International Journal of Audiology

ISSN: 1499-2027 (Print) 1708-8186 (Online) Journal homepage: informahealthcare.com/journals/iija20

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To cite this article: Charlotte Thunberg Jespersen, Michael Bille & Jonas Vester Legarth (2014) Psychometric properties of a revised Danish translation of the international outcome inventory for hearing aids (IOI-HA), International Journal of Audiology, 53:5, 302-308, DOI: 10.3109/14992027.2013.874049

To link to this article: https://doi.org/10.3109/14992027.2013.874049

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Published online: 29 Jan 2014.

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International Journal of Audiology 2014; 53: 302–308

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Original Article

Psychometric properties of a revised Danish translation of the international outcome inventory for hearing aids (IOI-HA)

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Abstract

Objective: The original Danish translation of the international outcome inventory for hearing aids (IOI-HA) proved problematic as the wording of item 5 was not semantically clear, rendering the questionnaire internally inconsistent. The objective of this study was to examine data collected with a revised Danish translation of the IOI-HA in order to: (1) evaluate the effect of the revision, and (2) to examine if the psychometric properties of the revised translation of the IOI-HA are equivalent to those of previously validated translations. *Design:* Psychometric properties were evaluated performing inter-item correlation analysis, principal component analysis, and item-total correlation. *Study sample:* Three hundred forty-one adult hearing-impaired participants – all of whom were voluntary hearing aid testers attached to the Global Audiology Group in GN ReSound A/S on a non-payment basis – were mailed a revised Danish IOI-HA questionnaire. *Results:* Statistical analysis revealed good internal consistency along with a clear division of items into two distinct factors. *Conclusions:* The revised Danish translation of the IOI-HA proves internally consistent. Furthermore, it possesses psychometric properties equivalent to those reported in several corresponding studies of other translations. Data obtained from it can therefore validly be considered comparable to data obtained from previously validated translations of the IOI-HA.

Key Words: IOI-HA; psychometric properties; hearing aid fitting outcome

The international outcome inventory for hearing aids (IOI-HA) was developed in order to make a standardized and internationally useful self-report measure. It was desirable to get a self-report measure making it possible to achieve comparable and quantifiable data on how fitting of hearing aids impacts hearing aid users' lives (Cox et al, 2000). The IOI-HA is a short questionnaire developed to quantify the outcome of a hearing aid fitting from a hearing aid user's point of view (Cox & Alexander, 2002). The IOI-HA consists of seven items, each investigating a different aspect of the personal impact of a hearing aid fitting on the hearing-impaired person's life. The items relate to: (1) daily use, (2) benefit, (3) residual activity limitations, (4) satisfaction, (5) residual participation restrictions, (6) impact on others, and (7) quality of life. The wording and construction of the items intend to minimize literacy and cognitive demands. Each item has a separate response continuum with response choices always proceeding from worst outcome on the left to best outcome on the right, to maximize the comprehensibility of the inventory. All items are scored using the integers from 1 (poorest outcome) to 5 (best outcome) for the five response choices. While the total score gives an indication of the overall outcome, several studies have identified two distinct subscales within the IOI-HA (Cox & Alexander, 2002; Kramer et al, 2002; Heuermann et al, 2005; Smith et al, 2009; Brännström & Wennerström, 2010). These subscales respectively relate to introspective aspects of the hearing aid treatment (items 1, 2, 4, 7); and to the hearing-impaired person's interaction with his or her surroundings (items 3, 5, 6). The inventory is intended to be administered by paper-and-pencil and to be self-explanatory with no formal instructions required for the hearing aid user (Cox & Alexander, 2002). However, the IOI-HA can be administered in an online format and yield similar results as its paper-and-pencil counterpart without compromising reliability (Thorén et al, 2012).

In order to make the IOI-HA useful across different applications around the world it is essential to generate psychometrically equivalent translations in a number of native languages from countries where hearing aid treatment and assessment are performed. This will make results obtained with the IOI-HA directly comparable across countries and studies. Apart from the English original, translations were made available in 21 other languages (Cox et al, 2002). Detailed analyses of the psychometric properties are published for the English version in the United States (Cox & Alexander, 2002; Smith et al, 2009), Nigeria (Olusanya, 2004) and Wales (Stephens, 2002), as well as for the Dutch (Kramer et al, 2002), German (Heuermann et al, 2005), Turkish (Serbetcioglu et al, 2009), Portuguese (Gasparin et al, 2010), and Swedish (Brännström & Wennerström, 2010) translations.

