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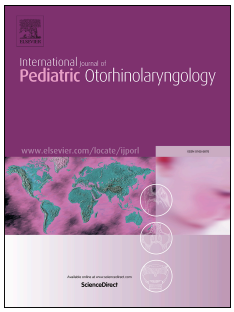

Face and content validity analysis of the Speech, Spatial and Qualities of Hearing Scale for Parents (SSQ-P) when used in a clinical service without interviews or week-long observation periods

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Face and content validity analysis of the Speech, Spatial and Qualities of Hearing Scale for Parents (SSQ-P) when used in a clinical service without interviews or week-long observation periods

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ABSTRACT

Objectives: To assess the face and content validity of the Speech, Spatial and Qualities of Hearing Scale for Parents (SSQ-P) when used in a clinical setting without the recommended interviews and observation periods.

Methods: SSQ-P responses completed by 145 parents of children with bilateral cochlear implants (aged between 5 and 16 years old) were analysed. To assess face validity, the proportion of missing/ambiguous and alternative responses was recorded for each of the 23 items. Where additional written comments were included in responses, a thematic-based analysis was used to identify reasons for the missing/ambiguous or alternative responses. Content validity was assessed using item response theory (IRT), with items having information score less than 0.5 and discrimination score less than 2.0 identified as poorly performing items.

Results: All items of the SSQ-P exhibited some proportion of missing/ambiguous or alternative responses, with six items having >10% missing/ambiguous or alternative responses. IRT identified thirteen items that performed poorly in terms of information and discrimination. These included four of the six items with the most missing/ambiguous or alternative responses.

Conclusions: SSQ-P items that performed worse tended to describe scenarios that parents perceived as too specific, too vague or hazardous. Without the recommended administration via interviews following three week-long observation periods, parents found these items difficult to complete. The SSQ-P is therefore not recommended for use without the recommended administration method. However, several items performed well in terms of face and content validity, despite independent parent completion without formal observation periods. Thematic analysis suggested that minor re-wording might improve the face validity

of items with high content validity but a high proportion of missing/ambiguous or alternative responses. Therefore, the results of the analyses form the basis on which a shortened version of the SSQ-P, more suitable for use in a clinical setting, could be developed in future studies.

Keywords: Children; Cochlear implants; Outcome measure; Questionnaire; Speech, Spatial and Qualities of Hearing for Parents

1. Introduction

There is a clinical need for tools to assess hearing-impaired children's listening in challenging auditory environments, including spatial listening skills such as speech perception in background noise and sound localization. These outcomes are important in the assessment and management of both peripheral hearing impairments and auditory processing disorders. Some Audiology services can directly assess speech perception in complex noise and sound localization abilities in the clinic. However, the necessary equipment can be prohibitively expensive, and clinical tests cannot fully replicate real-world listening environments. Even when available, these tests may be rarely used, due to resource constraints [1]. It is therefore desirable to complement clinic-based tests with reports of children's hearing ability in relevant real-world settings [e.g. 2, 3].

The Speech, Spatial and Qualities of Hearing Scale (SSQ) is an example of a questionnaire developed to obtain real-world information regarding an individual's hearing ability [4]. In its original form the SSQ consists of 49 items that provide scenarios to assess abilities across the three dimensions of speech perception, spatial hearing and other qualities of hearing such as naturalness and clarity of sounds, and is established as a reliable tool for use with adult patients [e.g. 5, 6-10]. Shortened versions of the SSQ have been developed [e.g. 11, 12] as well as versions in languages other than English [e.g. 13, 14].

The SSQ has also been adapted as a research tool for use with children. Galvin and Noble [15] provide a description of a version of the SSQ completed by parents. Development of this version (referred to in the present paper as the SSQ-P) aimed to make as few changes as possible to the intent, format and structure of the original SSQ. Only a small number of

modifications were made, including changes in wording to reflect that the questionnaire was completed by a parent, and removal of questions that were considered either not relevant to hearing impaired children or were difficult to answer by a parent on behalf of their child. The resultant SSQ-P consists of 23 items that mapped well to the dimensions of the original SSQ [15]. It is recommended that each section of the SSQ-P be administered separately via face-to-face or telephone interviews of a child's parents, each interview to take place after a separate week-long period over which parents were instructed to actively observe their child's hearing behaviour. Since its development, the SSQ-P has been successfully used in a number of research studies exploring outcomes in children with CIs [e.g. 16, 17-20], providing information about children's listening abilities such that hypotheses could be tested.

