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Research Article

Validation of the Chinese Translation of the Spatial Hearing Questionnaire and Its Short Form

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Purpose: Few questionnaires address how to measure spatial hearing ability in complex listening situations. The purpose of the study was (a) to validate the Chinese translation of the Spatial Hearing Questionnaire (C-SHQ) among Chinese participants and (b) to provide a shortened version for the purpose of clinical screening.

Method: This was a cross-sectional study. The C-SHQ was developed from the process of translation and back-translation of the original 24-item, English version (Tyler, Perreau, & Ji, 2009). The C-SHQ was administered to 146 patients at the Department of Otolaryngology Clinic of Sichuan Provincial People's Hospital between October 2013 and May 2014 at Sichuan, China. Exploratory factor analysis and reliability tests were performed for the full version, and confirmatory factor analysis was applied for the shortened version of the C-SHQ.

Results: The exploratory factor analysis revealed scores loaded on 3 similar factors compared with the original SHQ. The internal consistency reliability was high (Cronbach's $\alpha = 0.99$). The confirmatory factor analysis indicated that a shortened version of 12 items is sufficient to measure spatial hearing abilities.

Conclusions: The C-SHQ and its short form are both reliable and valid questionnaires, which are suitable for both research and clinical settings to measure spatial hearing ability in the Chinese population.

For individuals with hearing loss, the primary goal targeted by audiologists and hearing health care providers is to reduce any deficits as a result of hearing impairment. In doing so, we aim to improve the hearing thresholds and the speech perception abilities of our patients, most often by dispensing hearing devices to the listener and providing counseling on their use and care. However, to fully address the communication problems and the needs of individuals with hearing loss, it is also necessary to assess additional hearing functions of the listener using a combination of objective and self-report outcome measures, moving beyond tests of simple audibility and speech perception. Moreover, successful aural rehabilitation programs utilize a holistic approach, specifically identifying the deficits and the needs of the listener and targeting performance in these more complex listening situations.

Sound localization, or the ability to locate a sound source, is an important auditory function that is not only difficult for individuals with hearing loss, but is often overlooked. Localization provides us with a sense of spatial orientation. Using our spatial hearing abilities, we are aware of sounds around us, including birds chirping while on a walk or, for more immediate safety, a car passing by. Further, adequate sound localization abilities are crucial in commonly encountered listening situations, such as group conversations, in which the sound environment is quite complex. Here, the listener with hearing loss must be able to locate or track the talker as the conversation quickly switches from one person to the next. As reported by Byrne and Noble (1998), localization plays a greater role in our speech communication abilities than is likely realized.

Related to our spatial hearing ability is binaural hearing or the ability to use two ears to process auditory cues, such as interaural timing and level differences, which aids in segregating different speech and noise sources (Blauert, 1997). By relying on these binaural hearing cues, hearing in difficult listening situations is enhanced, such as being able to parse out the speech of a talker in background noise and

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identifying the location of a speaker in the sound field, all of which are essential skills for listeners.

In recent years, several spatial hearing outcome measures have emerged—for example, the Speech Spatial and Qualities of Hearing Scale (SSQ; Gatehouse & Noble, 2004) and the Spatial Hearing Questionnaire (SHQ; Tyler, Perreau, & Ji, 2009)—providing hearing health care providers with the necessary tools to assess the self-reported spatial hearing abilities of individuals with hearing loss. The SSQ, a 49-item questionnaire, has been widely implemented when evaluating spatial hearing abilities in individuals with hearing loss among other aspects of listening. Screening versions of the SSQ have emerged more recently, including five-item and 12-item versions (Demeester et al., 2012; Noble, Jensen, Naylor, Bhullar, & Akeroyd, 2013), which have yielded similar results when compared with the full version of the SSQ (Mertens, Punte, & Van de Heyning, 2013).

The SHQ (Tyler et al., 2009) also measures subjective spatial hearing ability; however, the primary target of assessment is on situations in which binaural hearing is emphasized. The SHQ consists of 24 items, and subjective outcomes can be compared using a total score of all 24 items or from any of the eight subscales, including the perception of male, female, and children's voices; music listening; sound localization; and speech perception in quiet and in noise with target and noise sources from the front and spatially separate (Tyler et al., 2009). Psychometric study of the SHQ has shown it is a reliable (Cronbach's $\alpha = 0.98$) and valid measure of spatial hearing abilities with strong correlations to actual localization performance and subjective abilities (i.e., compared with the SSQ) for listeners with hearing loss using cochlear implants (CIs; Tyler et al., 2009). Furthermore, studies have shown significantly higher post-implant SHQ scores for bilateral and hybrid CI users compared with bimodal and unilateral CI users, indicating that the questionnaire is sensitive to differences in hearing ability among various patient populations (Perreau, Ou, Tyler, & Dunn, 2014; Tyler et al., 2009). Last, studies have investigated the SHQ responses from listeners with normal hearing to establish a criterion for self-assessed localization ability (Perreau, Spejcher, Ou, & Tyler, 2014). Here, ratings for the speech in quiet subscale were higher than those from the noise and localization subscales as expected given the changes in demands placed on any listener. In addition, SHQ scores from the listeners with normal hearing were significantly higher than previously reported scores from CI users, indicating that the questionnaire is sensitive to changes in function as a result of hearing impairment.