Jespersen and colleagues (2005) determined the psychometric properties of the original Danish translation. They found that the translation in general had similar psychometric properties to those

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(Received 21 May 2013; accepted 7 December 2013)

ISSN 1499-2027 print/ISSN 1708-8186 online © 2014 British Society of Audiology, International Society of Audiology, and Nordic Audiological Society
DOI: 10.3109/14992027.2013.874049

Abbreviations

BTE	Behind-the-ear
IOI-HA	International outcome inventory for hearing aids
ITE	In-the-ear
PTA	Pure-tone average

of the English original (Cox & Alexander, 2002) as well as to the Dutch and German translations (Kramer et al, 2002; Heuermann et al, 2005). However, it was also established that item 5 (residual participation restrictions) did not make a logical contribution to the overall score in the original Danish translation. This rendered the translation incommensurable in regards to the validated translations. It was suggested that the problem had a semantic origin which might be remedied by a rewording of item 5. This concern was also raised by Vestergaard (2006) who also found that item 5 in the original Danish translation did not make a consistent contribution.

The wording of item 5 was subsequently changed to address the flaw, as seen in Table 1. The original English question was, '*Over the past two weeks, with your present hearing aid(s), how much have your hearing difficulties affected the things you can do?*' The main difference between the original and the revised Danish translation of this item is how the word '*affected*' is translated. In the original translation, the word '*indflydelse*' (influence) was used and grammatically utilized as a noun rather than a verb. In the revision, this has been changed to the word '*begrænset*' (limited) and grammatically used as a verb in the current validation. This change was believed to remove the doubt about whether '*affected*' was understood as having a positive or negative meaning. The word '*indflydelse*' (influence) can be interpreted as either positive or negative, whereas the word '*begrænset*' (limited) solely has a negative connotation in the given context. Furthermore, '*hearing difficulties*' was changed to '*remaining hearing difficulties*' to signify that this question is to be answered when considering the difficulties that are present even while using hearing aids. Overall, the changes in item 5 allow the scale to remain uninverted and unidirectional, meaning that a higher score still expresses a positive response. This is fully in line with the other IOI-HA items.

The original Danish IOI-HA translation has been used for research purposes prior to its original revision and validation (Parving & Christensen, 2004), and the revised translation has already been used in a study although it was not yet validated at that time (Olsen et al, 2012). There is thus a need for an analysis of the psychometric properties of this revised translation to ensure that the issue concerning item 5 has been resolved, and to investigate whether or not the revised Danish IOI-HA can be instituted as a valid and reliable research instrument.

The purpose of this study is thus twofold; to obtain and analyse data achieved with the revised Danish IOI-HA translation in order to: (1) evaluate if the revision of item 5 has rendered the translation internally consistent, and (2) to examine if the revised translation is psychometrically equivalent to previously validated versions of the IOI-HA.

Method

The revised Danish translation of the IOI-HA was mailed to all hearing-impaired individuals attached to the Global Audiology Group in GN ReSound A/S, Denmark. These individuals are all voluntary participants who validate hearing aids and accessories on a non-payment basis. Demographic and audiometric data, as well as hearing aid ownership information are updated for participants on a yearly basis. A total of 341 adult participants received the IOI-HA questionnaire. They were asked to fill out the IOI-HA based on experience with their own personal current hearing aid. To ensure that the hearing aid information available was up-to-date, the respondents were asked to add information regarding type and age of their current hearing aid. They were informed that they were welcome to make contact if they had any queries regarding the questionnaire. No effort was made to sample the participants by type or brand of hearing aid, type and severity of hearing loss or any demographic variable. A total of 281 participants responded yielding a response rate of 82.4%. Ten questionnaires were returned unanswered as the participants did not possess hearing aids at the time while another ten

Table 1. Wording of item 5 in the English original IOI-HA, along with the original and revised Danish translations supplied with English literal translations.