In order to obtain information regarding a child's real-world hearing ability, the SSQ-P has been used at the Yorkshire Auditory Implant Service (YAIS) as part of the routine management of children with CIs. It was hoped that the SSQ-P could provide information to inform counselling with parents, identify areas requiring targeted rehabilitation, and confirm improvement in listening ability over time. However, due to time and resource restrictions, the original recommendations of administering the SSQ-P via three separate interviews with a child's parents could not be followed. Instead, the SSQ-P was completed independently without a member of YAIS staff, and with no formal requirement to complete the three week-long observation periods. These modifications made it feasible to collect information on children's real-world listening ability within a busy clinical service. However, without the recommended observation periods or professional support during questionnaire completion, our experience shows that parents found the SSQ-P somewhat complicated and time-consuming to complete (i.e. up to 45 minutes). This resulted in some incomplete, incorrectly

completed or non-retuned questionnaires, and raised questions about whether the SSQ-P is effective in collecting clinically useful information about children's listening ability when administered in this way. The aim of this study was therefore to investigate the validity of the SSQ-P administered without professional support or formal observation periods, via a retrospective review of responses obtained from our clinical service.

2. Methods

2.1. Format of the SSQ-P

Figure 1 shows the format of SSQ-P items. Each item provides a scenario followed by a question about a child's hearing ability in that scenario. Items are mapped to one of three dimensions: speech perception, spatial hearing and qualities of hearing. Parents are required to provide a rating between 0 and 10 (where 0 indicates the child could not perform in the scenario at all and 10 indicates perfect performance) on a visual analogue scale (VAS). If parents are unable to respond to a particular item because they believe the scenario would be inaudible to their child, they do not know how their child would perform in the particular scenario or they believed the scenario was not applicable to their child for some other reason, they can indicate this on the SSQ-P by ticking the appropriate box. Parents are also required to indicate how often the scenario would occur and rate the importance of the listening skills required for the scenario.

2.2. Selection of analysis methods

We defined a clinically useful item as a scenario that met the following criteria: a) a scenario that commonly occurred in children's lives; b) a scenario in which parents were routinely present; c) a scenario in which the parent could observe the child in such a way that they could rate their child's performance; and d) a scenario described with a level of detail that allowed parents to give VAS responses without further explanation or qualification. By this definition, we deemed that missing responses, unclear VAS responses (such as choosing two different numerical values from the VAS scale), or selection of the alternative responses "would not hear it", "do not know" and "not applicable" were indicators of a less clinically useful item. We therefore assessed face validity by describing the percentage of missing, unclear or alternative responses for each item. We also required that an item should contribute significant and unique information about the underlying domains of speech discrimination, spatial hearing or sound quality perception, and that it be able to discriminate between children's different performance levels. We therefore applied content validity analysis via item response theory (IRT), to compare the relative contributions of each item. Last, we applied thematic analysis of descriptive feedback from parents.

2.2.3. Face validity

To assess face validity, a review of routinely collected SSQ-P data was undertaken. This identified SSQ-P data were available for 145 children who had used bilateral cochlear implants (either sequentially or simultaneously implanted) for at least one year (mean time since bilateral implantation was 3.3 years). No other inclusion or exclusion criteria were set. This sample represents approximately 70% of all bilaterally-implanted children under the care of YAIS. Table 1 summarises patient characteristics.

SSQ-P was completed independently by the parent. Parents were instructed to assess their child's hearing abilities retrospectively from memory. Families who did not speak English as a first language had access to a family liaison officer to provide translation where needed. For each child only the most recent SSQ-P response was included in the descriptive analysis.

For each of the 23 items of the SSQ-P, parents' responses were categorised as either unclear VAS (i.e. no rating was provided on the VAS or the response was not clear, for example because parents had provided more than one rating for the scenario) or as one of the alternative responses (i.e. "would not hear it", "do not know" or "not applicable"). A descriptive analysis of the SSQ-P responses was achieved by determining the proportion of unclear VAS or alternative responses obtained for each SSQ-P item. Items with total unclear VAS or alternative responses greater than 10% were arbitrarily considered as problematic for parents to complete independently and therefore were taken as indicating poor face validity. Responses to the frequency and importance of scenarios were not included in the analysis as preliminary inspection had revealed low response rates for these questions. A number of SSQ-P responses contained written comments given by parents that provided additional detail in response to the scenarios or explanation why certain items were not completed. An informal thematic-based analysis of these comments was undertaken to identify potential problems faced by parents when completing the SSQ-P.