The factor structure of the SHQ has been evaluated in several studies (Perreau, Spejcher, et al., 2014; Potvin, Punte, & Van de Heyning, 2011; Tyler et al., 2009), which have found that questionnaire responses load on three to four separate factors relating to sound localization, speech and music understanding in a background of noise, speech and music understanding in quiet, and spatial hearing of other sound sources (e.g., car, airplane). In sum, studies to date have shown that the SHQ is a reliable, valid, and sensitive measurement tool that can be used to assess self-reported spatial hearing ability in all types of listeners, including those with and without hearing impairment.

The need for additional versions of the SHQ, including in multiple languages, has received the attention of hearing researchers. One such study investigated the psychometric properties of a Dutch-translated SHQ (Potvin et al., 2011). The Dutch version was translated, back-translated, and then administered to 71 patients with symmetrical and asymmetrical hearing loss. Results showed that the Dutch version of the SHQ was a valid measure of spatial hearing ability with significantly lower scores for individuals with asymmetrical hearing loss across the majority of the subscales and for the total score compared with those with symmetrical loss (Potvin et al., 2011). In addition, internal consistency reliability (Cronbach's $\alpha = 0.98$) was high, and the psychometric properties of the Dutch version were similar to the original English SHQ. Therefore, the results of this study by Potvin et al. (2011) successfully produced a Dutch version of the SHQ that can be used in research and clinical applications.

In this study, a Chinese translation of the SHQ (C-SHQ) is investigated by examining its psychometric properties relative to the English SHQ. In addition, a screening version of the SHQ is explored to determine the robustness of a shortened version compared with the full 24-item SHQ. Therefore, the purposes of the study were twofold: (a) to validate the C-SHQ and (b) to provide a shortened version of the SHQ for the purpose of clinical screening.

Method

Chinese Version of the Spatial Hearing Questionnaire

The original English version of the SHQ includes 24 items with scores ranging from 0 = *very difficult* to 100 = *very easy*. The steps of forward translation, backward translation, and committee review (Guillemin, Bombardier, & Beaton, 1993) were followed to create the C-SHQ. The C-SHQ was first translated from the original English version to the Mandarin Chinese version by two bilingual physicians. The C-SHQ was then translated back to English following the guidelines previously described (Guillemin et al., 1993). Each item was assessed between the original and the translated Chinese version by a bilingual review committee with two additional independent individuals. Comprehensibility, cross-cultural equivalence, and possible inappropriate items were discussed through the review committee before the final version was released for use. Figure 1 displays the final translated Mandarin Chinese version of SHQ for the study.

Participants

A total number of 146 participants were recruited from the patients of the Department of Otolaryngology Clinic of Sichuan Provincial People's Hospital between October 2013 and May 2014 at Sichuan, China. Of the total 146 participants, 91 (62.3%) had hearing loss and 55 (37.7%) had

Figure 1. The Chinese version of the Spatial Hearing Questionnaire.

空间听力问卷

姓名____________ 病历编号#____________

日期____________

请对应下面每一个问题给出一个 0-100 的数字。数字 0 代表情况非常困难，数字 100 代表情况非常容易。请回答每一个问题不要留白。

0…非常困难 100…非常容易

1	在一个非常安静的房间，一男子站在您面前和您说话，您能听懂多少？	
2	在一个非常安静的房间，一女子站在您面前和您说话，您能听懂多少？	
3	在一个非常安静的房间，一孩童站在您面前和您说话，您能听懂多少？	
4	在一个非常安静的房间，从您的前方传来音乐，声音大小适中。您能听清楚多少？	
5	一男子站在您面前和您说话，此时在他背后有一个很响的电扇，您能听懂多少？	
6	一女子站在您面前和您说话，此时在她背后有一个很响的电扇，您能听懂多少？	
7	一孩童站在您面前和您说话，此时在他（她）背后有一个很响的电扇，您能听懂多少？	
8	在您面前有一个很响的电扇，此时从您的前方传来音乐，声音大小适中，您能听清楚多少？	
9	一男子站在您面前和您说话，此时在其侧面有一个很响的电扇，您能听懂多少？	
10	一女子站在您面前和您说话，此时在其侧面有一个很响的电扇，您能听懂多少？	
11	一孩童站在您面前和您说话，此时在其侧面有一个很响的电扇，您能听懂多少？	
12	在您侧面有一个很响的电扇，此时从您前方传来音乐，声音大小适中，您能听清楚多少？	
13	当您听到一男子的声音却看不到他，您能多准确辨别他在哪里？	
14	当您听到一女子的声音却看不到她，您能多准确辨别她在哪里？	
15	当您听到一孩童的声音却看不到他（她），您能多准确辨别他（她）在哪里？	
16	当听到声音而看不到音源，比如说收音机，您能多准确辨别它在哪里？	
17	一男子在您身后说话，您能多准确辨别他在哪里？	
18	一女子在您身后说话，您能多准确辨别她在哪里？	

