is necessary (Humes, 1999; Humes et al, 2001). According to Humes (1999), outcome from any intervention can be assessed using measures of speech perception, self-report inventories, amount of use, and so on. Self-report inventories are intended to quantify limitations in activities, participation restriction, perceived benefits, health-related quality of life, and satisfaction.

Self-reported satisfaction for hearing aid users has been explored extensively. However, due to inherent differences between hearing aid and cochlear implant (CI) users (e.g., degree of hearing loss, cost of management), the factors that contribute to the satisfaction of each group may not be similar. We will explore literature on satisfaction measures related to hearing aid and CI users below.

SATISFACTION RELATED TO HEARING AID USERS

Numerous studies have reported on the satisfaction level of hearing aids users (see Wong et al, 2003, for a summary). Although various approaches have been used to quantify satisfaction, two commonly used inventories include the MarkeTrak Survey (MarkeTrak I-VII) and the Satisfaction with Amplification in Daily Life (SADL) inventory. These two inventories have been widely used to directly address the satisfaction domain. Satisfaction can also be inferred from other self-report measures. For example, one of the items in the International Outcome Inventory-Hearing Aids (IOI-HA) addresses satisfaction. The other six items target other domains including daily use, benefit, residual activity limitations, residual participation restrictions, impact on others, and quality of life (Cox and Alexander, 2002). The Glasgow Hearing Aid Benefit Profile (GHABP) addresses questions about the satisfaction level with hearing aids in different situations of daily life (Gatehouse, 1999).

The MarkeTrak Survey has been conducted over the past 15 years. In the most recent survey, Kochkin used a direct rating of overall satisfaction on a seven-point Likert scale from “very satisfied” to “very dissatisfied” (2005). The scores were reported as percentages of respondents being satisfied on each of 46 statements. Kochkin (2005) noted that satisfaction ranges from 66 to 78%, depending on the topic being addressed. According to him, the top three factors contributing to hearing aid satisfaction are the overall benefit, the clarity of sound, and the value (i.e., the amount of money paid in relation to the amount of reduction of handicap).

The SADL inventory developed by Cox and Alexander (1999) consists of 15 items. The terms *satisfaction* or *satisfied* are not used in this inventory. Instead, the inventory uses descriptors ranging from *not at all* to *tremendously* with a seven-point scale assigning scores from 1 to 7. Thus, the SADL is considered an indirect measure of satisfaction. Cox and Alexander (2001) showed in later work that hearing aid satisfaction can be quantified without mentioning the word *satisfaction* in the inventory.

Humes et al (2002) compared the measures of satisfaction obtained with the MarkeTrak-IV questionnaire and the SADL tools. Even though they found that the same hearing aid users had equivalent results on the SADL global scores and MarkeTrak IV surveys, the SADL inventory is more efficient for clinic use than the MarkeTrak-IV survey because the SADL inventory has only 15 questions, whereas the MarkeTrak-IV survey has 40. Furthermore, no data have been published on the reliability and validity of the MarkeTrak survey. However, the SADL has been shown to have good construct validity and test-retest reliability (Cox and Alexander, 1999, 2001). Hosford-Dunn and Halpern (2000, 2001) confirmed its psychometric properties and recommended that the SADL can be used as a “gold standard” for measuring satisfaction outcomes.

SATISFACTION RELATED TO COCHLEAR IMPLANT USERS

Since their inception in the early 1960s, cochlear implants have become widely used for management of profound hearing loss. However, data relative to satisfaction in CI users are not so readily available. Nicholas and Geers (2003) assessed the satisfaction level of the parents of 181 pediatric CI recipients using a questionnaire titled *Parents and Their Implanted Children: Views and Experiences*. The rating was a five-point Likert scale from “strongly agree” to “strongly disagree.” The 107 items were grouped into nine domains. They found that the parents were significantly influenced by their child’s speech and language achievements and were found to be generally satisfied with the implantation. Zwolan et al (1996) conducted a study using a self-developed questionnaire on the satisfaction of 12 prelingually deafened adult CI users. These CI users indicated higher levels of satisfaction with the quality of environmental sounds than with speech. Tateya et al (2000) conducted a questionnaire-based study on 37 CI users and found that understanding conversation/speech was one of the most important aspects of satisfaction. Several other studies (e.g., Zhao et al, 1997; Faber and Grontved, 2000; Krabbe et al, 2000; Hawthorne et al, 2004), which were not designed to specifically measure satisfaction but, rather, the general health domain, found that CIs can bring important improvements in health-related quality of life (HRQoL). For example, Zhao et al (1997) found that CI users considered that the impact of CIs on their lives had more advantages than disadvantages. Krabbe et al (2000) observed that post-CI scores were significantly higher than pre-CI scores in terms of sound quality and speech perception, as well as social functioning, role functioning, and mental health. On the other hand, the level of satisfaction of CI users does not always correspond to the degree of improvement in speech perception scores (Tateya et al, 2000; Lassaletta et al, 2006). Consequently, we cannot predict satisfaction with CIs from speech recognition scores alone. Humes et al (1996) also pointed out that speech perception scores generally have a weak correlation with hearing aid benefit, satisfaction, or use.

With advances in implant technology and speech processing strategies, the criteria for CI candidacy have been extended from profound hearing loss to include moderate-to-severe bilateral hearing losses. Unilateral CI users may still have residual hearing amenable to hearing aids in the nonimplanted ears. CI users who have a hearing aid in the opposite ear (CIHA) have what is commonly termed *bimodal* stimulation. A number of investigators have tried to evaluate whether hearing aids in the opposite ears can

Table 1. Demographic Information for the CI-Only and CIHA Groups

	Gender		Age at implantation (yr)		Years of deafness		Test time after implantation (yr)	
	M	F	Mean	SD	Mean	SD	Mean	SD
CI-only (*N* = 100)	47	53	55.4	15	10.3	13.2	7.3	5.5
CIHA (*N* = 35)	18	17	61.9	12.6	9.4	12.9	3.0	3.0

provide any additional benefits to CI users. Some results have shown significant binaural speech perception benefits (Armstrong et al, 1997; Ching et al, 2005; Luntz et al, 2005; Morera et al, 2005; Mok et al, 2006) or better sound localization (Ching et al, 2004; Seeber et al, 2004). Others have shown little bilateral benefit (Tyler et al, 2002) or improvement when speech perception was tested in noise or little benefit on sound localization with two devices (Dunn et al, 2005). It has also been recommended that bimodal stimulation could become a way of standard rehabilitation for unilateral CI users when appropriate (Ching et al, 2004; Morera et al, 2005). However, whether bimodal stimulation improves the overall satisfaction of CI users has not been explored to date.