2.2.4. Content validity

Content validity was assessed using item response theory (IRT). IRT is an established statistical modelling approach for assessing content validity [e.g. 21]. It achieves this by measuring how much information an item provides about an underlying construct, and how good an item is at discriminating between different levels within this construct. For this

analysis, the underlying constructs were taken as hearing ability within the dimensions of the SSQ-P, i.e. speech perception, spatial hearing and qualities of hearing. As SSQ-P responses were considered to be ordinal, IRT was performed using graded response models [22] within the three dimensions separately. Graded response models predicted the likelihood of an individual responding in a particular ordinal response category, resulting in information and discrimination scores being obtained for each mapped item. Pre-set criteria for information and discrimination scores were used to assess content validity. Items with an information score less than 0.5 [23] or a discrimination score less than 2.0 [24] were considered to have poor content validity.

If possible, it would have been worthwhile to use both the fully- and partially-completed questionnaires for content validity analysis (n = 145). However, including partially-completed questionnaires would require missing data imputation methods such as multiple imputation [25] for which the underlying theory and software are not yet developed for IRT analysis. Therefore, only data from children where all 23 SSQ-P items had received clear VAS responses could be included (n = 66). Table 1 summarises characteristics for this sub-group of patients.

An assumption of IRT is that unidimensionality exists between items and their underlying construct, i.e. the covariance among items is explained by the dimension they are mapped to. Thus, prior to IRT analysis unidimensionality was explored via confirmatory factor analysis (CFA). For each dimension of the SSQ-P, the fit of a structural equation model (SEM) containing all mapped items was assessed. Good model fit to data was taken as evidence of unidimensionality. SEM fit was evaluated using three measures: the root mean square error

of approximation (RMSEA), the comparative fit index (CFI) and the Tucker-Lewis fit index (TLF). For RMSEA a small value (≤0.06) indicates good fit, whilst for CFI and TLI greater than 0.9 are held to indicate good fit. All statistical analysis was performed using STATA (StataCorp LLC, US).

3. Results and Discussion

3.1. Face validity

From the 145 SSQ-P collected, only 66 (45.5%) were completed with numerical ratings for all 23 items. All other collected SSQ-P had at least one item with an unclear VAS or alternative response. Tables 2, 3 and 4 show the number of response categories for each item mapped to the speech perception, spatial hearing and qualities of hearing dimensions respectively. In each case the items are ranked in order of the total proportion of unclear VAS or alternative responses (highest to lowest).

Table 2 shows there were instances of unclear VAS or alternative responses given for all nine items of the speech perception dimension. Item SP7 received the highest proportion of these (23.4%), with the majority of responses indicating that parents did not know what their child's hearing ability was in that particular scenario. Item SP9 had the second highest proportion of unclear VAS or alternative responses (10.3%). In this case, the majority of responses were ambiguous, with parents adding text to the scenario in order to qualify what they understood as a "telephone". The remaining items in the speech perception dimension had less than 10% unclear VAS or alternative responses. Results for items within the spatial hearing dimension are shown in Table 3. Again, unclear VAS or alternative responses were evident across all six items. Most notably 25.5% of responses to item SH6 were either unclear or alternative, with a large number of parents providing a "do not know" response. SH5 also had a relatively high proportion of "do not know" responses. Finally, Table 4 shows the results for the eight qualities of hearing items. As was the case for the other two dimensions, all items received unclear VAS or alternative responses. In particular, two items are flagged as being problematic. First, QH5 received a high proportion of unclear VAS or

alternative responses (20.7%), with 25 parents indicating that they do not know how their child performs in that specific scenario. Second, QH8 had a high proportion of unclear VAS and "do not know" responses (13.8%).

This descriptive analysis suggests that the SSQ-P, when administered without interview or the three week-long observation periods, has poor face validity. Possible reasons for this can be identified from the informal thematic analysis of parents' written responses. The first possible reason relates to the specificity of the SSQ-P scenarios. Parents' comments revealed difficulty in recalling specific situations that may only happen infrequently or not at all. An example of this is item SP7 which was identified as the most problematic item for parents to complete. This item requires judgements to be made in an "echoey place" with suggested locations given as a swimming pool or school hall. Parent feedback suggests that they interpreted these scenarios as being definitive rather than suggested examples and that they are scenarios that are not frequently experienced by parent and child together. There are several possible reasons for this. First, the population served by our service is ethnically and socio-economically diverse and it is to be expected that parental attendance at sporting and school events will vary between families. Cultural barriers to participation in sport are known to include a need to prioritise work over leisure time, to provide for the family; cultural sensitivities around sports clothing; and lower awareness of the levels of physical activity needed to gain health benefits [26]. Second, some parents that do attend events at school halls or swimming pools could be spectating from a distance and / or entertaining younger siblings, restricting their ability to assess their hearing-impaired child's listening in that environment. Finally, financial barriers may prevent some parents from attending sporting venues with their children.