0…非常困难 100…非常容易

19	一孩童在您身后说话，您能多准确辨别他（她）在哪里？	
20	当音乐声（比如说来自收音机）从您身后传来，您能多准确辨别它在哪里？	
21	当听到声音而看不到正在飞行的飞机，您能多准确辨别它在哪里？	
22	当远远的听到汽车的声音却看不到它，您能多准确辨别它从哪里开来的？	
23	如果您闭上眼睛站在路边，您能多准确辨别经过汽车行驶的方向？	
24	您在房间里听到一声巨响，您能多准确辨别声音的位置有多远？	

normal hearing. The demographic information for all participants is shown in Table 1. For those with hearing loss, the severity ranged from mild to severe in either one or two ears. The types of losses included sensorineural, conductive, and/or mixed loss. Due to differences in severity between the ears, hearing symmetry was defined as an interaural difference of less than 15 dB across the frequencies of 500, 1000, 2000, and 4000 Hz. Of the 91 participants with hearing loss, 61 (67.0%) were found to have symmetrical hearing loss. None of the participants with hearing loss wore hearing aids. For all participants, the average age was 38 years (SD = 12.8), and the average years of receiving education was 12 years (SD = 3.16). Two participants with the minimum education level in the present study had finished at least 6 years of elementary school education when they completed the questionnaire. Although most of participants spoke Sichuan dialect (very similar to Standard Mandarin), the official written language is the same across Mainland China. Therefore, using a paper-and-pencil method for administering the questionnaire, as opposed to an interview style, was inclusive to all participants and their linguistic background. No compensation was provided for participation in the study. This project was approved by the local institutional review board in the Sichuan Province, China.

Table 1. Demographic information for both groups.

	Gender		Age (years)		Education (years)	
Group	**M**	**F**	***M***	***SD***	***M***	***SD***
HL (n = 91)	36	55	41.2	13.0	11.6	3.3
NH (n = 55)	23	32	33.2	10.7	13.5	2.7

Note. HL = hearing loss; NH = normal hearing.

Procedure

Pure-tone air (octave frequencies of 250–8000 Hz) and bone conduction (octave frequencies of 500–4000 Hz) audiometric testing was performed bilaterally for all participants in a sound-treated booth at the Department of Otolaryngology Clinic of Sichuan Provincial People's Hospital. Following the hearing testing, the participants were administered the C-SHQ using paper and pencil. All the questions were answered independently; no items were left blank. All of the questionnaires collected in the study were considered valid.

Data Analysis

The questionnaire scores for the eight subscales and the total score were reported separately for participants with hearing loss and with normal hearing. The Cronbach's coefficient alpha and the item–total correlation coefficients were used to assess the internal reliability. The Kaiser-Meyer-Olkin measure of sampling adequacy was performed first to determine if the factor analysis was appropriate for the data. The 24-item inventory responses from the hearing loss group comprised the source data for the factor analysis. The exploratory factor analysis (EFA) was first administered on the basis of the principle component analysis. The EFA is a method to identify the latent structure of a set of variables. The primary model was established from the EFA results. Arbitrary but conventional thresholds of 0.40 for the factor loadings and 1.0 for the eigenvalues were applied when interpreting and labeling the factors. The eigenvalue for a given factor measures the variance in all the variables that is accounted for by that factor. A Varimax rotation was then used after the initial factoring method of principle component analysis, which was consistent with the development of the original SHQ (Tyler et al., 2009). This rotation method assumes factors to be uncorrelated. The sensitivity of the questionnaire was assessed among the hearing loss group comparing differences in hearing symmetry versus asymmetry.

Last, we evaluated the questionnaire items of the screening version of SHQ on the basis of the current data set for all participants with and without hearing loss. The number of items for the short version of the SHQ was predetermined to be no more than 12. Then, the questions in each subscale with the highest loadings from the EFA results were chosen. Next, a confirmatory factor analysis was performed to investigate the validity of new chosen subscales on all the participants for the short form of the C-SHQ. For all tests, statistical significance was defined as a $p < .05$. Data were analyzed using Statistical Analysis System version 9.4.

Results

The questionnaire item, subscale, and total scores for the two groups with hearing loss (HL) and normal hearing (NH) are displayed in Tables 2 and 3. Both groups showed a similar pattern when comparing responses across subscales —that is, the mean score was lowest for the understanding speech in noise with spatially separate target and noise sources subscale (76.7% for HL and 83.0% for NH, respectively). The mean score was highest for the understanding speech in quiet subscale (91.4% for HL and 96.9% for NH, respectively). The NH group reported better spatial hearing ability on all eight subscales compared with the HL group, $t(141.8) = 2.5$, $p = .01$. Comparing responses on individual items from the questionnaire, both groups reported the lowest self-assessed ability on Item 21, "How well are you able to determine the location of a flying airplane when you cannot see it?" (74.2% for HL and 80.3% for NH, respectively). No significant differences were found between the C-SHQ scores for male and female participants for the HL group, $t(89) = -0.33$, $p = .75$.