No standard outcome inventory for CI users has been developed. Because the SADL inventory has been shown to have good psychometric properties for use within hearing aid wearers (Hosford-Dunn and Halpern, 2000, 2001; Cox and Alexander, 2001), the present study adapted the SADL for CI use and assessed the validity and reliability of the adapted version. However, if the SADL inventory is tested with different patient populations and in different clinical environments, and over different assessment intervals, the validity and reliability of the scales and subscales need to be reevaluated (Hosford-Dunn and Halpern, 2001; Humes et al, 2001; Vestergaard, 2006). We cannot assume that those psychometric properties of the original SADL inventory would be maintained for CI users because the SADL was originally developed and evaluated with hearing aid users. Therefore, a factor analysis needed to be carried out to determine the number and nature of factors or outcome dimensions in order to explain individual variations in performance among participants (see Humes, 1999, for a review). Specific items may cluster differently for CI users than for hearing aid users. The normative references may also change for different populations.

The purposes of this study were (1) to explore the factor structure (i.e., subscales), validity, and reliability of the SADL inventory applied to CI users in a hospital setting and compare the resulting factor structure to that reported by Cox and Alexander (1999) for hearing aid users; and (2) to evaluate the satisfaction level of CI users as measured by the SADL inventory and compare the satisfaction level of unilateral CI users to that of users of a CI and hearing aid in opposite ears.

METHODS

Participants

Participants for the present study were chosen from the cochlear implant research database at the University of Iowa Hospitals and Clinics. All participants had cochlear implantation surgery at the Department of Otolaryngology-Head and Neck Surgery at the University of Iowa. One hundred and twenty-four unilateral CI users completed the inventories, and 100 users (CI-only group) met the inclusion criteria of the present study: all participants were native speakers of English; the average onset age of hearing loss was greater than 6 years (i.e., postlingually deafened); and all participants were at least 12 months postimplantation to increase the likelihood of stable fitting parameters. Bilateral CI users and hybrid CI (short electrode) users were excluded. Fifty-six participants in the CI-only group repeated the SADL within an average 13 months of their original assessments to see if there were any changes on SADL scores.

Fifty-two CI users with hearing aids in the opposite ears completed the inventories, and 35 users (CIHA group) were eligible to join the study based on the inclusion criteria discussed above. All CIHA users in this study voluntarily elected to wear their hearing aids in conjunction with their CIs. Their current hearing aid fittings were not verified to determine appropriateness of fit. We did not validate the hearing aid fittings of the CIHA users because it is unclear as to the best way to fit hearing aids for CI users. In the current study we were trying to survey the satisfaction levels for those CI users who are using hearing aids fit as they wear in their everyday life.

Demographic information is shown in Table 1. Of the total 135 participants, 20 of 100 participants in the CI-only group, and 30 of 35 participants in the CIHA group reported using a hearing aid in the nonimplanted ear before implantation. The nonimplanted ear hearing threshold ranges are similar in both groups. Forty-two CI-only and 19 CIHA listeners were implanted with Clarion devices; 54 CI-only and 16 CIHA listeners were implanted with Nucleus devices; and four CI-only listeners were implanted with Ineraid devices.

Materials

The SADL inventory developed by Cox and Alexander (1999) was used in the present study. The SADL

Table 2. Loadings of Each of the 15 Items in the SADL Inventory for the CI-Only Group (rotation method: Promax and Varimax) of the EFA Model

	Factor 1 Positive Effect		*Factor 2* Negative Features		*Factor 3* Contentment		*Factor 4* Service and Cost	
*Items and short interpretations**	Promax	Varimax	Promax	Varimax	Promax	Varimax	Promax	Varimax
1 (Help you understand people)	0.79	0.77	-----	-----	-----	-----	-----	-----
2 (Frustrated with background sounds)	-----	-----	0.82	0.82	-----	-----	-----	-----
3 (Was in your best interests)	0.84	0.82	-----	-----	-----	-----	-----	-----
4 (Others notice loss more)	-----	-----	0.41	0.45	-----	-----	-----	-----
5 (Reduce asking for repetition)	0.71	0.65	-----	-----	-----	-----	-----	-----
6 (Worth the trouble)	0.81	0.80	-----	-----	-----	-----	-----	-----
7 (Bothered by feedback)	-----	-----	0.85	0.84	-----	-----	-----	-----
8 (Content with the appearance)	-----	-----	-----	-----	0.76	0.75	-----	-----
9 (Improve your self-confidence)	0.59	0.66	-----	-----	---	---	-----	-----
10 (How natural is the sound)	-----	-----	-----	-----	0.59	0.61	-----	-----
11 (Helpful on the telephone)	-----	-----	-----	-----	0.63	0.62	-----	-----
12 (Competent hearing aid provider)	0.80	0.82	-----	-----	-----	-----	-----	-----
13 (Makes you seem less capable)	-----	-----	0.47	0.53	-----	-----	-----	-----
14 (Cost seems reasonable)	-----	-----	-----	-----	-----	-----	0.88	0.87
15 (Pleased with dependability)	-----	-----	-----	-----	-----	-----	0.76	0.78

Note: Each short interpretation for the question is from Cox and Alexander (1999). Loadings <0.40 are not shown.

clustered 15 items into four subscales: Positive Effects (evaluation of acoustic and psychological benefits), Negative Features (e.g., background noise, feedback), Cost and Service, and Personal Image (cosmetics and hearing aid stigma). A value of each of the 15 items was obtained by assigning integers ranging from 1 to 7 correlating to the seven-point Likert scale. The values assigned for the 15 responses were then averaged to determine the global score. For the purpose of the study, the SADL inventory was modified slightly from its original version by changing the term *hearing aid* and replacing it with *hearing devices* (see Appendix 1). The inventory contained the following instructions for answering the 15 items from Cox and Alexander (1999): “Listed below are questions on your opinions about your hearing device(s). For each question, please circle the letter that is the best answer for you. The list of words on the right gives the meaning for each letter. Keep in mind that your answers should show your general opinions about the hearing device(s) that you are wearing now or have most recently worn.”