Original English IOI-HA	Over the past two weeks, with your present hearing aid(s), how much have your hearing difficulties affected the things you can do?" *(1) affected very much, (2) affected quite a lot, (3) affected moderately, (4) affected slightly, (5) affected not at all*
Original Danish IOI-HA translation	Hvor meget har dine høreproblemer med dit nuværende høreapparat i de seneste to uger haft indflydelse på de ting, du kan gøre? *(1) betydelig indflydelse, (2) en hel del indflydelse, (3) moderat indflydelse, (4) lidt indflydelse, (5) slet ingen indflydelse* How much have your hearing difficulties, with your current hearing aid, over the past two weeks had an influence on the things you can do? *(1) significant influence, (2) a great deal of influence, (3) moderate influence, (4) slight influence, (5) no influence at all*
Revised Danish IOI-HA translation	Hvor meget har dine resterende høreproblemer med dit nuværende høreapparat begrænset dig i dit daglige liv i de seneste to uger? *(1) begrænset mig betydeligt, (2) begrænset mig en hel del, (3) begrænset mig moderat, (4) begrænset mig lidt, (5) slet ikke begrænset mig* How much have your remaining hearing difficulties, with your current hearing aid, limited you in your daily life, over the past two weeks? *(1) limited me significantly, (2) limited me a great deal, (3) limited me moderately, (4) limited me slightly, (5) not limited me at all*

questionnaires were incompletely filled out and hence omitted from the data set. No reminder was issued. A little more than one year later, 60 randomly selected participants that had already responded to the revised Danish IOI-HA questionnaire were mailed the questionnaire once more and asked to fill it out again based on their current hearing aids. Fifty-four of these responded resulting in a retest response rate of 90%.

All participants consented to take part in the study and were informed that they could leave the study at any time. Participants also consent to GN ReSound keeping a record of demographic and audiometric information on a yearly basis in accordance with Danish data protection law. Participants were not compensated for their participation.

Participants

The participants' mean age was 69 years (SD = 11 years). Thirty-one percent were female. There was a broad variety in the participants' current hearing aids in regards to device type, purchase date, level of technology, and manufacturer. A total of 83% were currently fitted with BTE instruments while 17% were using custom ITE instruments. Eighty-eight percent of the participants were fitted bilaterally. The mean wear time of the current hearing aids was 26 months (SD = 18 months). The hearing losses of the participants included sensorineural hearing losses as well as conductive and mixed hearing losses. The mean pure-tone threshold of both ears averaged across 0.25, 0.5, 1, 2, and 4 kHz ranged from 11 dB HL to 109 dB HL (mean 46 dB HL, SD = 17 dB). Audiograms were available for all subjects and their hearing loss shape was categorized in agreement with a commonly used definition (Allen et al, 2010). An audiogram was characterized as *flat* if the average pure-tone threshold of respectively 0.25 and 0.5 kHz, 1 and 2 kHz, 4 and 8 kHz were all within 15 dB of each other. An audiogram was categorized as *high-frequency gently sloping* if the difference between the average of 0.5 and 1 kHz and the average of 4 and 8 kHz were greater than 15 dB but below 30 dB. If this difference was at least 30 dB, the audiogram was then characterized as *high-frequency steeply sloping*. Audiograms that did not meet the criteria of these three definitions were labeled *other*. Fifty-seven percent could be characterized as high-frequency steeply sloping, 21% as high-frequency gently sloping, 11% as flat, while an additional 11% were classified as 'other'. Demographic data corresponded to the time at which the participants filled out the IOI-HA questionnaire. The audiometric data was up to one year old.

