



Production and evaluation of a Polish version of the LittlEars questionnaire for the assessment of auditory development in infants

Anita Obrycka^{a,*}, José-Luis Padilla García^b, Agnieszka Pankowska^a, Artur Lorens^a, Henryk Skarżyński^a

^a Institute of Physiology and Pathology of Hearing, 1 Zgrupowania AK "Kampinos" str, 01-943 Warsaw, Poland

^b Social Psychology and Methodology of the Behavioural Sciences Department, University of Granada, Campus de Cartuja, 18071 Granada, Spain

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ABSTRACT

Objective: To adapt the LittlEars questionnaire into Polish and to evaluate the psychometric properties of the Polish version of the questionnaire.

Methods: A back-translation method was used to translate the LittlEars questionnaire into Polish. The translated version was first evaluated by means of an expert-appraisal method. After having improved the Polish version of LittlEars with the results obtained from that evaluation, various psychometric analyses were conducted. Study participants included 310 parents or other caregivers of children with normal hearing whose ages ranged between 0.5 and 24.0 months. Corrected item-total correlations were calculated to evaluate the extent to which the different questions distinguish levels of auditory development of the assessed children. Cronbach's alpha coefficient—to evaluate internal consistency across items—was also calculated. To obtain estimates of validity, correlations between item/total score and age were calculated. A non-linear regression model was derived to obtain normative data for expected and minimum values of total scores from the questionnaire according to age.

Results: Corrected item-total correlations ranged from 0.14 to 0.84. The Cronbach's alpha coefficient was 0.95, indicating that the measurements were highly reliable. The linear correlation between total scores and age was 0.90 ($p < .001$). The regression analysis conducted to obtain normative data showed that 83% of the variance in the total scores can be explained by age.

Conclusion: The results of psychometric analyses support the use of the Polish version of the LittlEars questionnaire as a sensitive and reliable tool to assess the development of auditory behavior in Polish children between 3 and 24 months of age.

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1. Introduction

Cochlear implants have provided the first effective treatment for deafness or severe hearing loss. Indeed, implants have revolutionized the fields of otology and audiology, as there were no effective treatments just 30 years ago.

The experience with cochlear implants has shown that intervention at the earliest possible age is important to outcomes. In particular, an implant for a congenitally-deaf child before the expiration of the so-called "critical" or "sensitive" periods for auditory development and language acquisition is generally far more effective than an implant at a later time. This finding has been replicated in many studies [1,2]. Thus, early identification of hearing loss is the key to helping such children to the maximum extent possible.

A useful way to identify hearing losses in pre-verbal children is to ask their parent(s) or other caregiver(s) about the child's behavior with a structured questionnaire [3]. One such questionnaire is the LittlEars questionnaire (LE-Q), which was developed in Germany [4]. The questionnaire assesses auditory behavior in infants up to two years of age. It is also designed to indicate auditory development from birth to two years, and to indicate changes in development following interventions with a cochlear implant or (for less severe cases) a hearing aid. The questionnaire reflects three dimensions of auditory behavior: receptive, semantic, and productive. The psychometric properties of the original version of the questionnaire support its use for assessing auditory behavior in children up to two years of age and with normal hearing [4].

The value and validity of the LE-Q were first demonstrated for the German language and German-speaking parents or caregivers. This demonstration has motivated adaptations of the questionnaire for other languages. However, such adaptations are not a simple matter of translation, as some or even many of the original questions may have well subtle but important differences in

* Corresponding author. Tel.: +48 223560334; fax: +48 223560367.

E-mail address: a.obrycka@ifps.org.pl (A. Obrycka).

meanings when translated into another language. In addition, some words or expressions have no direct equivalents in another language [5], which present obvious problems in translation. The belief that “anyone who knows the two languages can produce an acceptable translation of a test” is regarded by experts as naive and unrealistic [6]. Instead, a “back-translation” method is needed to assure identical or highly similar meanings between the original and translated versions. This method includes (1) direct translation from the source language into the target language; (2) “back-translation” of the generated version of the material in the target language to the original language; and (3) comparison of the back-translation with the original text to evaluate the accuracy of the translated material. Step 3 is usually performed by a panel of experts in the languages and in the field of application, in this case audiology.

Although the back-translation method can help assure comparability of meanings across languages, subtle differences in languages, or sometimes-substantial differences in cultures of different countries using different languages, can affect results obtained with the translated version. Thus, a full psychometric evaluation of a translated version of a questionnaire or other test is necessary before it can be applied with confidence. Indeed, the evaluation may identify further flaws in the translation, which must be repaired to achieve full equivalence of the tests between the original and target languages.