SADL Measures

The SADL inventory was mailed to each subject, and the participant was asked to either return the inventory in the enclosed self-addressed stamped envelope or by bringing it to their next follow-up clinical session with their implant team. As a result, no audiologists or other clinic staff were involved when participants filled out the inventories. If the participant had questions about the inventory, a contact person was provided when the inventory was mailed. The SADL inventories were completed as a paper and pencil exercise.

For 11 items (1, 3, 5, 6, 8, 9, 10, 11, 12, 14, 15), “tremendously” meant full satisfaction and was scored 7, while “not at all” indicated complete dissatisfaction and was scored 1. For items 2, 4, 7, and 13, scoring is reversed because the wording of each item was negatively related to satisfaction according to Cox and Alexander (1999). For example, “tremendously” on these items would indicate complete dissatisfaction and would be scored 1, and “not at all” would indicate full satisfaction and would be scored 7.

Data Analysis

When the inventories were returned, each was screened to make sure that at least two-thirds of the items in each subscale were completed for the score to be considered valid and used in the analyses (Cox and Alexander, 1999). All of the inventories in this study were considered valid. The missing items were excluded from the data analysis.

The 15-item inventory responses from the CI-only group comprised the source data for the factor analysis. Because the response scale was ordinal in nature and was assumed to reflect underlying continuous variables, factor analytic methods appropriate for ordinal data were employed. Polychoric correlations, which extrapolates what the ordinal variables’ distributions would be if continuous, were first computed in the Statistical Analysis System (SAS), version 9 (SAS Institute, 2004).

To generate a testable model, an exploratory factor analysis (EFA) was conducted based on the polychoric correlation matrix. The EFA is a method to identify the latent structure (dimensions) of a set of variables.

Table 3. Item Groupings for the EFA and Cox Models

	Subscale name	EFA model	Subscale name	Cox model
Factor 1	Positive Effect	1, 3, 5, 6, 9, 12	Positive Effect	1, 3, 5, 6, 9, 10
Factor 2	Negative Features	2, 4, 7, 13	Service and Cost	12, 14, 15
Factor 3	Contentment	8, 10, 11	Negative Features	2, 7, 11
Factor 4	Service and Cost	14, 15	Personal Image	4, 8, 13

Varimax (orthogonal) and Promax (oblique) rotations were both applied to each factor solution. Cox and Alexander (1999) used Varimax rotation method, which resulted in independent factors. A Varimax rotation assumes factors to be uncorrelated whereas a Promax rotation assumes factors to be correlated. It is indicated that the Promax rotation may produce a better estimate of the true factors and more realistic structure than a Varimax rotation would (Thurstone, 1947; Fabrigar et al, 1999). Furthermore, Fabrigar et al (1999) compared Varimax and Promax rotation methods and found that a Promax rotation often created a slightly better simple structure than did a Varimax rotation, but the pattern of loadings was usually the same with Varimax as with Promax rotation. In the present study, we believe that the latent structures were, in fact, correlated, and thus we did the Promax rotation. However, in order to compare to the factor structure from Cox and Alexander (1999), we did Varimax rotation as well. Arbitrary but conventional thresholds of 0.40 for the factor loadings and 1.0 for eigenvalues were applied when interpreting and labeling factors. The eigenvalue for a given factor measured the variance in all the variables that is accounted for by that factor. The preliminary model was established based on the EFA results. We will refer to this as the EFA model throughout this paper. Another issue we need to address here is about item 7 (hearing device feedback). Even though it may not seem appropriate for unilateral CI users, this item can be applied to CIHA users. In addition, we did not develop a new questionnaire for CI users but adapted the developed SADL inventory. If we deleted one item, it might have substantially changed the factor structure of the SADL. Therefore, we decided to keep all the items in the EFA model. We did not specifically instruct the CI users how to answer item 7 in the current study.

The second model was from Cox and Alexander (1999), which was also tested in order to assess whether the factor structure that they reported for hearing aid users also described the structure for CI users in the current study. We will refer to this model as the Cox model.

A confirmatory factor analysis (CFA) was performed via Mplus package software (v1.24) to test whether the data fit either of the models. The EFA is typically most appropriate in the initial stages of model development whereas the CFA provides a more powerful tool in the second stage of research when a model has already been established. In other words, the CFA is used to model data based on previous research. However, there was a limitation to the use of the CFA to test the EFA model in the present study. A better methodology may be to use different data or to split the data in half to test the EFA model. The sample size in the present study was not large enough to split the data in order to properly administer the CFA on the EFA model. Thus, only the Cox model was tested by the CFA in the present study. Future research needs to use a separate group of data to test the EFA model.

Cronbach's alpha (α), corrected item-total correlation, Pearson correlation among the four subscales from the EFA model, Cohen's effect size (d), and the norms were determined for the CI-only group via the Statistical Package for the Social Sciences (SPSS), version 12. Cronbach's alpha (α) is a measure of internal consistency for categorical variables. Corrected item-total correlation indicates the correlation coefficient when an item is deleted. Cohen's effect size is a measure of the magnitude of a treatment effect. It was calculated from the mean global score difference of the CI-only and CIHA groups divided by the pooled standard deviation of both groups (Cohen, 1988). The norms included mean scores and 20th and 80th percentile score values. A nonparametric test (Mann-Whitney Test) was administered to compare the CI-only and CIHA groups.