Statistics

To ensure maximum inter-study comparability, the statistical analysis in this study was largely in line with the procedure applied by Cox & Alexander (2002). The item scores were examined for correlation to several demographic variables. The psychometric properties were studied by examining to which extent the different items were internally related. Due to skewed distributions in certain items, inter-item correlation was examined by calculation of Spearman's rho correlation coefficient; $p < 0.01$ was deemed statistically significant. Subsequently, a principal component analysis was performed using varimax rotation identifying components with an eigenvalue above 1. The item loadings on the factors were calculated; only item loadings of at least 0.5 were deemed statistically significant. Furthermore, item-total statistics were performed by calculation of the corrected item-total correlation, i.e. the correlation between the score of an item and the total score for all remaining items combined. Cronbach's alpha values were calculated for the general total scale, for each of the two subscales, and for each item in case the item hypothetically was removed from the data set. To assess test-retest reliability, questionnaires were mailed to 60 randomly selected respondents more than a year after the original data collection. Respondents who had received a new hearing aid since the first time they filled out the questionnaire were omitted from the data set to minimize external test-retest variation. Spearman's rho correlation coefficients were calculated for the total score and the two subscales. However, as the retest took place more than one year after the original data collection, a flawless correlation would not be anticipated as some participants' hearing losses might have progressed, and their hearing aids due to wear might no longer be optimal, and might even have reached a state where they are eligible for replacement. Therefore, Cronbach's alpha was calculated to ensure that the internal consistency of the scale was stable over time as the psychometric properties are the focus of the study.

All statistical analyses were performed using XLSTAT 2012.

Results

No statistically significant correlations were found between item scores and the demographic variables participant age, participant gender, hearing aid type, unilateral vs. bilateral fitting, or current hearing aid age. Correlation analysis showed a weak but statistically significant positive correlation between PTA (0.25, 0.5, 1, 2, 4 kHz) and item 1 (daily use) and item 4 (satisfaction). A weak yet statistically significant negative correlation was discovered between PTA and item 5 (residual participation restrictions) and item 6 (impact on others). The mean scores for each of the seven items, as seen in Figure 1, were relatively high. For items 1, 2 and 4, the most frequent score given was five, while items 3, 5, 6 and 7 all had four as the modal score, as seen in Figure 2. The item-total score, which has a range from 7 at poorest to 35 at best, yielded a mean score of 28.0 (SD = 4.8, median = 29.0) and assumes a negatively skewed distribution, as shown in Figure 3. The item-total score for the Factor 1 subscale (items 1, 2, 4, 7) ranged from 4 to 20 with a mean score of 17.0 (SD = 3.2, median = 18.0). The item-total score for the Factor 2 subscale (items 3, 5, 6) ranged from 3 to 15 with a mean score of 11.0 (SD = 2.5, median = 12.0).

Each of the seven IOI-HA items is devised to address a different domain of hearing aid fitting outcome. For this reason

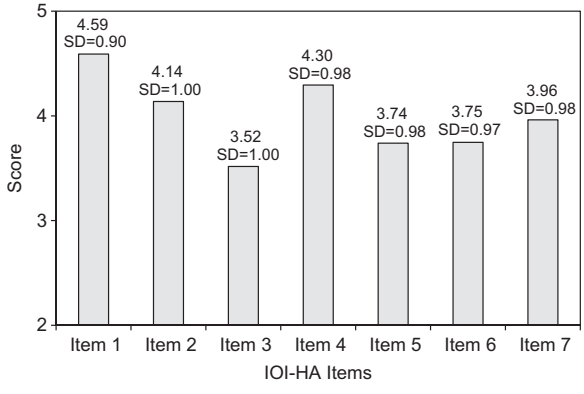

Figure 1. Mean score for each item on the revised Danish IOI-HA (n = 261).

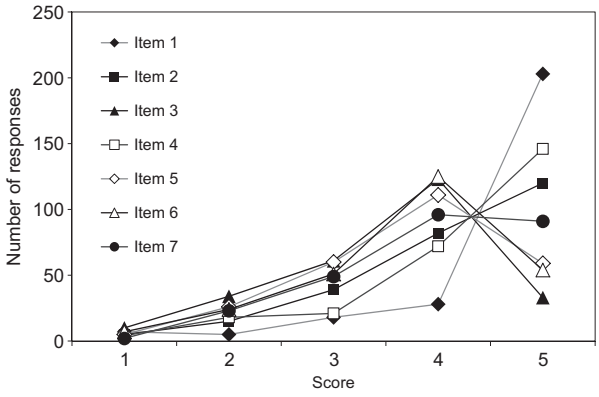

Figure 2. Distribution of responses for each item for the revised Danish IOI-HA (n = 261).

it was of interest to evaluate to what extent the responses to the different items are internally related. As seen in Table 2, the inter-item correlation analysis shows a wide variation in the correlation coefficients ranging from 0.10 between item 1 (daily use) and item 5 (residual participation restrictions) to 0.72 between item 2 (benefit) and item 7 (quality of life). Item 1 (daily use) appears to be the item with the overall lowest degree of inter-item correlation, while items 2 (benefit) and 7 (quality of life) possess the overall highest degree of inter-item correlation.