The aim of the present study was to produce an accurate and psychometrically equivalent version of the LE-Q in Polish. This involved (1) the back-translation method and (2) measures with normal hearing children of the psychometric properties of the translated questionnaire. One result of the study is a set of normative data for the Polish version of the questionnaire, which provides expected and minimum values relevant for Polish children.

2. Methods

2.1. Subjects

The subjects were 310 parents or caregivers of children with normal hearing. The ages of the children were between 0.47 and 24.00 months, and the mean age was 16.46 months. Among the children, 138 were girls and 172 were boys. Table 1 provides further information about the subjects and the children under their care. All subjects were volunteers and no subject received pay or other compensation for her or his participation.

2.2. The LittlEars questionnaire

The LE-Q includes 35 yes-or-no questions designed to assess the auditory behavior of children aged 24 months and younger. Most of the items are supplemented with examples to make the

questions more precise. Each subject was instructed to respond with a “yes” to a question if she or he had observed the behavior in their child at least once. Each subject was also instructed to respond with a “no” if either she or he had never observed the behavior or if she or he was not sure how to answer the question. All subjects were instructed to discontinue completion of the questionnaire after six successively given “no” answers. In such a case, the remaining answers were assumed to be “no.” This rule was recommended by the authors of the LE-Q and was used in 34 cases out of 310 in Polish validation study. The total score of the questionnaire for each subject was the sum of all “yes” answers.

To interpret the results, the total score is compared with two critical values: expected and minimum. The expected value is an average score for the particular child’s age. The average scores for each month of age were estimated on the basis of the results obtained in children from the group in a validation process described below. The minimum value is the lower limit of the 95% confidence intervals (unilateral) from the validation sample. The comparison with critical values allows an informed estimate of each child’s age related auditory behavior [4,7].

2.3. Translation into Polish

The translation of the LE-Q into Polish was conducted according to the best practices recommended by the International Test Commission (ITC) [8]. In particular, and for this project, a “back-translation” method was used, which is the most commonly used and the most recommended by the ITC among the several methods of questionnaires’ translation. The back-translation method focuses mainly on preserving the “variable meaning” of the questions or other test items, in addition to producing a linguistically correct version of each item in the target language [9]. The key steps in the method are (1) direct translation from the source language to the target language; (2) “back-translation” from the target language back to the source language; and (3) comparisons between the two versions in the source language to determine whether they are similar or not. If step 3 indicates a difference or differences in the versions, then the source is translated again with this additional information in mind and steps 2 and 3 are repeated. This process is continued until no significant difference is found in step 3.

The original version of the LE-Q is in the German language, as noted before. This version was subsequently translated with great care into English for use by English-speaking parents and caregivers and also for use as a source for translation into other languages [7]. We used the English-language version as the source for this study.

Fig. 1 illustrates the use of the back-translation method for adapting the 35 test items from English into Polish. The path taken in this example is indicated by the arrows and the box highlighted in gray. In this case, the two English versions from the original text and the first iteration of the Polish translation are different, and the highlighted path indicates the corrective action taken, which includes a re-translation of the source utilizing the additional information from the preceding comparison.

In this study, the direct translation step for each question in the LE-Q was carried out by a speech therapist and an audiologist, each of whom is fluent in both languages and each of whom has many years of experience in working with infants and very young children with severe hearing losses. The work of these two translators was supervised by a researcher with expertise in test construction and adaptation. Each of the translated items was discussed by this team of three. Full agreement was reached for 11 among the 35 questions and the translations for the 11 were regarded as straightforward and non-controversial. The translations for the remaining 24 questions were regarded as difficult,

Table 1
Descriptive statistics for participants.