Another item that was poorly completed was SH5 which directs parents to the specific scenario of localising a dog barking (i.e. a relatively short duration sound). Again, it is possible that the specificity of this scenario makes it difficult for parents to respond accurately. Interestingly, SH1 (which assesses localisation of longer duration sounds), performed better in terms of receiving a lower number of unclear VAS responses, perhaps because a broader range of examples are given (e.g. a lawnmower, aeroplane or power tool) and as a result it is less specific.

A further reason for low face validity is that parents considered some of the scenarios to be inappropriate due to perceived hazards associated with the scenario. This is the case for SH6 (the worst performing item in spatial hearing dimension) which asks parents to assess their child's localisation of traffic on a busy road. Developing the ability to locate engine sounds is a skill that might be important to help children safely develop independence. When the SSQ-P is administered according to the recommendations, parents would be primed to observe their child's listening ability in this scenario. However, when administered without the formal observation periods, parents feedback to us was that they had been so concerned with ensuring their child's safety, and monitoring the oncoming traffic, that they were not able to provide an accurate, retrospective judgment on their child's ability. Similar feedback is apparent for QH5 which received the highest number of unclear VAS or alternative responses in the qualities of hearing dimension. QH5 asks parents to judge whether their child is able to discriminate between similar sounds, with example sound pairs being a car versus a bus, or water boiling in a pot versus food cooking in a frying pan. Children are frequently in situations near food preparation, and around traffic. However, parents reported that they would discourage their children from getting too close to hot pans, and by a roadside would focus on keeping the child safe rather than discussing whether the sounds

around them came from one type of vehicle or another. As a result, parents were less likely to provide a VAS response.

As well as items being viewed as specific, other items were reported as being too vague. QH8 (which was the second worse performing item in the qualities of hearing dimension) refers only to "other sounds" and listening to "something" and received a relatively high number of "do not know" and unclear responses. Parents also noted that is not always easy to determine the extent to which their child was responding to non-auditory cues, and that it was not clear whether this should be factored in their response. This is especially the case when parents are completing the SSQ-P from memory. A number of parents reported that item SP9 (telephone use) was out-of-date and unclear. Feedback indicated that the scenario could be interpreted in a number of ways, for example listening via the handset or speaker phone, landline or mobile, whether an induction loop was used or even whether video-calling was included as telephone use. Parents were also unclear what was meant by "conversation" in terms of level of interactivity, and indicated that their child's ability was dependent on the familiarity of the person they were talking to.

All the reasons for poor face validity cited above could be addressed if the recommended approach to complete the SSQ-P via interview was followed. For example, an experienced interviewer would be able to provide additional examples of listening situations or explain where parents were unclear regarding a specific scenario. Similarly, if parents were instructed to undertake the recommended observation periods of their child's hearing ability prior to completion of the SSQ-P, as per the original administration instructions, then items not being completed due to problems with recall of information would also be minimised. However, for SSQ-P items to be administered in a clinically feasible manner, without guided

completion or observation periods, consideration could be given to rewriting item scenarios with additional less-specific or non-hazardous examples. Specifically, for SH5 where the face validity issue was due to specificity of the scenario, additional examples of relatively short duration sounds (a car horn and door slamming shut) could be added. For QH5, where parents had reported problems due to scenarios being hazardous (i.e. water boiling in a pan or traffic noise), different examples could be given that are less hazardous (a kettle boiling versus a washing machine and a tap running versus a toilet tank filling).

In considering these findings, it is important to note that the analysis of face validity was based on a retrospective review of SSQ-P responses rather than a systematic collection of data. Parents were not asked to provide additional written detail explaining their difficulty in completing the SSQ-P, though where this was given it was included in the descriptive analysis. This has the potential to bias our analysis in that it is possible that the views of those parents who provided extra information are not consistent with those who also faced difficulties in completing the questionnaire but did not leave comments explaining their reasons. As a consequence, our analysis may have missed other important difficulties faced by parents, or over-emphasised those reasons identified by the sub-group of parents that responded with additional detail. Similarly, our approach did not attempt to explore reasons for non-return of SSQ-P. This may have identified other important difficulties experienced by parents that were not evident in the responses of the parents of the 145 children for whom a SSQ-P was available. It is also possible that the age range of children included in this study (5-16 years old) contributed to response missingness. Scenarios perceived as hazardous would be more likely avoided for younger children, and it is possible that parents found it difficult to reliably report listening behaviour for older children with whom they would typically spend less time.