Factorial Validity

The overall Kaiser-Meyer-Olkin score was 0.92 for all 24 items. All items scored greater than 0.87 with most of the items close to 1.0. Given these results, it was appropriate to conduct the factor analysis for the current data set. A scree plot (i.e., a simple line segment plot to show the eigenvalues and the associated number of factors) was used to determine the number of factors for the study. Three factors (eigenvalue > 1.0) were extracted, accounting for 89.3% of the variance in the C-SHQ data from the factor analysis. Factor 1 (eigenvalue = 18.6, 77.5% of variance) is referred to as *source localization*, including Items 13 through 24. This factor accounted for the highest variance. Factor 2 (eigenvalue = 1.7, 7.2% of variance), referred to as *speech and music in noise with spatially separate noise sources*, encompassed eight items (Items 5 through 12). This factor is related to how well listeners are able to parse out speech and music when background noise is present and spatially separated from the signal. Factor 3 (eigenvalue = 1.1, 4.6%

Table 2. Average Spatial Hearing Questionnaire item scores for participants with hearing loss (HL) and normal hearing (NH).

	HL (n = 91)		NH (n = 55)	
Items[a]	*M*	*SD*	*M*	*SD*
1. Man's voice in quiet	93.3	13.7	97.7	8.3
2. Woman's voice in quiet	92.9	14.2	97.7	8.3
3. Child's voice in quiet	91.3	16.0	95.6	10.1
4. Music in quiet	87.9	20.5	96.4	6.5
5. Man in front, noise behind	80.3	21.9	86.2	17.4
6. Woman in front, noise behind	79.9	22.7	86.4	14.0
7. Child in front, noise behind	78.8	23.0	85.1	15.4
8. Music and noise in front	77.3	24.3	83.7	16.2
9. Man in front, noise to side	78.2	22.4	84.5	13.9
10. Woman in front, noise to side	77.6	23.0	84.2	15.2
11. Child in front, noise to side	76.0	24.2	82.2	16.7
12. Music in front, noise to side	75.1	25.3	81.1	18.3
13. Location of man's voice	78.8	26.5	88.0	12.6
14. Location of woman's voice	78.2	26.9	87.6	12.4
15. Location of child's voice	77.5	27.0	87.5	12.9
16. Location of music	78.1	25.7	86.5	14.1
17. Location of man's voice, behind	82.2	22.2	87.9	14.0
18. Location of woman's voice, behind	80.2	25.1	88.6	13.5
19. Location of child's voice, behind	80.5	25.1	87.9	14.7
20. Location of music, behind	80.0	25.6	87.3	14.9
21. Location of airplane	74.2	26.8	80.3	19.3
22. Direction of car	78.4	25.5	82.9	18.2
23. Movement of car	78.3	24.8	83.7	17.3
24. Distance of sound source	79.4	22.4	80.8	18.6

[a]Each short explanation for the item was from Perreau, Spejcher, et al. (2014).

Table 3. Average Spatial Hearing Questionnaire subscale and total scores for participants with hearing loss (HL) and normal hearing (NH).

	HL (n = 91)		NH (n = 55)	
Subscale	*M*	*SD*	*M*	*SD*
Male's voices	82.6	19.0	88.9	9.9
Female's voices	81.8	20.1	88.9	9.6
Children's voices	80.8	20.7	87.7	10.9
Music	79.7	21.9	87.0	10.9
Localization	78.8	23.3	85.7	13.3
Speech in quiet	91.4	15.2	96.9	7.2
Speech in noise–behind	79.0	22.1	85.4	13.5
Speech in noise–separate	76.7	23.1	83.0	15.4
Total	80.6	20.3	87.1	10.7

of variance) offloads on Items 1 through 4, which referred to *listening in quiet*. Table 4 displays the rotated loadings of the each of 24 items for three factors.

The communality values for each item on the C-SHQ ranged from 0.69 to 0.96. Because the communality indicates the proportion of common variance in that item, the results suggested that the variation in Items 10 (woman in front, noise to side), 2 (woman's voice in quiet), 6 (woman in front, noise behind), and 9 (man in front, noise to side) can be best explained by the factor analysis. The communalities for these four items were either equal to or greater than 95%. Although the communality for Item 24 (distance of sound source) was relatively low compared with all other items, the factor analysis results found that this item explained 69% of the variance.

Reliability

The results revealed that the Cronbach's coefficient α was 0.99. Generally speaking, any scores of 0.70 or higher suggest good reliability for the psychometric instrument. The Cronbach's coefficient α at 0.99 indicated good internal consistency reliability for the C-SHQ. The item–total correlation ranged from 0.75 to 0.92 (see Table 5). This suggested that the self-reported performance for all the individual items was consistent with the average total performance for the C-SHQ. It is worth mentioning that item–total correlation coefficients for all items except the last one for the Chinese version of the SHQ were higher than those for the original SHQ reported in Tyler et al. (2009). The Cronbach's

Table 5. Item–total correlation coefficients for each item on the Chinese (C-SHQ; n = 91) and original (n = 142) versions of the Spatial Hearing Questionnaire (SHQ).