	N	%
Children		
Boys	172	55.5
Girls	138	44.5
Subjects		
Mother	270	87.1
Father	39	12.6
Caregiver	1	0.3
Educational level of the subjects		
Primary/Vocational	22	7.1
Secondary	72	23.3
Bachelor	40	12.9
Higher university	175	56.6

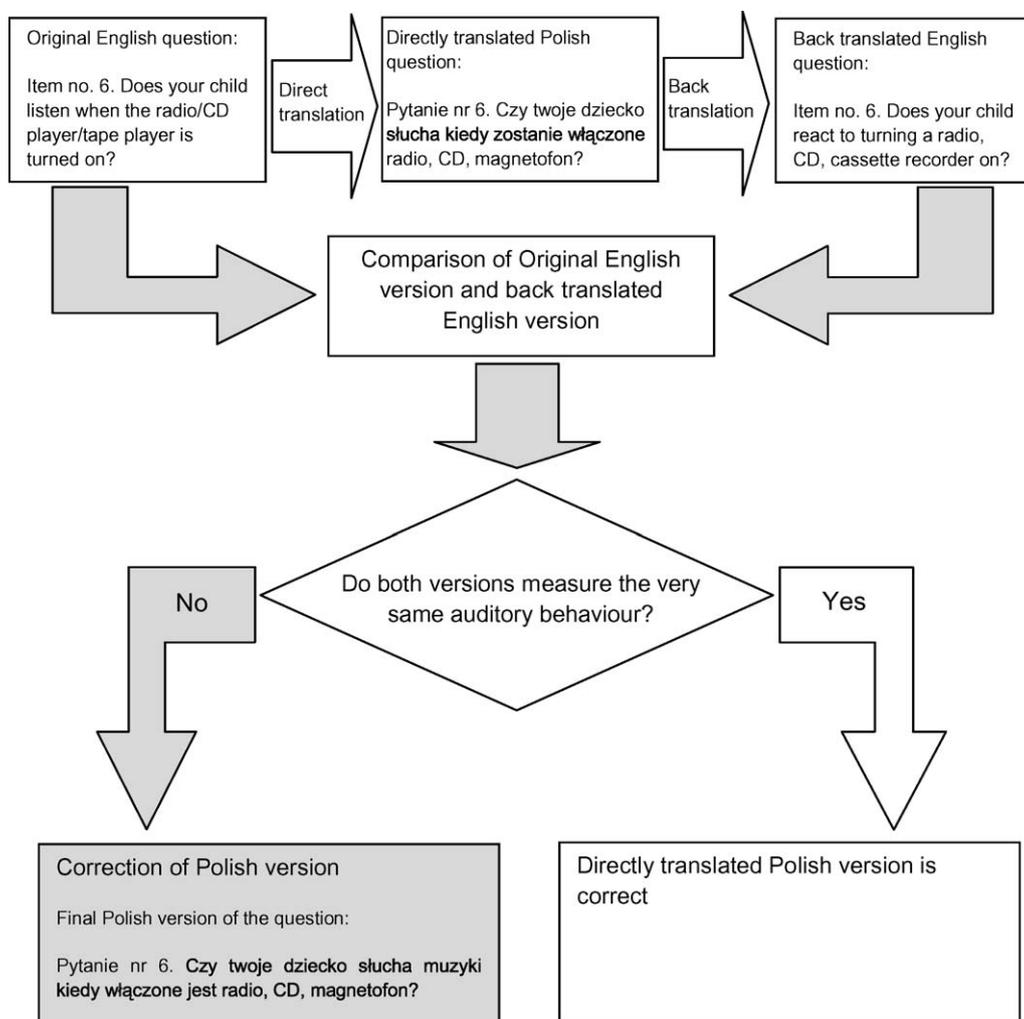


Fig. 1. Illustration of back-translation design with a real LittleEars item.

principally due to absences of direct equivalents in Polish for some English expressions, e.g., the English expressions “without seeing him/her,” “acoustic rituals,” and “to sing along when hearing a song.” In these difficult cases, the team developed a consensus for the best-possible translation for each item, in the absence of the corrective actions provided by the back-translation method.

The back-translation step (step 2) was carried out by a professional translator. This assured that step 2 would be independent of step 1 and also that the back-translation would be competently done.

All investigators in the study participated in step 3, the comparison between the English-language versions produced in steps 1 and 2 for each question in the LE-Q. As a result of the comparisons across the 35 questions, 11 were identified as having a deficiency or deficiencies in the initial (direct) translation. Table 2a presents summaries of the discussions for each these 11 test items, and Table 2b shows the corrective action taken for each of the items.

2.4. Evaluation by an expert appraisal

The translations produced with the back-translation method were evaluated further by a panel of five experts from among the staff at the Institute of Physiology and Pathology of Hearing in Warsaw, Poland. Such an appraisal by an expert panel can identify problems or flaws in translation that may persist even with the back-translation method [9].