RESULTS

Factorial Validity of the EFA Model

Four factors (eigenvalue >1.0) were extracted, accounting for 67.1% of the variance in the SADL data from the EFA. The rotated loadings from the Promax and Varimax rotation are both shown in Table 2; the names of the four factors were adapted from Cox and Alexander (1999). Although the loadings for each item were different, the factor structure was almost the same between the Promax and Varimax rotation methods. Factor 1 (38.5% of variance) is referred to as Positive Effect, such as improvements in hearing experience. Items 1, 3, 5, 6, 9, and 12 are loaded on this factor. Factor 2 (11.9% of variance) encompasses four items (2, 4, 7, 13) and is referred to as Negative Features, which is related to problems that CI users

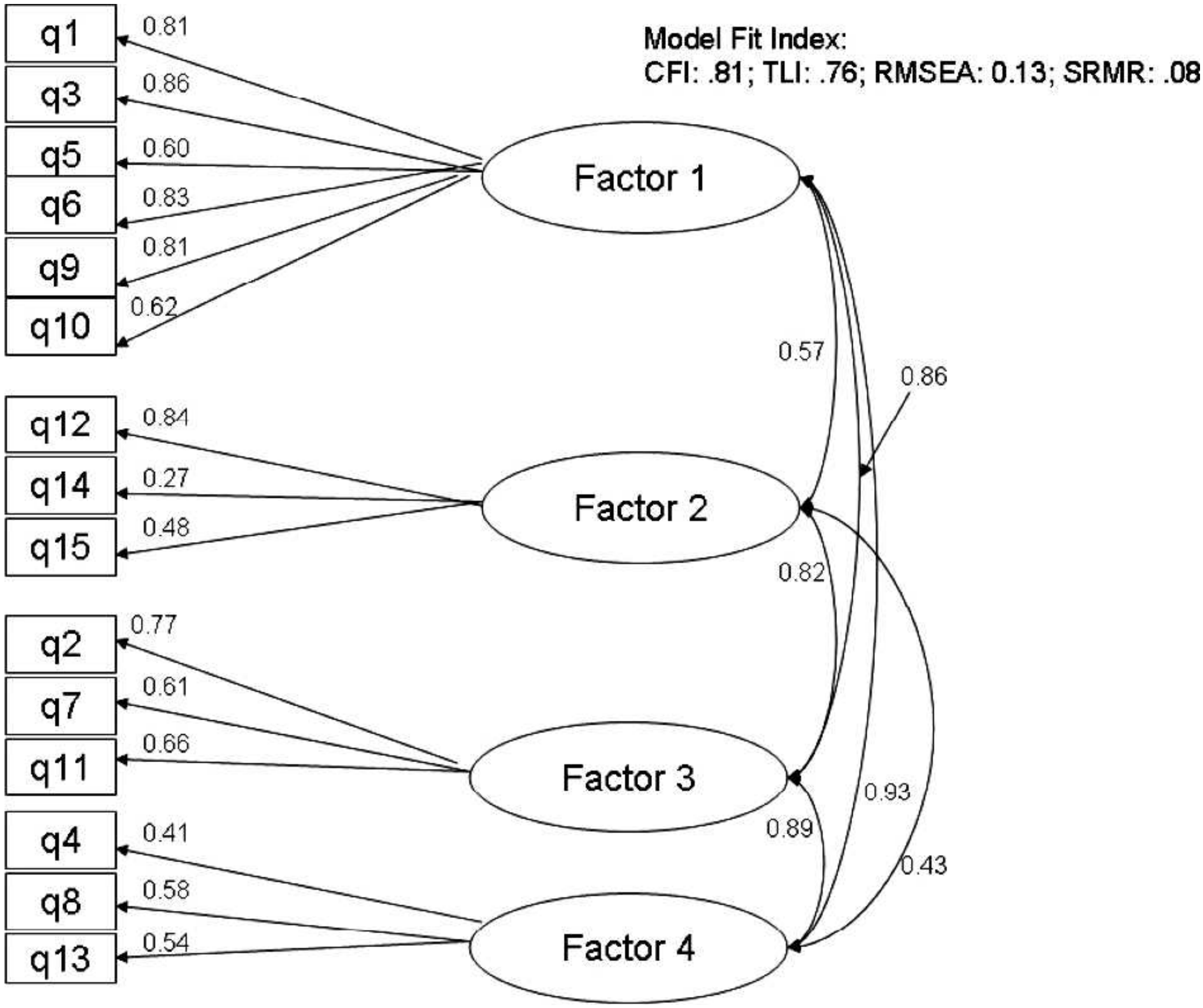

Figure 1. Confirmatory factor analysis (CFA) results for the Cox model. The loading for each item is shown above the arrow on the left side. The correlation coefficients among four factors are shown beside the lines between the factors. TLI = Tucker-Lewis Index; CFI = Comparative Fit Index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual. Reminder: the recommend threshold for each parameter is as follows: TLI > 0.95; CFI > 0.95; RMSEA < 0.06; SRMR < 0.05. q1 = item 1 in the SADL inventory.

may have when using their devices. Factor 3 (9.73% of variance), referred to as Contentment, is related to how content CI users are with their hearing devices. Items 8, 10, and 11 are loaded on this factor. Factor 4 (7% of variance) is referred to as Service and Cost and offloads on items 14 and 15. This factor relates to how satisfied the CI users are with the cost of their devices and clinical services they receive.

The original SADL item loadings (i.e., the Cox model) were found to have both differences and similarities from those for the EFA model. The detailed information of grouping items of both models is displayed in Table 3. Six items were loaded on Factor 1 (Positive Effect) in the EFA model, which accounted for the most variance in the CI-only group data. This factor reflects the benefits of CI. For the EFA and Cox models, items 1, 3, 5, 6, and 9 were loaded on Factor 1. Only one item differed between the EFA and Cox model. Item 12, which concerns the hearing device provider's competence, was loaded on Factor 1 in the EFA model, whereas item 10, which concerns the naturalness of sound, was loaded on Factor 1 in the Cox model. For Factor 2 (Negative Features), the loading differed across the two models. Four items (2, 4, 7, and 13) were loaded on this factor in the EFA model, which included the degree of irritation with environmental noise, hearing device feedback, and stigma. The same items were loaded on two different subscales (Negative Feature and Personal Image) in the Cox model. Relative to Factor 3 (Contentment) in the EFA model, three items (8, 10, and 11) were loaded on this factor, each relating to the hearing device appearance, sound quality, and telephone use, respectively. Factor 3 in the Cox model includes items 2, 7, and 11. The last two items (14 and 15) in the EFA model were loaded on Factor 4 (Service and Cost), which is similar to Factor 2 (12, 14, and 15) in the Cox model.