Another limitation of this study was that no data was available to document families' socio-economic status or parents' education level, and so it was not possible to investigate the effects of these on parents' ability to complete the questionnaire. It is likely that these factors, along with parents' understanding of hearing and the way in which hearing loss can impact on listening in the scenarios described, would influence the way in which they had observed their children prior to completing the questionnaire, and inform their VAS ratings. These would be valuable issues to explore in the future validation of a clinical short-form.

3.2.Content validity

CFA was consistent with sufficient unidimensionality for all three SSQ-P dimensions to be analysed in terms of content validity via IRT. SEMs showed good fit for speech perception (RMSEA = 0.04, CFI = 1.00, TLI = 0.99), spatial hearing (RMSEA = 0.00, CFI = 1.00, TLI = 01.03) and qualities of hearing (RMSEA = 0.03, CFI = 1.00, TLI = 0.99). Subsequent IRT analysis identified thirteen items with low content validity based on information (<0.5) and discrimination scores (<2.0). These were SP1, 2, 5, 7 and 9, SH3, 4 and 6 and QH1, 2, 6, 7 and 8. That is, when administered without interview or observation period, over half of the items included in the SSQ-P were not informative or were unable to discriminate between different levels of hearing ability in this group of bilaterally implanted children.

Comparison of the assessments of content and face validity reveals some overlap. Four of the items with low content validity (i.e. SP7 and 9, SH6 and QH8) were also identified as being problematic in terms of face validity. Interestingly, the two other items with questionable face validity (SH5 and QH5) were shown to have acceptable content-validity. This indicates that for the parents that completed the VAS, these items provide useful information about a

child's hearing ability, though as noted above, rewording of these items may be warranted if used in a clinical setting without interview or observation period. Together these preliminary findings could be used as a basis for the development of an abbreviated version of the SSQ-P that was more suited to use in a clinical setting where time pressures did not allow the recommended administration approach to be followed.

However, it should be noted that our IRT analysis was potentially limited by the sub-optimal sample size employed, i.e. 66 complete SSQ-P [27]. To provide some reassurance on the replicability of the content validity assessment, we undertook bootstrap resampling (ten replicates of 66 samples with replacement). Bootstrapping of the fully completed questionnaires treats this sample as a population and randomly generates new samples from this (see, for example [28]) which are each then analysed separately. Doing so seeks to mimic the process of splitting the data into separate training and testing datasets (as would be possible with a larger sample size) to give an assessment of how variable the findings are, were new patient data available. This demonstrated good replicability in the speech perception and spatial hearing dimension with the same items identified in the original analysis again shown to provide poor information of discrimination in all replicates where model convergence was achieved. Within the qualities of hearing dimension replicates demonstrated greater variability with regard to which items performed poorly. This suggests that a full replicability study is required that utilises independent data. One reason for the small sample size reported here is due to the approach of deleting whole cases where data was incomplete. Whilst it would be possible to exclude cases by dimension rather than full listwise deletion, the benefit of this will be limited by the overall sample size (n = 145) and would not be compatible with the SEM approach to testing of unidimensionality. Alternative approaches to testing unidimensionality, such as Confirmatory Factor Analysis (CFA) are

possible and would mitigate the need for listwise deletion. However, this would provide only marginal benefit relative to overall sample size, and criteria for CFA (such as size of factor loadings, proportion of variance explained) may be difficult to interpret conclusively given the limited sample size. A multi-centre study is required to achieve the necessary sample size to allow robust application of IRT analysis. This would also allow data to be split into model training and test sets, as well as alternative methodological approaches (such as CFA for test of unidimensionality, missing data exclusion by dimension) to be trialled.

4. Conclusions

Our analysis suggests that the SSQ-P has poor face and content validity when administered without interviews or week-long observation periods in a clinical setting. Its use without following the original instructions for administration is therefore not recommended.