	Item–total correlation	
Item	**C-SHQ**	**Original SHQ[a]**
1	0.80	0.41
2	0.79	0.42
3	0.80	0.66
4	0.84	0.67
5	0.89	0.85
6	0.86	0.84
7	0.86	0.85
8	0.90	0.77
9	0.88	0.82
10	0.90	0.75
11	0.89	0.81
12	0.86	0.76
13	0.89	0.83
14	0.92	0.83
15	0.90	0.86
16	0.89	0.85
17	0.87	0.84
18	0.90	0.85
19	0.92	0.88
20	0.92	0.83
21	0.85	0.79
22	0.90	0.82
23	0.86	0.83
24	0.75	0.84

[a]Data from Tyler et al. (2009).

Table 4. The factor loadings of the each of 24 items (rotation method: Varimax).

Items[a]	Factor 1	Factor 2	Factor 3
1. Man's voice in quiet	0.39	0.36	**0.81**
2. Woman's voice in quiet	0.38	0.34	**0.83**
3. Child's voice in quiet	0.37	0.40	**0.80**
4. Music in quiet	0.44	0.50	**0.62**
5. Man in front, noise behind	0.39	**0.76**	0.43
6. Woman in front, noise behind	0.30	**0.83**	0.42
7. Child in front, noise behind	0.34	**0.81**	0.39
8. Music and noise in front	0.47	**0.78**	0.28
9. Man in front, noise to side	0.42	**0.84**	0.25
10. Woman in front, noise to side	0.43	**0.83**	0.28
11. Child in front, noise to side	0.41	**0.84**	0.27
12. Music in front, noise to side	0.45	**0.81**	0.19
13. Location of man's voice	**0.79**	0.37	0.33
14. Location of woman's voice	**0.80**	0.40	0.32
15. Location of child's voice	**0.81**	0.39	0.27
16. Location of music	**0.81**	0.39	0.24
17. Location of man's voice, behind	**0.81**	0.34	0.29
18. Location of woman's voice, behind	**0.80**	0.41	0.29
19. Location of child's voice, behind	**0.79**	0.43	0.31
20. Location of music, behind	**0.79**	0.45	0.27
21. Location of airplane	**0.76**	0.45	0.16
22. Direction of car	**0.81**	0.39	0.27
23. Movement of car	**0.77**	0.30	0.39
24. Distance of sound source	**0.77**	0.18	0.33

Note. Bold text indicates the items that are included for that factor.

[a]Each short explanation for the question was from Perreau, Spejcher, et al. (2014).

alpha of three factors were computed respectively as well: Factor 1, α = 0.95; Factor 2, α = 0.99; Factor 3, α = 0.98.

Sensitivity

We assessed the sensitivity of the C-SHQ by comparing the scores between participants with symmetrical and asymmetrical hearing loss. Of the 91 participants, 61 with symmetrical hearing loss and 30 with asymmetrical hearing loss were included in this analysis. We expected that the symmetrical group would have better spatial hearing abilities compared with the asymmetrical group. The results from a two-tailed, independent-sample *t* test revealed a significant difference between these two groups, $t(40.64) = 2.49$, $p = .017$, and the self-reported ability on the C-SHQ was lower for the asymmetrical group across all eight subscales (see Figure 2).