Table 4. Cronbach's Alpha (α) for Each Subscale of the EFA Model and the Mean and SD for Each Item

Subscale and item	Mean	SD	Corrected IT	α
Positive Effect (*N* = 97)				
1 (Help you understand people)	6.30	1.17	0.57	
3 (Was in your best interests)	6.69	0.86	0.53	
5 (Reduce asking for repetition)	5.40	1.53	0.43	
6 (Worth the trouble)	6.59	1.08	0.46	
9 (Improve your self-confidence)	5.87	1.29	0.59	
12 (Competent hearing aid provider)	6.58	0.73	0.59	0.79
Negative Features (*N* = 90)				
2 (Frustrated with background sounds)	4.24	1.64	0.51	
4 (Others notice loss more)	5.46	1.64	0.32	
7 (Bothered by feedback)	6.02	1.65	0.54	
13 (Makes you seem less capable)	6.38	1.18	0.37	0.65
Contentment (*N* = 97)				
8 (Content with the appearance)	5.26	1.54	0.35	
10 (How natural is the sound)	5.08	1.43	0.51	
11 (Helpful on the telephone)	4.04	2.08	0.49	0.64
Service and Cost (*N* = 94)				
14 (Cost seems reasonable)	4.38	1.69	0.39	
15 (Pleased with dependability)	5.57	1.49	0.39	0.57

Note: Corrected item-total correlation (IT) shows what the correlation would be if that item is deleted.

We performed the CFA on the Cox model. The CFA results, including the loading of each item on the factors, the correlation between the four factors, and the CFA model fit parameters, are presented in Figure 1. All the loadings are greater than 0.40 except for the loading of item 14. The correlations are moderately high between factors. Although there are no universally accepted criteria for judging model fit, Thompson (2004) recommended acceptable thresholds of fit for models with Tucker-Lewis Indexes (TLI) and Comparative Fit Indexes (CFI) greater than 0.95. Acceptable thresholds of fit for root mean square error of approximation (RMSEA) are expected to be less than 0.06 and 0.05 or less for the standardized root mean square residual (SRMR). The Cox model did not meet any of the recommended parameter thresholds. The R-squared value, or percent of variance, for each factor (Positive Effect, $r^2 = 3.47$; Service and Cost, $r^2 = 1.01$; Negative Features, $r^2 = 1.39$; Personal Image, $r^2 = 0.79$) was also determined. It is interesting to notice that

Table 5. The Pearson Correlation Coefficients among the Four Subscales of the SADL for the EFA Model

	Positive Effects	Negative Features	Contentment
Negative Features	0.40*		
Contentment	0.47*	0.46*	
Service and Cost	0.23*	0.10	0.15

*$p < 0.05$ (2-tailed).

Table 6. Norms for the CI-Only Group Based on the EFA Model

Score	Mean	SD	20th percentile	80th percentile
Global score	5.6	0.8	5.1	6.2
Global score (CIHA group)	5.2	1.0	4.3	6.1
Positive effect	6.2	0.8	5.5	6.8
Negative features	5.5	1.1	4.5	6.5
Contentment	4.7	1.3	3.5	5.9
Service and Cost	5.0	1.3	4.0	6.0

Note: The global score and four subscale scores are displayed by mean, SD, and 20th and 80th percentiles. For the CIHA group, only the global score is presented because the subscales for the CIHA group have not been derived.

Factor 3 (Negative Feature subscale) actually explained more variance than Factor 2 (Service and Cost subscale) in the Cox model when it was applied to the CI users.

Internal Consistency

Cronbach's alpha (α) values for each subscale based on the EFA model, as well as the global Cronbach's alpha, were moderately high (0.57–0.79), which reflects the inter-item similarity. The corrected item-total correlations, means, and standard deviations are displayed for each item in Table 4. The relatively high corrected item-total correlations reflected that individual items could positively predict each other.

The Pearson correlation coefficients among the four subscales of the SADL based on the EFA model are presented in Table 5. Positive Effects were significantly correlated with the other three subscales ($p < 0.05$). Contentment was significantly correlated with Negative Features ($p < 0.05$).

Test and Follow-Up Test Stability

Fifty-six subjects in the CI-only group repeated the SADL within an average of 13 months from their original assessment of SADL. Of the 56 with follow-up inventory assessment, the correlation coefficient between the initial test and the follow-up test for global scores ($r = 0.83$) and the four subscales (Positive Effects, $r = 0.80$; Negative Features, $r = 0.76$; Contentment, $r = 0.76$; Service and Cost, $r = 0.55$) were determined. Correlations for the global scores were considered to be moderately high between original inventory assessment and follow-up inventory assessment. Even though test-retest reliability is usually tested within several weeks of an original assessment, all the participants in this analysis were more than 12 months postimplantation at the time of their original assessment, which means that CI users likely had stable fitting parameters with their CIs at both inventory assessments.