The experts included a psychologist, a professional translator, a speech therapist, and two audiologists, all of whom were fluent in Polish and English and all of whom but one were experienced in working with hearing-impaired children. Evaluation forms (Fig. 2) were provided to the experts so that the task could be carried out in a systematic way [10].

The experts were asked to compare the English and Polish versions of each item, including the question stem and the examples, and to assess the extent to which both versions measure the very same auditory behavior. The experts gave their ratings on a numbered scale from 1 to 5, where 1 indicated a clearly inappropriate translation and 5 indicated an absolutely appropriate translation. The experts were also asked to provide comments and to offer suggestions for improvement in cases of a rating of 3 or lower.

The experts' ratings were analysed statistically. As a result, eight items were reviewed again, two of which had the lowest median value (Median = 3), and six of which had the second lowest median value (Median = 4). The experts provided additional comments or suggestions or both for five additional items. Tables 3a and 3b present the items discussed in the expert appraisal procedure and the changes introduced as a result into a refined Polish version of the LE-Q.

2.5. Procedure for validating the translated version

The psychometric properties of the final translation of the LE-Q into Polish were measured with the cooperation of the subjects

Table 2a

Items discussed after a comparison of original and back translated versions.

Item no.	Summary of discussion
4	The English expression “interested in” was considered by the supervisor to be too sophisticated. The translators decided to leave this translation, because in Poland it is quite popular.
6	The expression “react on” was changed into “listen when the radio is on”; the reaction does not refer only to the moment of turning on but it rather means overall interest in listening. The Polish translation could suggest only the moment of turning on, so we finally decided to go back to the word “listen”.
12	The example previously added was eventually removed. It was considered inappropriate from the methodological point of view.
13	The part of item “to be calmed down or influenced by music” was changed into the expression “to be calmed down under the influence of music”. The Polish translation was too long.
19	The Polish expression “cease” was regarded as too sophisticated. Translators decided to use the word “interrupt” instead.
22	The English expression “follow simple commands” had to be translated as “understand simple commands” due to the lack of a better equivalent for the first expression in Polish.
27	The Polish expression “sounds that come from certain animals” was changed to “sounds that match certain animals”. In Polish there is not any more appropriate term for “go with”
31	The Polish expression “sing with the music when hearing the song” contains one additional word, i.e. “music”, which is not present in the original version. Nevertheless, adding this word was considered appropriate from the methodological point of view.
33	In the Polish translation of the question there was: “Does your child like when you read to him/her?”. To avoid a potential misunderstanding that a “child likes when its mother or father reads a book”, the question was changed into “Does your child like when somebody reads to him/her”. It should be translated without passive voice, because in Polish it is not correct to say that “someone is being read”. We can say “read to someone”.
34	In Polish, there is no good translation of the expression “to follow doing something”. Therefore, it was necessary to use the word “understand” in the Polish version of the questionnaire.
35	The English question “Does your child try to sing familiar songs?” was translated into Polish as “Does your child try to sing well-known songs?”. This translation was considered incorrect, because one could think that a child tries to sing well-known hits. We decided to change the question and add the word “him”: “Does your child try to sing songs it knows well”.

Table 2b

Changes introduced into the Polish version after a comparison of original and back translated versions.