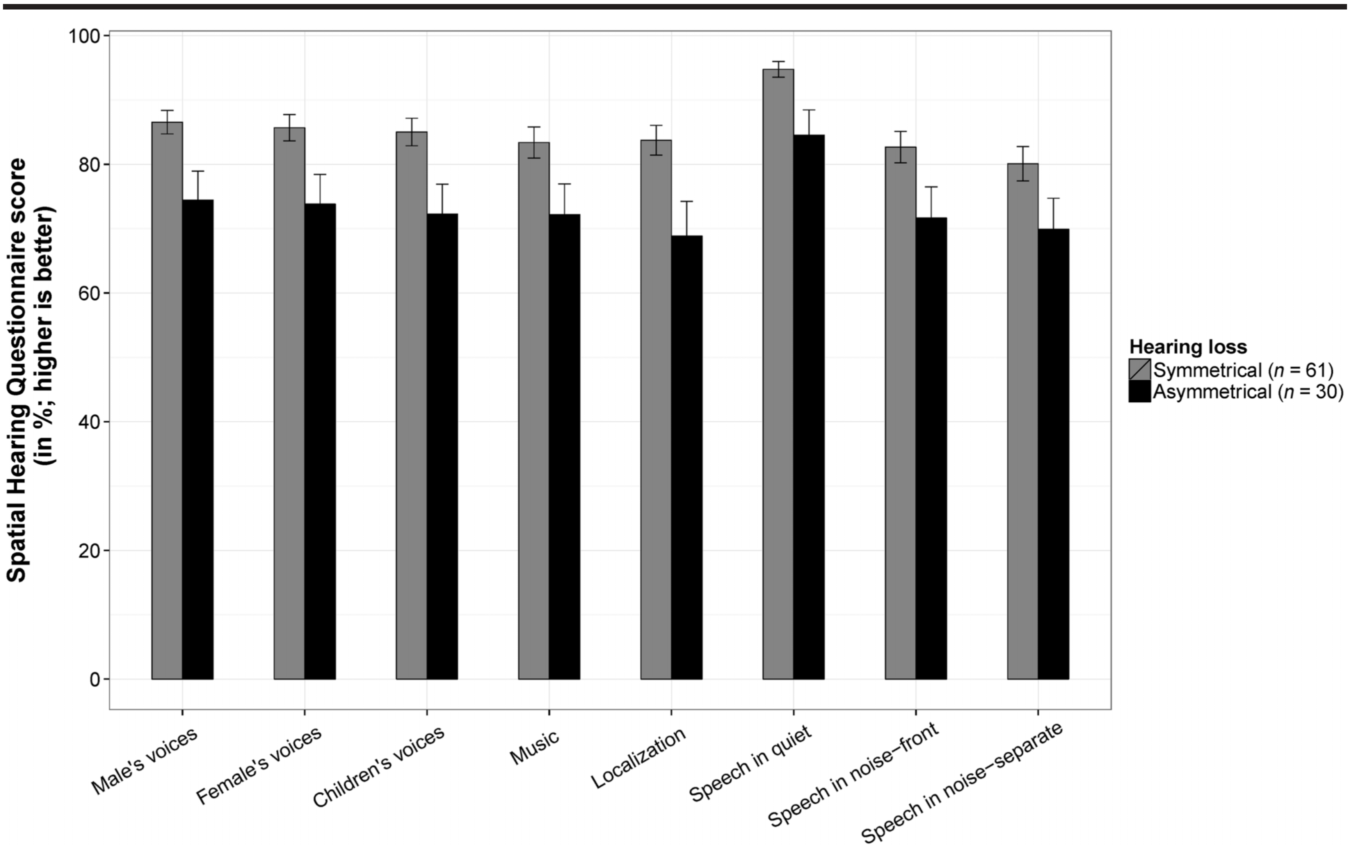
Creation of a Short 12-Item Questionnaire

To create the short version of the questionnaire, items in each subscale (except for subscale six, speech in quiet) with loadings equal to or greater than 0.80 (i.e., Items 6, 7, 9, 10, 11, 12, 14, 15, 16, 17, 18, and 22) were chosen. The sixth subscale pertaining to speech in quiet was found to only account for 4.6% of variance for the C-SHQ earlier in these analyses, which suggested a weak relationship between this subscale and the construct of spatial hearing. Furthermore, the items in this subscale, speech in quiet, often had difficulties with ceiling effects from the previous research (Perreau, Spejcher, et al., 2014), further suggesting that this subscale is not as sensitive as the rest of the questionnaire. Therefore, the items relating to this subscale were removed from the short version.

Confirmatory Factor Analysis for the 12-Item Version

A confirmatory factor analysis was performed to investigate the validity of the short version of the C-SHQ for the participants with hearing loss and normal hearing. The number of subscales in the short version was reduced from the original eight to two. Because the short version is intended to be used as a screening tool, it is logical to keep it brief. In the current analysis of the short-item version, the subjects-to-variables ratio was 12:1 (146 subjects/12 items = 12.2), which indicated that the data were appropriate for the factor analysis. We expected a relationship between the observed variables and the underlying two latent constructs