A principal component analysis led to the extraction of two factors (eigenvalue > 1) accounting for 43.2% and 16.0% of the score variance. After performing varimax rotation, a clear separation of items into the two factors was identified, as shown in Figure 4. The factor loadings can be seen in Table 3 and show that Factor 1 included item 1, 2, 4 and 7, while Factor 2 was comprised of item 3, 5 and 6.

When the score distributions for the two factors are isolated and portrayed, a clear trend becomes visible, suggesting that the two factors seem to measure two fundamentally different psychometric aspects. When fitted with a third order polynomial, as seen in Figure 5, the combined item scores of Factor 1 are monotonically increasing while the combined item scores of Factor 2 – apart from an outlier – to some extent resemble a negatively skewed bell-curve with a local maximum at the score 12.

To investigate the internal reliability of the scale, Cronbach's alpha value was calculated and found to be 0.82 for the overall scale, indicating good internal consistency. When divided into the two subscales, Cronbach's alphas were 0.81 for Factor 1 and 0.84 for Factor 2, revealing that both subscales individually were internally consistent. A corrected item-total correlation is useful in determining whether or not an item can be considered logically contributory in an overall scale. If an item yields a low item-total correlation, the overall internal consistency of the scale is weakened. This can be tested by hypothetically removing the item and recalculating Cronbach's alpha. If this value then increases, the removed item did not make a logical contribution to the scale and the item should then be considered for elimination from the scale. As seen in Table 4, item 1 (daily use) has the lowest correlation to the remaining items, while all other items have relatively strong item-total correlations. Item 1 is also the only item that would increase Cronbach's alpha if removed, though only by 0.01. With a value of 0.50, item 1 also assumes the lowest valid factor loading before the cut-off.

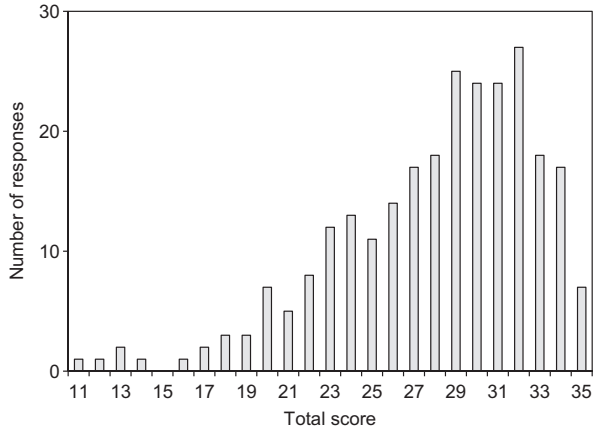

Figure 3. Distribution of total outcome scores for the revised Danish IOI-HA (n = 261).

Table 2. Inter-item correlations for the revised Danish IOI-HA using Spearman's rho (n = 261).

Item no.	*Item 2*	*Item 3*	*Item 4*	*Item 5*	*Item 6*	*Item 7*
Item 1	0.44**	0.15	0.40**	0.10	0.13	0.36**
Item 2		0.39**	0.61**	0.33**	0.30**	0.72**
Item 3			0.35**	0.59**	0.60**	0.39**
Item 4				0.21**	0.19**	0.60**
Item 5					0.70**	0.34**
Item 6						0.30**

**Correlation is significant at the 0.01 level.

Only 25 of the 54 test-retest participants still used the same hearing aid(s) as they did at the time of the original data collection. The test-retest assessment yielded a total score correlation coefficient of 0.75, while the Factor 1 subscale was 0.78 and the Factor 2 subscale was 0.54; all statistically significant at the $p < 0.01$ level. Cronbach's alpha was 0.79 for the overall total score, 0.74 for the Factor 1 subscale and 0.80 for the Factor 2 subscale indicating overall good internal consistency and thus good test-retest reliability.