However, given the time and resource constraints faced by busy clinical services, a shortened version of the SSQ-P that could be quickly and independently completed by a parent, or would take less clinician time to administer, would be helpful. Face validity analysis showed that several SSQ-P items prompted clear VAS responses from a large proportion of parents even when completed independently, indicating that these items describe commonly occurring real-life scenarios in which parents observe their children and feel able to unambiguously rate their child's performance. Content validity analysis identified several items that were also informative and able to discriminate between listening abilities amongst this group of bilaterally implanted children. Thematic analysis of parents' written feedback suggested that rewording of the items with high content validity but low face validity may be possible. Our findings may therefore be useful as the basis for the development of an abbreviated version of the SSQ-P for use in clinical settings where the recommended SSQ-P administration approach cannot be followed. Future studies could then seek to validate an abbreviated version with regard to its effectiveness as a clinical tool. For example, in monitoring children's progress over time, differentiating between hearing interventions, establishing its face and content validity for groups of hearing-impaired children other than bilateral CI users, and for facilitating targeted rehabilitation. It is also likely that different sub-sets of items may be found optimal for alternative short versions designed to be completed by children's teachers or older children themselves. These could complement a

392 short parent version in terms of including important listening scenarios that parents may not
393 regularly observe their child in, such as noisy dining halls or reverberant sports facilities.

Table 1 Patient characteristics

	Face Validity Group (*n* = 145)	Content Validity Group (*n* = 66)
Female	79 (54%)	32 (48%)
Male	66 (46%)	34 (52%)
Sequentially implanted	61 (58%)	35 (53%)
Simultaneously implanted	84 (42%)	31 (47%)
Device manufacturer		
Cochlear	67 (46%)	33 (50%)
Med-El	70 (48%)	29 (44%)
Advanced Bionics	8 (6%)	4 (6%)
Age range in years	5 to 16	5 to 16

Table 2 Number of unclear VAS or alternative responses for items mapped to the speech perception (SP) dimension.

Rank	Item	Unclear VAS	Inaudible	Do not know	Not applicable	Total
1	**SP7**: You are talking to your child in a place where there are a lot of echoes, such as a school assembly hall or indoor swimming pool. Can your child follow what you say?	4	1	21	8	34 (23.4%)
2	**SP9**: Can your child easily have a conversation with a familiar person on the telephone?	9	2	3	1	15 (10.3%)
3	**SP6**: Your child is in a group of about five people, sitting round a table. It is a noisy room, such as a busy restaurant or large family gathering at home. Your child cannot see everyone else in the group. Can your child follow the conversation?	5	2	5	0	12 (8.3%)
4	**SP3**: Your child is in a group of about five people, sitting round a table. It is an otherwise quiet place. Your child can see everyone else in the group. Can your child follow the conversation?	4	0	3	1	8 (5.5%)
5	**SP4**: Your child is in a group of about five people, sitting round a table. It is a noisy room, such as a busy restaurant or large family gathering at home. Your child can see everyone else in the group. Can your child follow the conversation?	2	1	3	1	7 (4.8%)
6	**SP2**: You are talking with your child in a quiet, carpeted lounge-room. Can your child follow what you're saying?	5	0	0	1	6 (4.1%)
7	**SP1**: You are talking with your child and there is a TV on in the same room. Without turning the TV down, can your child follow what you're saying?	4	0	0	1	5 (3.4%)
8	**SP8**: You are talking to your child in a room in which there are many other people talking. Can your child follow what you say?	4	0	1	0	5 (3.4%)
9	**SP5**: You are talking with your child. There is a continuous background noise, such as a fan or running water. Can your child follow what you say?	1	0	0	0	1 (0.7%)

Table 3 Number of unclear VAS or alternative responses for items mapped to the spatial hearing (SH) dimension.

Rank	Item	Unclear VAS	Inaudible	Do not know	Not applicable	Total
1	**SH6**: Your child is standing on the footpath of a busy street. Can your child hear right away which direction a bus or truck is coming from before they see it?	8	0	25	4	37 (25.5%)
2	**SH5**: Your child is outside. A dog barks loudly. Can your child tell immediately where it is, without having to look?	2	0	14	0	16 (11.0%)
3	**SH2**: Your child is sitting around a table with several people. Your child cannot see everyone. Can your child tell where any person is as soon as they start speaking?	5	0	9	0	14 (9.7%)
4	**SH1**: Your child is outdoors in an unfamiliar place A loud constant noise, such as from a lawnmower, aeroplane or power tool, can be heard. The source of the sound can't be seen. Can your child tell right away where the sound is coming from?	4	0	8	1	13 (9.0%)
5	**SH4**: You and your child are in different rooms at home. It is quiet. If your child hears you call out their name, will he/she know where in the house you are?	2	0	5	0	7 (4.8%)
6	**SH3**: Your child is sitting in between yourself and another person. One of you starts to speak. Can your child tell right away whether it is the person on their left or their right who is speaking, without having to look?	0	0	2	0	2 (1.4%)

Table 4 Number of unclear VAS or alternative responses for items mapped to the qualities of hearing (QH) dimension.