Item no.	Original English version	Polish version	English back translated version	Polish version corrected after back-translation
4	Is your child interested in toys producing sounds or music?	Czy twoje dziecko jest zainteresowane zabawkami grającymi, wydającymi dźwięki?	Does your child like playing toys or giving sounds?	Czy twoje dziecko interesuje się zabawkami grającymi lub wydającymi dźwięki?
6	Does your child listen when the radio/ CD player/tape player is turned on?	Czy twoje dziecko słucha kiedy zostanie włączone radio, CD, magnetofon?	Does your child react to turning a radio, CD, cassette recorder on?	Czy twoje dziecko słucha muzyki kiedy włączone jest radio, CD, magnetofon?
12	Does your child react to his/her name?	Czy twoje dziecko reaguje na swoje imię?	Does your child react on his/her name?	Czy twoje dziecko reaguje na swoje imię?
13	Does your child look for sound sources located above or below?	Czy twoje dziecko poszukuje dźwięków zlokalizowanych nad nim lub pod nim?	Does your child look for sound sources localized on the bottom or on the top?	Czy twoje dziecko szuka źródeł dźwięków zlokalizowanych u góry lub na dole?
19	Does your child respond to “No” by typically interrupting his/her current activity?	Czy twoje dziecko reaguje na “Nie” zaprzestając swojej dotychczasowej aktywności?	Does your child react to “No” giving up a previous activity?	Czy twoje dziecko reaguje na “Nie” przerywając swoją dotychczasową aktywność?
22	Does your child follow simple commands?	Czy twoje dziecko rozumie proste polecenia?	Does your child understand simple orders?	Czy twoje dziecko rozumie proste polecenia?
27	Does your child know that certain sound go with certain animals?	Czy twoje dziecko wie, że dane dźwięki pochodzą od danego zwierzęcia?	Does your child know that particular sounds come from particular animal?	Czy twoje dziecko wie, że dane dźwięki pasują do danego zwierzęcia?
31	Does your child try to sing along when hearing a song?	Czy twoje dziecko próbuje śpiewać, słysząc piosenkę?	Does your child try to sing together when hearing a song?	Czy twoje dziecko próbuje śpiewać razem z muzyką?
33	Does your child like being read to?	Czy twoje dziecko lubi kiedy mu czytasz?	Does your child like when you read something for him/her?	Czy twoje dziecko lubi kiedy ktoś mu czyta?
34	Does your child follow complex commands?	Czy twoje dziecko rozumie złożone polecenia?	Does your child understand complicated orders?	Czy twoje dziecko rozumie złożone polecenia?
35	Does your child try to sing with familiar songs?	Czy twoje dziecko próbuje śpiewać znane piosenki?	Does your child try to sing widely-known songs?	Czy twoje dziecko próbuje śpiewać znane mu piosenki?

Item n° 1	Auditory Response	Answer		Example
English	Does your child respond to a familiar voice?	Yes	No	Smiles; looks towards source; talks animatedly
Polish	Czy twoje dziecko reaguje na znany mu głos?	Tak	Nie	Uśmiecha się, szuka, żywo wokalizuje

Reviewing Task	Not Appropriate				Absolutely Appropriate
	1	2	3	4	5
	If your assessment is 3 or less, please:				
	a) Write the wrong translated word or expression:				
				
	b) and, make a suggestion:				
				

Fig. 2. The expert appraisal evaluation form.

Table 3a

Items discussed in the expert appraisal procedure.

Item no.	Summary of discussion
6	Experts found out that the word “music” is not present in the English version or in any of the previous Polish versions. Presumably this word was added by mistake as a semantic association of words “listen-to music-on the radio, CD...”.
20	In Polish there are two different expressions for names: name of the family member (e.g. a mother) and a first name”. Experts decided that in the Polish version we should use both terms conjoined with “or”. The Polish question was changed into “Does your child know the names or first names of the family members?”
14	Experts had serious doubts about the translation of the expression “sad child can be calmed down” – one can be calmed down when he/she is moody or angry not when this person is sad. Reviewing the original item: “When your child is sad or moody, can he/she be calmed down or influenced by music?”, all expert agreed that the problem could be not with the translation but with the original item.
15	After short discussion experts accepted the Polish translation
16	Some experts remarked that a better translation would be “move to the beat”. After explanation that it is not this skill which is considered in this question, all agreed not to make any changes in the Polish version.
19	As the English word “typically” was missed in the Polish translation, experts suggested adding this word to the Polish item.
27	Experts also discussed the Polish translation of the English expression “to go with”. Finally, they did not propose changing the item.
31	The suggestion was to simplify the Polish version of the item by removing the word “music” given that this word is not present in the English version.
2	In the Polish version the question was: “Does your child listen when somebody is saying something?”. The suggestion was to remove the word “something” which is not present in the original version.
5	There were also some doubts about the expression “to look for”. According to experts it should be explained to parents that this item is not about “going and searching” but it means “to follow the sound with a child's eyes” – remarks on the original version.
9	Experts suggested changing the syntax in the Polish item.
11	Experts tried to find a better word in Polish for the English term “located”, but they did not find one.
18	A suggestion to change the Polish translation of the English word “Yack” from “Fuj” into “Be”, since it is more popular in the Polish language.

Table 3b

Changes introduced into the Polish version in the expert appraisal procedure.