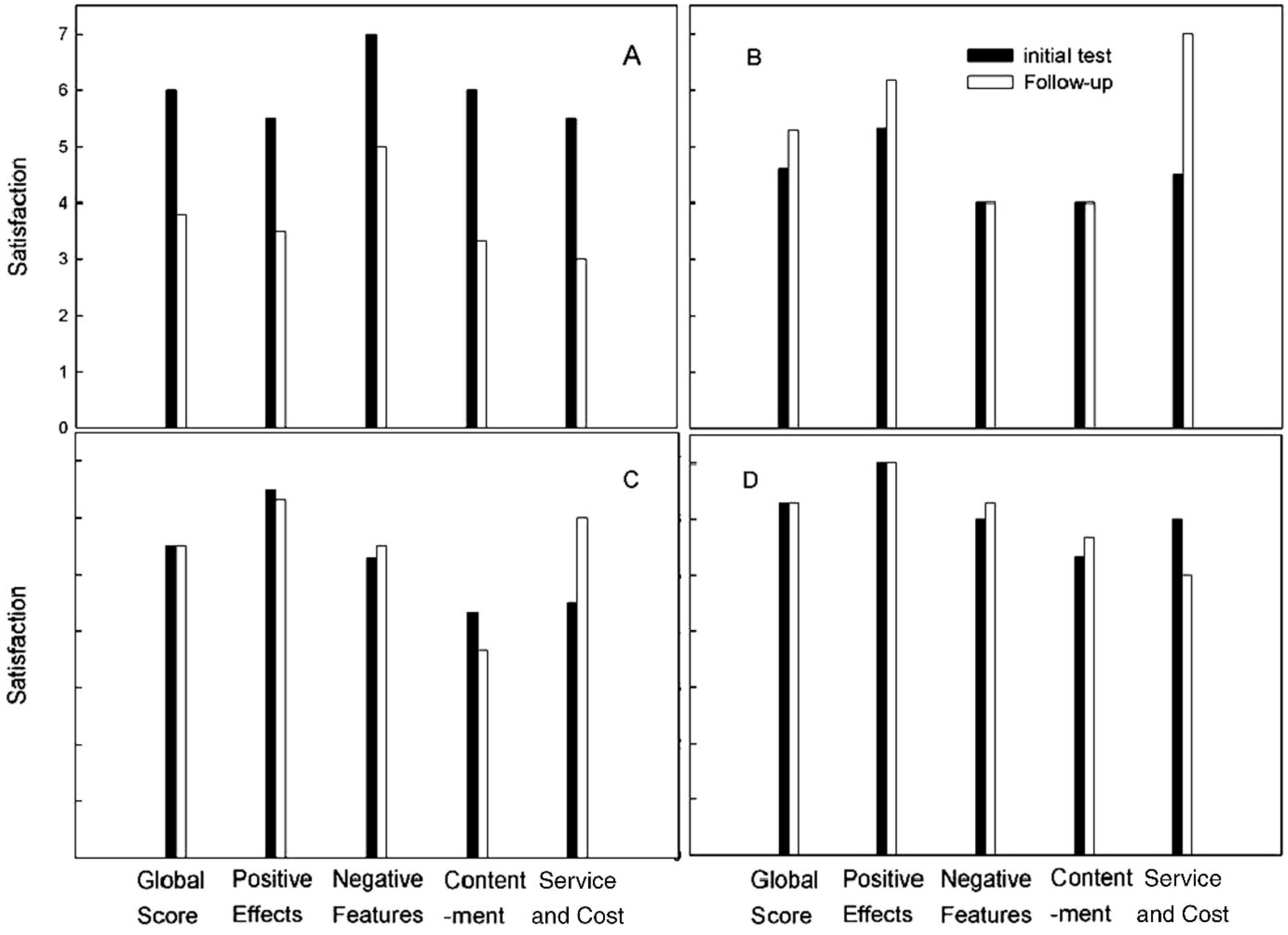

Figure 2. Panels *A–D* show four participant examples of different outcome comparisons between the initial SADL test (filled bars) and follow-up SADL test (open bars) results. Panel *A* shows that the maximum satisfaction level decreased between the initial test and follow-up test. Panel *B* shows that the maximum satisfaction level increased over time. Panels *C* and *D* both show stable global satisfaction levels between the initial test and the follow-up test. However, the subscale-pattern changes are different between these two participants.

Norms for Global and Subscale Scores

We generated the interim norms for global and subscale scores. Mean scores and 20th and 80th percentile scores values were included. Norms for the CI-only group and the CIHA group are given in Table 6. To illustrate individual differences, four examples of different outcomes observed from the original test and the follow-up test are presented in Figure 2. Panel A shows that the maximum satisfaction level decreased between the initial test and follow-up test. The bars are uniformly shifted downward from the initial test to the follow-up test. Panel B shows that the maximum satisfaction level increased over time. However, the biggest change was for the Cost subscale with minor improvement for the Positive Effects subscale and no change for the Negative Features and Contentment subscales. Panels C and D both show stable global satisfaction levels between the initial test and the follow-up test. Nevertheless, the subscales pattern changes are different between these two participants. Panel C shows improved satisfaction level for the Service and Cost subscale and decreased satisfaction for the Contentment subscale. Panel D displays an opposite pattern.

Comparison between CI-Only and CIHA Groups

We attempted a factor analysis for the CIHA group. However, the results were difficult to interpret because the sample size was small. The items were randomly grouped together. Nevertheless, it is not appropriate to assume that the CIHA group had a similar factor structure to the CI-only group. Nonparametric tests (Mann-Whitney) were used to compare scores for the CI-only group with scores for the CIHA group, and no significant differences ($p > 0.10$) were found except for item 7 (hearing aid feedback) ($p < 0.05$). The maximum effect size of the global score between the two groups was 0.5, which reflected a moderate effect (Cohen, 1988). The one-sample t-test was applied to compare the mean score of the CI-only, CIHA group, and Cox and Alexander (1999) data. Both the CI-only group (global score = 5.6) and the CIHA group (global score = 5.2) had significantly higher global scores ($p < 0.05$) than the hearing aid users (global score = 4.9) reported by Cox and Alexander (1999).

DISCUSSION

The purposes of this study were twofold: (1) to explore the factor structure (i.e., subscales), validity, and reliability of the SADL inventory when applied to CI users in a hospital setting and compare the resulting factor structure to that reported by Cox and Alexander (1999) for hearing aid users; (2) to compare the level of satisfaction in CI-only users to that of CIHA users.