Discussion

The revision of the original Danish IOI-HA translation has efficiently eliminated the internal inconsistency caused by item 5 that prevented

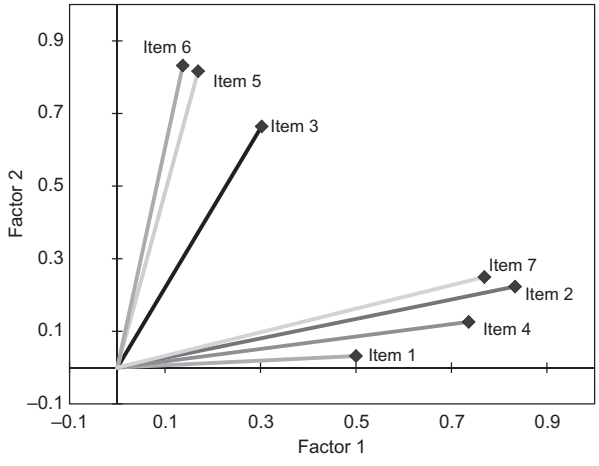

Figure 4. The location of each item in rotated space after varimax rotation on the revised Danish IOI-HA (n = 261).

Table 3. Loadings ≥0.5 of the revised Danish IOI-HA items on the two extracted factors after varimax rotation (n = 261).

Item no.	*Factor 1*	*Factor 2*
Item 1	0.50	
Item 2	0.83	
Item 3		0.66
Item 4	0.74	
Item 5		0.82
Item 6		0.83
Item 7	0.77	

Table 4. Item-total statistics for the revised Danish IOI-HA (n = 261).

Item no.	*Corrected item-total correlation*	*Cronbach's alpha if item deleted*
Item 1	0.34**	0.83
Item 2	0.66**	0.77
Item 3	0.59**	0.79
Item 4	0.55**	0.79
Item 5	0.57**	0.80
Item 6	0.55**	0.80
Item 7	0.65**	0.78
Cronbach's alpha		0.82

**Correlation is significant at the 0.01 level.

the original Danish translation from holding comparable validity (Jespersen et al, 2005). The clearest indication of the improvement can be illustrated by comparing the internal consistency of the two Danish IOI-HA translations. The original translation had an overall Cronbach's alpha value of 0.73, which was raised to 0.83 if item 5 were to be deleted (Jespersen et al, 2005). Vestergaard (2006) experienced the same phenomenon when using the original Danish translation and found that the deletion of item 5 would increase Cronbach's alpha from 0.67 to 0.83. The revised translation has an overall Cronbach's alpha value of 0.82, which is lowered to 0.80 if item 5 was to be deleted, clearly showing that the revision of the translation has had the intended positive effect. Likewise, the original item 5 had an item-total correlation of −0.09 while the revised item 5 returned an item-total correlation of 0.57. This substantial difference in contribution to internal consistency is solely attributed to a minor yet central change in the wording of item 5. This revision serves as a textbook example of the great impact even seemingly minor changes in wording can have on reliability and validity and greatly stresses the importance of semantics when formulating and translating questionnaires.

In regards to the psychometric properties, the overall results from the revised Danish translation of the IOI-HA are in general agreement with the findings of studies based on other translations (Cox & Alexander, 2002; Kramer et al, 2002; Heuermann et al, 2005; Smith et al, 2009; Brännström & Wennerström, 2010), while its factorial distribution differs slightly from Gasparin et al (2010) and Serbetcioglu et al (2009).

The study found a well-defined bifactorial distribution of items which suggests that the IOI-HA is psychometrically composed of two subscales measuring two different fundamental domains. In the bifactorial analysis, Factor 1 can be understood as pertaining to introspective aspects of the hearing aid treatment in relation to the individual hearing-impaired person, while Factor 2 relates to the interaction of the hearing-impaired person with the surroundings.