Item no.	Polish version corrected after back-translation	Polish version corrected after expert appraisal
6	Czy twoje dziecko słucha muzyki kiedy włączone jest radio, CD, magnetofon?	Czy twoje dziecko słucha, kiedy włączone jest radio, CD, magnetofon?
20	Czy twoje dziecko zna nazwy członków rodziny?	Czy twoje dziecko zna nazwy lub imiona członków rodziny?
19	Czy twoje dziecko reaguje na “Nie” przerywając swoją dotychczasową aktywność?	Czy twoje dziecko typowo reaguje na “Nie” przerywając swoją dotychczasową aktywność?
31	Czy twoje dziecko próbuje śpiewać razem z muzyką?	Czy twoje dziecko próbuje śpiewać, słysząc piosenkę?
2	Czy twoje dziecko słucha, kiedy ktoś coś mówi?	Czy twoje dziecko słucha, kiedy ktoś mówi?
9	Czy twoje dziecko reaguje niepokojem, kiedy słyszy gniewny głos?	Czy twoje dziecko niepokoi się, kiedy słyszy gniewny głos?
18	Czy twoje dziecko właściwie reaguje na krótkie, proste uwagi? Eg. “Stop!”, “Fuj”, “Nie!”	Czy twoje dziecko właściwie reaguje na krótkie, proste uwagi? Eg. “Stop!”, “Be”, “Nie!”

described above. The data was collected in day nurseries and pediatric clinics by staff from the Institute of Physiology and Pathology of Hearing. The subjects were informed about the project and asked to sign an informed-consent form before they participated in the study. Next, they were asked to read carefully the instructions for the Polish version of the LE-Q and then to complete the questionnaire. The persons in charge of data collection were not allowed to assist in the task; their role was to observe the subjects while they were filling out the questionnaires and to take notes about the particular respondent process on a separate sheet of paper (e.g., whether any circumstances interrupted the process). Lastly, each subject was asked to provide any comments she or he might have regarding the questionnaire or the test procedure.

2.6. Data analyses

The subjects' responses to the questionnaires were analysed in multiple ways, including derivation of descriptive statistics (means and standard deviations) and corrected item-total correlations. The latter were calculated to estimate the extent to which questions in the Polish version of the LE-Q distinguish levels of auditory development. To avoid spurious values of item-total correlations, the item under analysis is excluded from total scores when calculation item-total correlation. A corrected item-total correlation of more than 0.50 is usually regarded as sufficient for distinguishing levels with confidence and good reliability [11]. Higher corrected item-totals indicate greater sensitivities and confidence levels.

In addition to these metrics, Cronbach's alpha coefficient was calculated to evaluate the internal consistency of responses to each

question in the questionnaire. The higher the coefficient, the more reliable are the measurements, with reliability indicated as the consistency of answers to items provided by the subjects. A Cronbach's alpha value of more than 0.70 indicates good reliability [11].

The correlations between total/item scores and age can be seen as evidence for the validity of measures provided by the LE-Q, inasmuch as the total score is intended to be a measure of a child's age-appropriate auditory behavior.

To rule out the possibility of potential systematic errors in measurement, the possible dependence of the subject responses on the gender of the children was assessed. In addition, possible effects of the educational level of the subjects was evaluated. The means of the total scores for boys and for girls were compared using a *t*-test and an ANOVA was used to evaluate the possible effects of the educational background of the subjects.

Lastly, a non-linear least-squares regression between the total scores and age was calculated to obtain expected and minimum values (the expected minimum values were the lower 95% confidence intervals) for the assessed children with normal hearing. These values provided normative data of the Polish LE-Q for subsequent applications with other cohorts.

All statistical analyses were performed using version 16.0 of the SPSS program package [12].

3. Results

The descriptive statistics for each of the 35 items, along with the corrected item-total correlation values and the Cronbach's alpha coefficient value are shown in Table 4. The mean values range from

Table 4
Descriptive statistics and item analyses of the LittlEars questions.