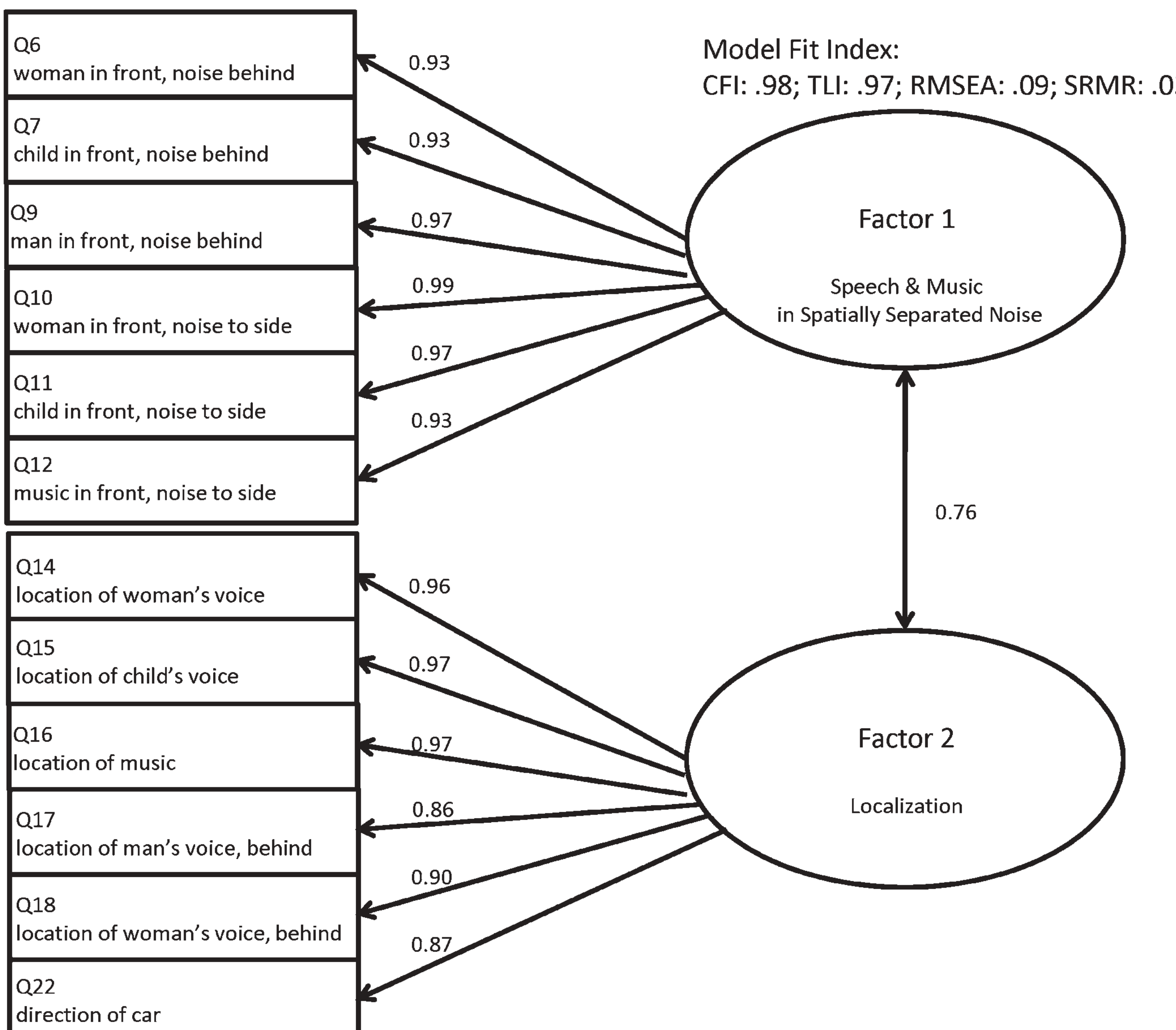
Figure 2. Average performance for all 24 items of the Chinese Spatial Hearing Questionnaire for the listeners with symmetrical (black bars, *n* = 61) and asymmetrical (gray bars, *n* = 30) hearing loss for all eight subscales. Error bars represent standard errors. Higher scores indicate better self-reported spatial hearing abilities.



on the basis of the previous exploratory factor analysis—that is, we hypothesized that Items 6, 7, 9, 10, 11, and 12 would be loaded on one factor, speech and music in noise–separate, and Items 14, 15, 16, 17, 18, and 22 would be loaded on the other factor, source localization.

Figure 3 shows the confirmatory factor analysis results, including the loading of each item on the factors, the correlation between Factor 1 (Items 6, 7, 9, 10, 11, and 12) and Factor 2 (Items 14, 15, 16, 17, 18, and 22), and the model fit parameters. All of the loadings are greater than 0.85. The correlations are moderately high between the two factors (r = .76). Although there are no universally accepted criteria for judging model fit, Thompson (2004) recommended acceptable thresholds of fit for models with comparative fit indexes and Tucker-Lewis indexes greater than 0.95. Acceptable thresholds of fit for the standardized root-mean-square residual are expected to be less than 0.05, and 0.06 for the root-mean-square error of approximation. These results suggest that three out of four criteria were met for the factor analysis, which provides an acceptable fit to the data. The R-squared value or percentage of variance for each item was also determined. Among them, there

Figure 3. Confirmatory factor analysis results for the short version of the Chinese Spatial Hearing Questionnaire. The loading for each item is shown above the horizontal arrow on the left side. The correlation coefficient between two factors is shown beside the vertical arrow between the factors. TLI = Tucker-Lewis index; CFI = comparative fit index; RMSEA = root-mean-square error of approximation; SRMR = standardized root-mean-square residual. Note. The recommend threshold for each parameter is as follows: TLI > 0.95, CFI > 0.95, RMSEA < 0.06, SRMR < 0.05. “Qn” in the figure represents the item number (n) in the the Chinese Spatial Hearing Questionnaire inventory.



were two items with $r^2 \geq 95\%$. The results suggest that the variation in Item 10 (woman in front, noise to side; $r^2 = .98$) and Item 15 (location of child's voice; $r^2 = .95$) can be explained the most by the factor analysis.

Average Scores Across Participants

The average total score for the 12-item version for the participants with hearing loss was 78.4% (*SD* = 22.1%), which was slightly lower than the total score for all 24 items (80.6%). The average item scores ranged from 75.1% (*SD* = 25.3%) to 82.2% (*SD* = 22.2%). The average total score for participants with normal hearing was 85.4% (*SD* = 12.5%).