Factor Structure Comparison between the EFA and Cox Models

Relative to the first purpose, the factor structure of the EFA model was comparable to the Cox model, but with some notable differences. Factor 1 in both models reflects perceived benefits or improved hearing experiences. One item of Factor 1 that was different between these two models was item 12 (competence of service provider) with the EFA model. This strong loading indicated that CI users consider clinician competence to be an important factor in their level of satisfaction with their CI. It should be noted, however, that item 12 displayed a ceiling effect with a narrow range of responses. Because all the participants were research volunteers, this might reflect a statistical sampling error. Interestingly, Hosford-Dunn and Halpern (2000) also found that item 12 displayed a ceiling effect for hearing aid users sampled from their private-practice clinic.

Factor 2 in the EFA model combines items involving the irritation with the noise or feedback from the Negative Features subscale and stigma from the Personal Images subscale of the Cox model. These items were related to dissatisfaction, in which the scores were reversed to indicate satisfaction. CI users weighed the dissatisfaction aspect expressed in this factor as an important factor contributing to their satisfaction. The second subscale (Factor 2) of the Cox model is Service and Cost, which should explain more variance than the third subscale (Negative Features). However, Negative Features explained more variance according to the CFA results when the Cox model was applied to CI users in the present study. It is consistent with the EFA model.

Factor 3 (Contentment) in the EFA model was different from all of the factors of the Cox model. Although the loading was strong (0.63) on Factor 3, item 11 (helpfulness on the telephone) had the lowest mean score with the largest variability for CI users. This finding is consistent with another study (Hosford-Dunn and Halpern, 2000) in which telephone use was associated with lowest benefit by hearing aid users. It is interesting to notice that item 8 (appearance) and item 11 in their study were also significantly correlated when Hosford-Dunn and Halpern conducted a factor analysis on their data. The substance of Factor 3 in the EFA model is that the cosmetics, the benefits from sound quality, and the helpfulness on the telephone are important to CI users to determine their satisfaction level.

Factor 4 in the EFA model parallels the Service and Cost subscale in the Cox model. The amount of variance, however, explained by the factors is different between these two models. Hearing aid users weighed cost and service more heavily than CI users. The original Cox model is consistent with Kochkin's finding (2005) that customer satisfaction was highly related to the amount of money patients paid. Hearing aids are not covered by most insurance in the United States, with the exception of Veterans Administration (VA) patients. On the other hand, CI devices and the associated surgery fees are mostly covered by insurance. Nevertheless, the battery and the related services (such as follow-up mapping) are usually only covered for one year. In the current study, this factor accounted for the least variance in the EFA model, perhaps because our participants were paid with extra batteries and service as compensation for being in the research protocol. It is interesting to notice that the loading for item 14 (cost) is lower than 0.40 from the CFA results of the Cox model. It suggested that this item may need to be either modified or removed for CI users.

Because we did not have a separate group of data to test the EFA model through the CFA, it is not appropriate to draw a conclusion about which model is the best for CI users. In addition, the CFA results indicated that the Cox model when applied to CI users did not meet the best-fit criteria.

Internal Consistency and Stability Based on the EFA Model

The estimates of internal consistency, as measured by Cronbach's Alpha in the EFA model, were moderately high. This means that the SADL inventory test is moderately reliable on each subscale. For the Positive Effect subscale, Cronbach's alpha (0.79) is consistent with other reports; for the rest of three subscales, Cronbach's alpha values (0.57–0.65) are even higher than other reports (Cox and Alexander, 1999; Hosford-Dunn and Halpern, 2000). In the present study, we did the follow-up measurement of the SADL within an average of 13 months of initial assessment. The average initial assessment was at least 12 months after implantation. On average, the follow-up SADL assessment was completed at 100.1 months following implantation, during which the fitting parameters were stable. The correlations indicated moderate stability for the global scores and four subscales. The follow-up assessment could be used as an indicator to see the trend change of satisfaction levels. It should be noted that the satisfaction level may have changed in response to either auditory acclimatization (improvement in auditory performance over time) or a shift in the expectations of the treatment in the present study. Therefore, it is possible that the follow-up assessment measured a longitudinal effect in CI satisfaction in the present study.

Limitations of the SADL Applied to CI Users

Some aspects of satisfaction, specific to CI users, were not included in the SADL inventory. For example, medical complications related to surgery and implantation of devices should be included. For instance, meningitis is a potential risk with implanted users. Biernath et al (2006) reported that 12 pediatric CI users were identified to have meningitis between 2002 and 2004. Therefore medical complications, such as meningitis, may need to be addressed in the inventory. Other issues, such as discomfort with the pedestal and cord, soreness and redness near implant site, and tinnitus after implantation need to be considered. In addition, it is common to observe some implanted electrodes being turned off because of short or open circuits among electrodes. Thus the reduced number of useful electrodes may result in deteriorated speech perception ability. It is possible that CI users might experience failed internal devices. Thus they may have to be reimplanted. This might cause the deterioration of satisfaction level.

Determining the Satisfaction Level of CI Users and Comparing Their Satisfaction with Hearing Aid Users

The CI users studied here had significantly higher global satisfaction than the hearing aid users studied by Cox and Alexander (1999). One possible reason for this finding could be that because CI users voluntarily elect to undergo surgery to improve their hearing ability, they are more vested in their hearing treatment and thus may have a more positive outlook on their performance. Another explanation for this finding may be the fact that most CI users have profound hearing loss before implantation, whereas hearing aid users have a wider range of degrees and configurations of hearing loss. Because of this, CI users may perceive a larger amount of improvement in hearing than do HA users, resulting in CI users having higher satisfaction levels than hearing aid users. However, it is inconclusive whether or not the degree of hearing loss has an effect on satisfaction levels. Some studies showed relatively weak to moderate correlations between hearing loss and hearing aid satisfaction (e.g., Dillon et al, 1997; Hosford-Dunn and Halpern, 2001). Others indicate that no significant relationship exists (e.g., Bentler et al, 1993; Gatehouse, 1999). In order to avoid the confounders of more residual hearing in hearing aid users when comparing CI users to hearing aid users, future comparisons should involve groups matched for baseline hearing (i.e., CI users should have similar preimplanted hearing as hearing aid users).