Question number	Mean	Standard. deviation	Corrected item-total correlation	Alpha if item is deleted
1	0.99	0.06	0.14	0.96
2	0.98	0.13	0.22	0.96
3	0.97	0.18	0.18	0.96
4	0.99	0.06	0.15	0.96
5	0.93	0.25	0.44	0.95
6	0.93	0.26	0.54	0.95
7	0.91	0.29	0.53	0.95
8	0.80	0.40	0.28	0.96
9	0.87	0.34	0.35	0.96
10	0.93	0.26	0.43	0.95
11	0.92	0.28	0.50	0.95
12	0.89	0.31	0.57	0.95
13	0.88	0.33	0.56	0.95
14	0.74	0.44	0.30	0.96
15	0.85	0.36	0.71	0.95
16	0.83	0.37	0.71	0.95
17	0.73	0.45	0.73	0.95
18	0.78	0.41	0.77	0.95
19	0.68	0.47	0.61	0.95
20	0.77	0.42	0.78	0.95
21	0.71	0.45	0.74	0.95
22	0.74	0.44	0.80	0.95
23	0.73	0.44	0.84	0.95
24	0.72	0.45	0.81	0.95
25	0.62	0.49	0.79	0.95
26	0.61	0.49	0.77	0.95
27	0.63	0.48	0.79	0.95
28	0.59	0.49	0.73	0.95
29	0.47	0.50	0.62	0.95
30	0.59	0.49	0.74	0.95
31	0.46	0.49	0.63	0.95
32	0.49	0.50	0.70	0.95
33	0.60	0.49	0.70	0.95
34	0.52	0.50	0.72	0.95
35	0.31	0.46	0.53	0.95

0.31 to 0.99. As the response format of each LittlEars item is dichotomous (i.e., only “yes” or “no” responses are permitted), the mean values of the items can be considered as indices of difficulty, with high values indicating little difficulty and low values indicating greater difficulty. The mean values for the first four questions (0.97 or higher; see Table 4) show that the behaviors probed by the questions were observed in almost all children, whereas the mean values for final eleven questions (0.62 or lower) show that the behaviors probed by those questions were less frequently observed and therefore presumably more difficult to attain. In general, the behaviors probed by the questions become less frequent as the question number increases. This is in accordance with the structure of the LittlEars questionnaire as the questions have been sorted by their difficulty indexes.

Table 4 also shows the corrected item-total correlations, which range from 0.14 to 0.84. Consistent with the idea that responses to easy questions will be least predictive of the total scores, the first four questions have the lowest corrected item-total correlation values (0.22 or lower). All questions but 9 have values higher than 0.50, indicating a high predictive power for most questions. In addition, the Cronbach’s alpha coefficient value is 0.95 or higher for all questions in the Polish version of LE-Q, indicating that the subject responses are highly consistent across the LittlEars items. Taken together, the corrected item-total correlation and the Cronbach’s alpha coefficient values show that the LittlEars items can distinguish in a reliable way the level auditory development of the assessed children.

The values of the correlations between item scores and age are given in Table 5. The correlation values between item scores and age range from 0.14 to 0.88. The lowest values are found for items from 1 to 4. These items are intended for measuring auditory

behavior that even very young children can demonstrate. Therefore, a weak correlation with age for those particular questions is not surprising. The correlation between total scores and age is 0.90 ($p < 0.001$), this strongly supports the concept that the tested Polish version of the LE-Q provides a sensitive measure of auditory development, which is highly correlated with age for children with normal hearing [4].

The result of the *t*-test did confirm the null hypothesis on the equality of the means when comparing boys’ and girls’ scores in the LE-Q ($t = 0.82$; $p = 0.41$). Thus, the expected and minimum values can be calculated without differentiating by gender. In addition, the ANOVA did not show significant differences in total scores due to the educational background of the subjects who responded to the LE-Q ($F = 1.39$; $p = 0.25$). This latter result indicates that the Polish version of the LE-Q is suitable irrespective of the educational level of the parents or other caregivers responding the questionnaire. Due to the relatively small size of the sample (310 children whose ages ranged from 0.47 to 24.00 months), it was considered most appropriate to calculate the expected and minimum values by means of a regression of total scores to age. (The values also could have been calculated as the mean values and confidence intervals for each one-month “bin” or interval of age, but the number of observations would be quite low in some bins and zero in others using this approach.) In the regression model, the total score was the dependent variable and age was the independent variable. A non-linear regression was used to improve the fit to the data. The results show that the age variable contributes significantly to the model of total scores. The model can be presented by the following equation: $y = -0.028x^2 + 1.98x - 4.85$, where the total score is represented by the variable “*y*” and age is represented by the variable “*x*.” The coefficient of

Table 5
Correlations between question scores and age.

Question number	Pearson correlation with age
1	0.14
2	0.19
3	0.16
4	0.14
5	0.38
6	0.50
7	0.47
8	0.18
9	0.29
10	0.38
11	0.44
12	0.56
13	0.54
14	0.24
15	0.69
16	0.67
17	0.67
18	0.72
19	0.53
20	0.75
21	0.70
22	0.88
23	0.83
24	0.81
25	0.75
26	0.73
27	0.75
28	0.70
29	0.56
30	0.72
31	0.58
32	0.67
33	0.61
34	0.72
35	0.49

determination for the non-linear model shows that 83% of the variance in the total scores can be explained by age ($R^2 = 0.83$).