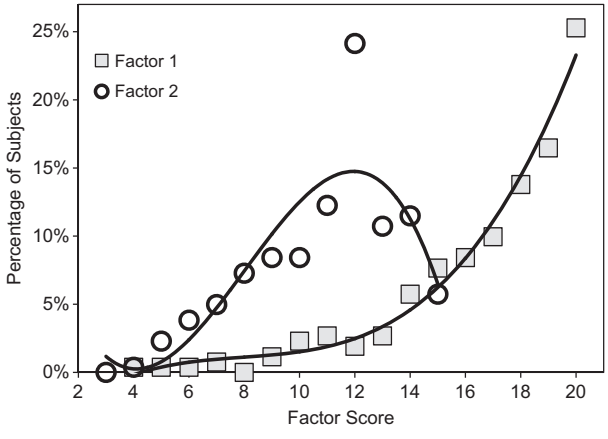

Figure 5. Distribution of IOI-HA outcome scores for Factor 1 and Factor 2 fitted with a best-fit third-order polynomial (n = 261).

This factorial distribution is similar to what the majority of previous studies have shown (Cox & Alexander, 2002; Kramer et al, 2002; Heuermann et al, 2005; Smith et al, 2009; Brännström & Wennerström, 2010) whereas it differs from the analysis by Serbetcioglu et al (2009) and Gasparin et al (2010), which respectively yielded a unifactorial and trifactorial result. Olusanya (2004) and Stephens (2002) both reported a bifactorial distribution but found that item 3 had a higher loading on Factor 1 than on Factor 2.

Although all items in the revised translation in general are logically contributory, item 1 marginally differs from the other items. It is the only item that causes an increase in Cronbach's alpha value if removed, though this marginal increase of 0.01 is acceptably low. Cox and Alexander (2002) also report a 0.01 increase in Cronbach's alpha if item 1 is deleted, while Heuermann and colleagues (2005) report a 0.03 increase. Gasparin and colleagues (2010) on the other hand experience a 0.02 decrease in Cronbach's alpha if item 1 is deleted, while several studies do not disclose this information (Brännström & Wennerström, 2010; Serbetcioglu et al, 2009; Stephens, 2002; Kramer et al, 2002; Smith et al, 2009). In addition to item 1, Cox & Alexander (2002) also identified item 5 to cause a 0.03 increase in Cronbach's alpha if removed. Gasparin et al (2010) report a 0.01 increase in Cronbach's alpha if item 6 were to be removed. However, these slight differences are of minor significance to the overall result.

In the inter-item assessment, most items were significantly correlated to one or several other items, but no single item was very strongly correlated to all other items. This suggests that all items reflect some aspect of hearing aid fitting outcome, but all of the items are not addressing the same fundamental aspect. This result is consistent with previous findings (Cox & Alexander, 2002; Kramer et al, 2002; Stephens, 2002; Heuermann et al, 2005; Gasparin et al, 2010; Brännström & Wennerström, 2010).

In relation to demographic variables, the study found positive correlations between PTA and items 1 (daily use) and 4 (satisfaction), while negative correlations were discovered between PTA and items 5 (residual participation restrictions) and 6 (impact on others). Apart from these, no further correlations to the demographic variables were found.

Brännström & Wennerström (2010) also report a statistically significant positive correlation between PTA and item 1 (daily use).

Heuermann et al (2005) found no significant direct influences of demographic variables on IOI-HA outcomes. Kramer and colleagues (2002) found a significant correlation between duration of hearing loss and Factor 1. Olusanya (2004) reports a correlation between item 6 (impact on others) and the variables gender, user experience, and type of hearing aid. Serbetcioglu and colleagues (2009) found a significant correlation between age and total score, while Vestergaard (2006) reports a correlation between age and the Factor 2 subscale. Liu and colleagues (2011) found a significant effect of hearing aid price on total score as the only demographic variable. Hearing aids and aural rehabilitation are free of charge in the public health care system and subsidized in the private health care sector in Denmark. This demographic factor might therefore be of less importance in this context and was not included in the analysis. Furthermore, it would have been difficult to obtain information about hearing aid price from the respondents as only a small number of them might have any knowledge of this.

Overall, there appears to be little consistency across studies in regards to the ability of demographic variables to predict item score outcomes.