Rank	Item	Unclear VAS	Inaudible	Do not know	Not applicable	Total
1	**QH5**: Can your child tell the difference between sound that are somewhat similar, for example, a car versus a bus, OR water boiling in a pot versus food cooking in a frypan?	0	1	25	4	30 (20.7%)
2	**QH8**: Can your child easily ignore other sounds when trying to listen to something?	10	0	10	0	20 (13.8%)
3	**QH1**: Think about when there are two noises in or around the home at once, for example, water running into the bath and a radio playing, OR a truck driving past and the sound of knocking at the door. Is your child able to identify the two separate sounds?	2	0	8	0	10 (6.9%)
4	**QH4**: Can your child distinguish between different pieces of familiar music? Note that producing words or movements relevant to a song can indicate recognition.	2	0	6	1	9 (6.2%)
5	**QH7**: Does your child have to put in a lot of effort to hear what is being said in conversation with others?	6	0	2	0	8 (5.5%)
6	**QH3**: Can your child recognise family members or other very familiar people by the sound of each one's voice without seeing them?	3	0	3	0	6 (4.1%)
7	**QH6**: Can your child easily judge another person's mood from the sound of their voice?	3	0	1	0	4 (2.8%)
8	**QH2**: You are in a room with your child and music is playing. Will your child be aware of your voice if you start speaking? Note that the child does not have to understand what you say.	1	0	1	0	2 (1.4%)

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References

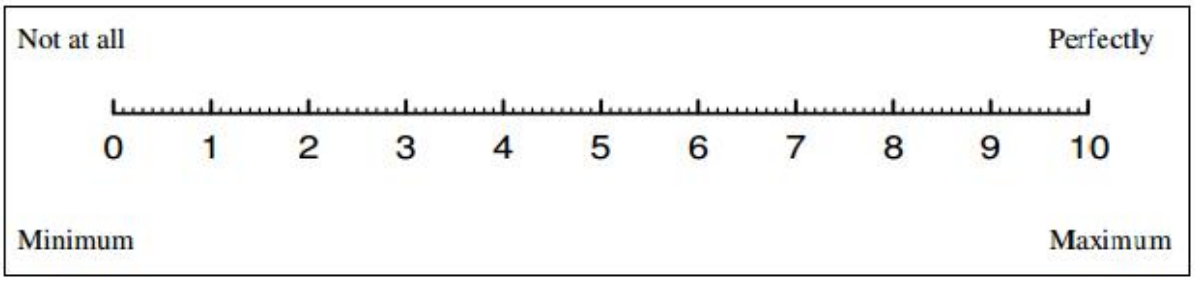
1. Iliadou, V., et al., *A European Perspective on Auditory Processing Disorder-Current Knowledge and Future Research Focus.* Frontiers in Neurology, 2017. **8**(622).
2. Arlinger, S.D., *Clinical assessment of modern hearing aids.* Scand Audiol Suppl, 1998. **49**: p. 50-3.
3. Cox, R.M., G.C. Alexander, and G.A. Gray, *Audiometric correlates of the unaided APHAB.* J Am Acad Audiol, 2003. **14**(7): p. 361-71.
4. Gatehouse, S. and W. Noble, *The Speech, Spatial and Qualities of Hearing Scale (SSQ).* Int J Audiol, 2004. **43**(2): p. 85-99.
5. Ahlstrom, J.B., A.R. Horwitz, and J.R. Dubno, *Spatial benefit of bilateral hearing AIDS.* Ear Hear, 2009. **30**(2): p. 203-18.
6. Akeroyd, M.A., et al., *A factor analysis of the SSQ (Speech, Spatial, and Qualities of Hearing Scale).* International Journal of Audiology, 2014. **53**(2): p. 101-114.
7. Noble, W. and S. Gatehouse, *Effects of bilateral versus unilateral hearing aid fitting on abilities measured by the Speech, Spatial, and Qualities of Hearing Scale (SSQ).* Int J Audiol, 2006. **45**(3): p. 172-81.
8. Noble, W., et al., *Unilateral and bilateral cochlear implants and the implant-plus-hearing-aid profile: Comparing self-assessed and measured abilities.* International Journal of Audiology, 2008. **47**(8): p. 505-514.
9. Potts, L.G., et al., *Recognition and localization of speech by adult cochlear implant recipients wearing a digital hearing aid in the nonimplanted ear (bimodal hearing).* J Am Acad Audiol, 2009. **20**(6): p. 353-73.
10. Tyler, R.S., A.E. Perreau, and H. Ji, *The Validation of the Spatial Hearing Questionnaire.* Ear and hearing, 2009. **30**(4): p. 466-474.
11. Demeester, K., et al., *Hearing disability measured by the speech, spatial, and qualities of hearing scale in clinically normal-hearing and hearing-impaired middle-aged persons, and disability screening by means of a reduced SSQ (the SSQ5).* Ear Hear, 2012. **33**(5): p. 615-6.
12. Noble, W., et al., *A short form of the Speech, Spatial and Qualities of Hearing scale suitable for clinical use: The SSQ12.* International journal of audiology, 2013. **52**(6): p. 409-412.
13. Kießling, J., et al., *Übertragung der Fragebögen SADL, ECHO und SSQ ins Deutsche und deren Evaluation.* Z Audiol, 2011. **50**(1): p. 6-16.
14. Most, T., et al., *Everyday hearing functioning in unilateral versus bilateral hearing aid users.* American Journal of Otolaryngology, 2012. **33**(2): p. 205-211.
15. Galvin, K.L. and W. Noble, *Adaptation of the speech, spatial, and qualities of hearing scale for use with children, parents, and teachers.* Cochlear Implants Int, 2013. **14**(3): p. 135-41.
16. Beijen, J.W., A.F.M. Snik, and E.A.M. Mylanus, *Sound localization ability of young children with bilateral cochlear implants.* Otology & Neurotology, 2007. **28**(4): p. 479-485.
17. Galvin, K.L. and M. Mok, *Everyday Listening Performance of Children Before and After Receiving a Second Cochlear Implant: Results Using the Parent Version of the Speech, Spatial, and Qualities of Hearing Scale.* Ear Hear, 2016. **37**(1): p. 93-102.
18. Hassepass, F., et al., *Unilateral deafness in children: audiologic and subjective assessment of hearing ability after cochlear implantation.* Otol Neurotol, 2013. **34**(1): p. 53-60.
19. Lovett, R.E.S., et al., *Bilateral or unilateral cochlear implantation for deaf children: an observational study.* Archives of Disease in Childhood, 2010. **95**(2): p. 107.
20. Sparreboom, M., A.M. Snik, and E.M. Mylanus, *Sequential bilateral cochlear implantation in children: Quality of life.* Archives of Otolaryngology–Head & Neck Surgery, 2012. **138**(2): p. 134-141.