A third contributing factor that may explain the differences between the satisfaction of CI users in comparison to the satisfaction of hearing aid users may be the time interval after receiving their hearing devices when they were given the SADL inventory. McLeod et al (2001) reported that mean scores of the SADL among hearing aid users in their study declined from the initial assessment given at two weeks post-device fitting to the second assessment given at 12 months post-device fitting. They used the term *honeymoon effect* to explain the high scores at two weeks. However, they did not recommend an appropriate time to measure the satisfaction by the SADL inventory. Auditory acclimatization may explain the honeymoon effect. Tyler and Summerfield (1996) found that the majority of the adult CI users showed significant performance improvements with time and the performance reached asymptote over 30 to 40 months of implant use. In the present study, the follow-up test of the SADL was administered on average 13 months after initial testing on the CI listeners, and the initial testing was at least 12 months postimplantation, which may not have reached the peak of the performance. However, Vestergaard (2006) evaluated the satisfaction change over 13 weeks through different self-reported measures including the SADL, and no significant changes or only small changes in some subscales were observed. Furthermore, Vestergaard (2006) pointed out that early self-report outcome measurement may give misleading information because of poor face validity found in the data collected immediately after hearing aid fitting. Because the test-retest interval in the present study was much longer than the interval used by McLeod et al (2001) or Vestergaard (2006), future research needs to determine a short term follow-up test to observe changes in satisfaction postimplantation.

The second purpose of this study was to compare the level of satisfaction in the CI-only group to that of the CIHA group. As discussed previously, we could not do a factor analysis for the CIHA group because the sample size was too small. However, the item comparisons indicated no significant differences between the two groups except for item 7 (hearing aid feedback). It should be noted that the comparison of item 7 is not applicable to unilateral CI users' experiences because it is not possible for CIs to produce auditory feedback. In contrast, CIHA users still can experience feedback through their hearing aids. It is interesting to find that the satisfaction level of item 7 (Mean = 5, SD = 1.75) in the CIHA group was moderately high, which means that CIHA users in general were not bothered by the feedback problem. Nevertheless, Vestergaard (2006) found that item 7 had poor validity because most respondents in his study seemed not to understand the relationship between preventing feedback and obtaining sufficient gain. The effect size between CI-only and CIHA groups was relatively moderate, which may indicate that the hearing aid does not bring higher satisfaction for CIHA users in comparison to CI users who do not utilize a hearing aid. However, it should be noted that the comparison in the present study is not between CI and CIHA use within a CIHA group of participants. It is possible that the level of satisfaction for CIHA use may well be higher than that for CI-only use within the same group when bimodal benefits are present. Furthermore, because the sample size of the CIHA group was small, future studies should involve a larger sample size to confirm this notion. In addition, a larger sample size for the CIHA group would allow for a different factor structure to be developed for the SADL inventory.

Clinical Applications

The SADL inventory can be used in clinical settings to help identify problem areas that may not be identified through standard objective tests. The validity and reliability of the SADL in the present study was consistent with that reported in previous studies (Cox and Alexander, 1999, 2001; Hosford-Dunn and Halpern, 2000, 2001). Thus, clinicians can use the SADL to measure satisfaction level for CI users. Different outcomes across subscales can help explain the various aspects of satisfaction for individuals. For example, some individuals may be less satisfied with the sound quality, and others may be less satisfied with issues of cost and service. These findings can help the clinician not only focus on the follow-up counseling but also guide ongoing management of those individuals by assessing changes in their follow-up tests. For example, if a CI user has a decline in satisfaction, it may provoke the clinician to investigate the reason for the change and perhaps alter some fitting parameters. Thus, the SADL inventory could have high clinical usefulness.

In summary, this study demonstrated that the adapted SADL inventory has good factorial validity and psychometric properties for CI users. As a result, the SADL inventory could be a useful clinical tool for CI users as well as hearing aid users.

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Appendix 1. Satisfaction with Amplification in Daily Life (SADL)

Instructions:

Listed below are questions on your opinions about your hearing device(s). For each question, please circle the letter that is the best answer for you. The list of words below gives the meaning for each letter.

Keep in mind that your answers should show your general opinions about the hearing device(s) that *you are wearing now or have most recently worn*.

A = Not At All, B = A Little, C = Somewhat, D = Medium, E = Considerably, F = Greatly, G = Tremendously

1.	Compared to using no hearing device(s) at all, does your hearing device(s) help you understand the people you speak with most frequently?	A	B	C	D	E	F	G
2.	Are you frustrated when your hearing device(s) pick up sounds that keep you from hearing what you want to hear?	A	B	C	D	E	F	G
3.	Are you convinced that obtaining your hearing device(s) was in your best interests?	A	B	C	D	E	F	G
4.	Do you think people notice your hearing loss more when you wear your hearing device(s)?	A	B	C	D	E	F	G
5.	Does your hearing device(s) reduce the number of times you have to ask people to repeat?	A	B	C	D	E	F	G
6.	Do you think your hearing device(s) is worth the trouble?	A	B	C	D	E	F	G
7.	Are you bothered by an inability to turn your hearing device(s) up loud enough without getting feedback (whistling)?	A	B	C	D	E	F	G
8.	How content are you with the appearance of your hearing device(s)?	A	B	C	D	E	F	G
9.	Does wearing your hearing device(s) improve your self-confidence?	A	B	C	D	E	F	G
10.	How natural is the sound from your hearing device(s)?	A	B	C	D	E	F	G
11.	How helpful is your hearing device(s) on MOST telephones with no amplifier or loudspeaker?	A	B	C	D	E	F	G
12.	How competent was the person who provided you with your hearing device(s)?	A	B	C	D	E	F	G
13.	Do you think wearing your hearing device(s) makes you seem less capable?	A	B	C	D	E	F	G
14.	Does the cost of your hearing device(s) seem reasonable to you?	A	B	C	D	E	F	G
15.	How pleased are you with the dependability (how often it needs repairs) of your hearing device(s)?	A	B	C	D	E	F	G