The mean score for item 1 (daily use) assumes a notably high value of 4.6, leaving little room for improvement on the 1–5 scale and thus heavily skewing the distribution. The value surpasses the mean score of item 1 in nearly all other comparable studies disclosing item means (Cox & Alexander, 2002; Brännström & Wennerström, 2010; Stephens, 2002; Kramer et al, 2002; Smith et al, 2009). Heuermann and colleagues (2005) reach a similar item 1 mean score of 4.6 in their field substudy. Only the study by Gasparin and colleagues (2010) surpasses this result with an item 1 mean score of 4.7. One possible account for the comparatively high item 1 score could be that this particular study sample is extraordinarily motivated for hearing aid use. All the participants in this study were voluntary hearing aid and accessories testers at GN ReSound A/S, and this voluntary activity naturally requires an amount of personal motivation that may arguably be above the mean when considering an entire clinical population. However, as the main objective of this study is to investigate the psychometric properties of the revised Danish IOI-HA and not to establish norms for clinical use, the possible bias on item mean scores caused by self-selection will not have an impact on the overall validity of the results.

Item 2 (benefit) had a score of 4.1 which was the same value as found by Stephens (2002). It is the highest item 2 value reported compared to previous studies (Brännström & Wennerström, 2010; Cox & Alexander, 2002; Gasparin et al, 2010; Heuermann et al, 2005; Kramer et al, 2002; Liu et al, 2011; Olusanya, 2004; Smith et al, 2009). The high item 2 score could be explained by the fact that the participants' mean wear time for their current hearing aids was 26 months while most previous studies report significantly lower mean wear time for the participants' current hearing aids; often because all participants were first-time users. Vestergaard (2006) found that first-time users who used their hearing aids more than four hours per day experienced improved outcomes on the IOI-HA over time. This means that lower scores are expected when the study sample consists primarily of first-time users.

When considering the score distribution of item 5, it becomes evident that the original item 5 might have been misunderstood and perceived in the opposite way than intended by the participants. In the original Danish translation of the IOI-HA, item 5 was given the lowest score by 15.5% of the respondents against only 1.9% in the revised translation (Jespersen et al, 2005).

The test-retest assessment showed that the questionnaire is stable over time. The total score correlation proved good although an excellent total score correlation was not anticipated. The fact that the retest was performed more than one year later might have negatively influenced the results, as it is possible that the participants' hearing losses and hearing difficulties might have slightly progressed while their hearing aids are the same. However, the strength of the test-retest assessment would likely be further reduced if participants with new hearing aids had been included. The conditions under which the questionnaires were filled out would then have been even less similar.

The Factor 2 subscale had a correlation coefficient moderately lower than the Factor 1 subscale. The same observation was reported by Kramer and colleagues (2002). This finding suggests that the time factor might have had a greater impact on the Factor 2 subscale (interaction with the surroundings) than on the Factor 1 subscale (introspective aspects).

Internal consistency was examined to assess the stability of the psychometric properties. Although Cronbach's alpha values were lower when data was obtained one year later, all values are satisfactory, indicating that the internal consistency of the questionnaire is stable over time. Smith and colleagues (2009) also reported that test-retest assessment revealed reliability stability over time.

Conclusion

The purpose of this study has been to address the request put forth by Cox & Alexander to validate all translations of the IOI-HA questionnaire by obtaining data and analysing the psychometric properties. The original Danish translation of the IOI-HA was not deemed psychometrically valid for comparison (Jespersen et al, 2005), and the translation was revised due to internal inconsistency. This revision has now been evaluated and found internally reliable. Furthermore, the psychometric characteristics of the revised translation have been evaluated and have been found psychometrically equivalent to the English, Dutch, German, and Swedish (and to some extent the Portuguese and Turkish) translations of the IOI-HA based on similar statistical analyses. This finding suggests that data derived from the revised Danish IOI-HA holds general validity and reliability and is psychometrically comparable to data obtained from other validated translations (Cox & Alexander, 2002; Kramer et al, 2002; Heuermann et al, 2005; Smith et al, 2009; Brännström & Wennerström, 2010).

This study has focused on psychometric properties. The next step would be to establish normative data for the revised Danish IOI-HA for clinical use based on a representative study sample.

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

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