21. Edelen, M.O. and B.B. Reeve, *Applying item response theory (IRT) modeling to questionnaire development, evaluation, and refinement.* Qual Life Res, 2007. **16 Suppl 1**: p. 5-18.
22. Samejima, F., *Graded Response Model*, in *Handbook of Modern Item Response Theory*, W.J. van der Linden and R.K. Hambleton, Editors. 1997, Springer New York: New York, NY. p. 85-100.
23. Weinhardt, J.M., et al., *An item response theory and factor analytic examination of two prominent maximizing tendency scales.* JUDGMENT AND DECISION MAKING, 2012. **7**(5): p. 644-658.
24. Hafsteinsson, L.G., J.J. Donovan, and B.T. Breland, *An Item Response Theory Examination of Two Popular Goal Orientation Measures.* Educational and Psychological Measurement, 2007. **67**(4): p. 719-739.
25. van Buuren, S., Groothuis-Oudshoorn, K., *mice: Multivariate Imputation by Chained Equations in R.* journal of Statistical Software, 2011. **45**(3): p. 1-67.
26. Patel, N., et al., *Barriers and Facilitators to Healthy Lifestyle Changes in Minority Ethnic Populations in the UK: a Narrative Review.* Journal of Racial and Ethnic Health Disparities, 2017. **4**(6): p. 1107-1119.
27. Embretson, S.E. and S.P. Reise, *Item Response Theory*. 2013, London: Taylor & Francis.
28. Taylor, C. *What is bootstrapping in statistics?* 2019 [cited 2020 9th January 2020]; Available from: https://www.thoughtco.com/what-is-bootstrapping-in-statistics-3126172.

480 **Figure 1 An example item from the SSQ-P**

1. You are talking with your child and there is a TV on in the same room. Without turning the TV down, can your child follow what you're saying?

(i)



Would not hear it ☐ Do not know ☐ Not applicable ☐

(ii) How often does this type of situation occur for your child, in which he/she needs to follow what someone is saying with the TV on in the same room?

- Very often (4 or more times in a week) ☐
- Often (1 to 3 times in a week) ☐
- Not often (1 or 2 times in a month) ☐

(iii) How important do you think is it for your child to have, to develop, the listening skills required for this type of situation?

- Very important ☐
- Important ☐
- Only a little bit important ☐
- Not important ☐