Reliability

When assessing reliability for the 12-item short C-SHQ version, the results revealed a high Cronbach's coefficient $\alpha = 0.98$, which indicated good internal consistency reliability. The item–total correlation ranged from 0.86 to 0.92. The Cronbach's alpha of two factors was computed, and the following results were obtained, respectively: Factor 1, $\alpha = 0.98$; Factor 2, $\alpha = 0.97$.

Sensitivity

The participants with symmetrical hearing loss reported better overall spatial hearing ability ($M = 82.5\%$; $SD = 18.5\%$) compared with those with asymmetrical hearing loss ($M = 70.0\%$; $SD = 26.3\%$). The results from a two-tailed, independent-sample *t* test revealed a significant difference between these two groups of participants, $t(43.7) = 2.34$, $p = .02$. The results were similar to that of the full version of the questionnaire. Furthermore, the self-reported performance was reported to be worse for the asymmetrical group compared with the symmetrical group for both subscales.

Discussion

This study aimed to validate the C-SHQ and explore the use of a short version of the C-SHQ for the purpose of clinical screening. Relative to the first aim, the factor structure of the C-SHQ was comparable to the original version of the SHQ (Tyler et al., 2009) with only one item (Item 4) loading on a different factor in the C-SHQ data. The internal consistency reliability was high (Cronbach's coefficient $\alpha = 0.99$) and comparable to the original SHQ. The results from the comparison between the two groups with symmetrical and asymmetrical hearing loss revealed that the C-SHQ is a sensitive test. Taken together, the translated Chinese version of the SHQ is also a reliable and valid inventory. Relative to the second aim, the shortened version of the C-SHQ was also found to have good reliability, validity, and sensitivity, which was comparable to the full version of the questionnaire.

Factor Structure Comparison With the Original English and the Translated Chinese Version of SHQ

Factor 1 in both the original and Chinese versions of the SHQ reflects perceived localization ability. The same group of items (Items 13 through 24) of the C-SHQ loaded on Factor 1 compared with the original SHQ (Tyler et al., 2009). In a similar manner, for Factor 2 related to listening to speech and music in spatially separated noise, Items 5–12 loaded on the same factor for both versions of the questionnaire. However, Item 4 was loaded on Factor 3 for the C-SHQ along with Items 1–3 in the current study. It is logical that all four items that related to the ability to listen in quiet were grouped together. The discrepancy for Item 4 loading on a different factor between the original SHQ and the C-SHQ may be due to differences in the subject populations studied here. For example, music listening abilities even in a quiet background likely vary among CI users as was studied in the original SHQ (Tyler et al., 2009) and the participants with hearing loss in the present study. It is interesting to point out that the translated Dutch version of the SHQ (D-SHQ; Potvin et al., 2011) shared a similar factor structure compared with the C-SHQ. The validation of both the Chinese and the Dutch versions of the SHQ was limited to listeners with hearing loss (not using CIs or hearing aids). The factor analysis for the D-SHQ revealed four factors. The items loaded on which factor were similar between the D-SHQ and the C-SHQ. However, the order of the factors was somewhat different. The items loaded on Factor 1 for the D-SHQ were the ones loaded on Factor 2 (Items 5–12) in the present study. The items loaded on Factors 2 and 3 for the D-SHQ were essentially the same as the items loaded on Factor 1 (Items 13–24) for the C-SHQ. Factor 3 (Items 1–4) in the current study combines the same items as those for Factor 4 for the D-SHQ. Both the C-SHQ and D-SHQ indicated that the factors with eigenvalues greater than 1.0 can account for up to 89% of the variance, which was slightly higher than the variance explained (83%) in the original SHQ data for CI users (Tyler et al., 2009). The overall findings suggest that the factor related to the self-perceived localization ability accounted for the most variance for both the Chinese version of the SHQ (full version) and the original SHQ (Tyler et al., 2009) but not for the Dutch version (Potvin et al., 2011).

Short Version of the C-SHQ

In developing the short version of the C-SHQ, results from our analyses indicated that total scores were comparable between the full and short versions of the C-SHQ. Furthermore, the results from the confirmatory factor analysis revealed two underlying constructs that are suitable to measure spatial hearing abilities—that is, the short version of the questionnaire can quickly assess the self-perceived localization ability and the ability to listen in spatially separated noise. Similar to the short form of the SSQ–12 (Noble et al., 2013), no items represent the situation of listening in quiet. Although the original 24-item SHQ is relatively fast to administer to patients in a busy clinic, the 12-item short version should further improve test efficiency. Future research should investigate the short version of the SHQ in other populations, such as CI and hearing aid users, to observe if they will maintain the same psychometrical strength.

Conclusion

The Chinese version of the SHQ is a reliable and valid instrument, suitable for measuring spatial hearing abilities in the Chinese population. Similar factor structure of the Chinese version of the SHQ was found in listeners with hearing loss compared with CI users from Tyler et al. (2009). The C-SHQ shares similar psychometric characteristics with the original English version of the SHQ. The short version of the C-SHQ can be used as a screening tool in a busy clinic.

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