The expected and minimum values were calculated using the results of the regression analysis. Fig. 3 shows these values for children from 0 to 24 months of age together with total scores

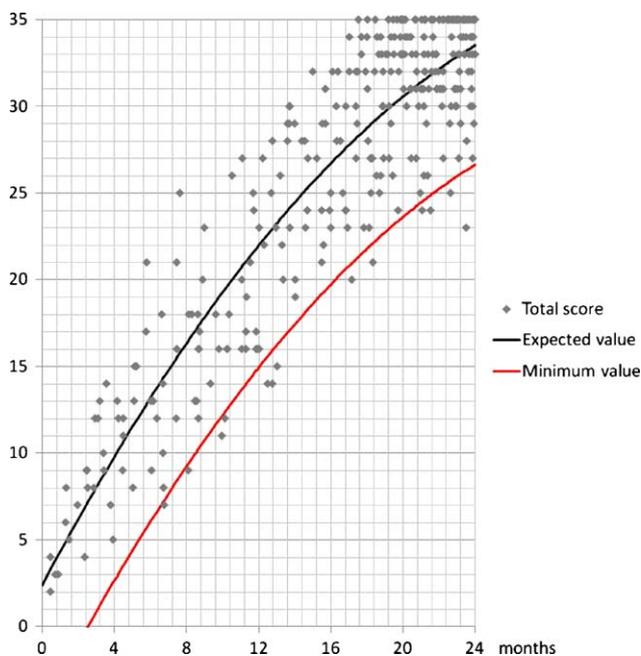


Fig. 3. The plot of expected and minimum values together with total scores for the tested subjects.

Table 6
Psychometric properties of the original and Polish-language versions of the LittlEars questionnaire.

Parameter	Original version [4]	Polish version
Cronbach's alpha	0.96	0.95
Correlations between total score and age	0.91	0.90
R^2 -coefficient	0.86	0.83

for the tested subjects. Decisions for children under 3 months must be made using other tools, in that the expected minimum values for these children are all zero and therefore zero scores cannot discriminate between normal and abnormal auditory development.

4. Discussion

The principal aims of this study were to (1) adapt the LE-Q for use with Polish-speaking parents or other caregivers and (2) measure the psychometric properties of the developed Polish version of LE-Q. An additional aim was to provide normative data for interpreting scores obtained for Polish children.

The translated Polish version of the LE-Q is the result of applying a back-translation method. Use of the method identified flaws in the initial direct translation of the LE-Q, that were corrected in an iterative process. The psychometric properties of the final version of the Polish LE-Q are excellent and indicate high reliability and repeatability of measures. The results obtained from the item analyses and the high values of Cronbach's alpha coefficient demonstrate that this final version of the Polish LE-Q can be used with confidence to estimate auditory development in Polish children who are between 3 and 24 months of age. The questionnaire is not sensitive to differences in auditory development for younger children, as the expected minimum values are all zero for ages up to 3 months.

The psychometric properties of the Polish LE-Q are quite similar to the properties reported by the authors of the original German version (Table 6). The values are nearly identical (and not statistically different) for Cronbach's Alpha coefficient and for the correlations between total scores and age. A small difference is found between the R^2 coefficients for the two versions. This difference shows that age is slightly more predictive of the total score for the German version of the questionnaire ($R^2 = 0.86$) than for the Polish version ($R^2 = 0.83$). Possibly, this small difference might be the result of a small difference in the distributions of ages for the children in the two studies.

The high correlations found between the total scores and age strongly support the use of the tested Polish version of the LE-Q to make informed and accurate inferences about auditory development in infants and young children. In addition, the high level of the R^2 coefficient lends confidence to the calculations for the expected and minimum values, which are needed for the interpretation of the total scores in other cohorts.

5. Conclusion

The rigorous process carried out to adapt the LE-Q for use with Polish-speaking parents or other caregivers, along with the results of psychometric analyses of the developed Polish version of the LE-Q, support the use of the Polish version as a sensitive and highly-reliable tool to assess auditory behavior in Polish children who are between 3 and 24 months of age. Future research should be performed to obtain data on the utility of the Polish version of the LE-Q for populations of children with abnormal hearing, e.g., by comparing auditory development as indicated by the questionnaire with other measures of auditory function.

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