Interpretation of Functional Listening Evaluation Results of Normal-Hearing Children with Reading Difficulties

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This report follows up on the article by Dodd-Murphy & Ritter (2012) that presented Functional Listening Evaluation (FLE) group data for normal-hearing children with reading difficulties. The current study describes a retrospective analysis of the same database, focusing on clinical interpretation of individual FLE results. The FLE (Johnson & VonAlmen, 1997), frequently used by educational audiologists to assess the need for classroom accommodations in children with hearing loss, is a protocol that measures the effects of noise, distance, and visual information on speech recognition under typical classroom listening conditions. FLE summary forms were reviewed for each child to determine whether the results would support the recommendation of hearing assistance technology (HAT) in the classroom. Judgments were made based on potentially significant noise and/or distance effects on speech recognition from the FLE interpretation matrix. Specific criteria and examples of FLE profiles are provided. The FLE pattern of results was judged to support HAT recommendation for 44% of the children. Mean speech recognition scores for the children who were not HAT candidates were 90% or above in all listening conditions. Mean scores for children judged to need HAT in the classroom were below 90% in all conditions. The FLE may provide evidence of classroom listening needs that assist the clinician in making appropriate intervention recommendations for this population. Further prospective research is needed to evaluate the efficacy of the FLE in predicting which children may benefit from the use of HAT in the classroom.

Introduction

Educational audiologists have long been aware of the benefit that classroom hearing assistance technology (HAT) can provide for children with hearing impairment (Johnson & Seaton, 2012; Lewis, 2010). In recent years, there has been a greater awareness of how poor classroom acoustics can reduce access to auditory learning not only for children with hearing loss, but for children in general (Jamieson, Kranjc, Yu, & Hodgetts, 2004; Nelson & Soli, 2000; Stelmachowicz, Hoover, Lewis, Kortekaas, & Pittman, 2000; Stuart, 2008). Though not as extensive as the literature related to the use of HAT with children who are deaf or hard of hearing, a growing body of evidence has indicated that remote microphone technology can improve classroom behavior and academic performance in children with normal hearing belonging to various clinical populations (Darai, 2000; Dockrell & Shield, 2012; Flexer, Millin, & Brown, 1990; Johnston, John, Kreisman, Hall, & Crandell, 2009; Sharma, Purdy, & Kelly, 2012). Professional guidelines published by the American Academy of Audiology (2008) identify children with normal hearing and special listening requirements as one of three groups who are candidates for the use of remote microphone HAT. Crandall, Smaldino, & Flexer (2005) enumerate at-risk populations that would benefit from an increased signal-to-noise ratio (SNR) such as that provided by classroom HAT, including children with typical hearing who have learning disabilities, language disorders, attention deficits, and/or children who are English language learners. Not all children in these groups would require HAT for improved access to auditory learning; thus, careful assessment of the educational need for HAT is critical in this population (Johnson, 2010; Johnson & Seaton, 2012; Lewis, 2010; Schafer, 2010). This type of assessment typically includes classroom observation, teacher questionnaire, and a direct measurement of functional listening abilities (AAA, 2008; American Speech-Language-Hearing Association, 2002; Johnson, 2010; Schafer, 2010).

The Functional Listening Evaluation (FLE, Johnson & VonAlmen, 1997) is an assessment tool commonly used by educational audiologists to determine the need for hearing assistive technology (HAT) and/or other classroom accommodations. The FLE was designed to show the effects of noise, distance, and visual input on the speech recognition performance of children with hearing loss under conditions simulating a typical classroom environment. Eiten (2008) stressed the importance of using quantifiable measures and providing supporting information related to a child's speech recognition performance without HAT when determining candidacy. The FLE fulfills both of these objectives. Additionally, the FLE can satisfy the requirement of Individuals with Disabilities Education Act (IDEA) for functional evaluation in the child's regular classroom environment. The FLE is valued as a direct measurement of a child's performance to corroborate and supplement other findings such as child, teacher, or parental reports of speech recognition difficulties.

It is crucial for audiologists to justify any recommendation of hearing assistive technology (AAA, 2008; Eiten, 2008; Johnson, 2010; Johnson & Seaton, 2012). This would be particularly true when working with children who have normal hearing sensitivity, who are typically not expected to need hearing-related interventions. In addition, their classroom listening problems may be much more subtle than those of children with hearing loss. In their research, Dodd-Murphy and Ritter (2012) used the FLE to evaluate a group of children with normal hearing who were diagnosed with language and reading impairment. They concluded that the FLE was potentially useful to justify the recommendation of HAT (e.g., personal FM systems or classroom audio distribution systems [CADS]) and other accommodations in children with normal hearing and special listening needs, particularly with modifications to the speech material and the protocol to increase the FLE's sensitivity in assessing children with normal hearing. This report describes the results of a retrospective analysis of individual FLE results from the same database to evaluate each child's educational need for HAT.

Methods

Participants

Participants were recruited from children who attended a university-sponsored language and literacy intervention program, held in the summer as an intensive month-long day camp. A group of 39 children (27 males) between the ages of 7;0 and 10;11 (years; months) participated in the project. All children were diagnosed by certified, licensed speech-language pathologists with oral and written language disorders affecting literacy and had passed a hearing screening. Following approval from the university Institutional Review Board, informed parental consent was obtained for each child, and monetary compensation was given for participation.

Materials

The researchers used the 2002 revision of the FLE (Johnson & VonAlmen, 1997) as described below to evaluate the need for HAT. The most recent version of the FLE protocol and form is available from ADEvantage (http://adevantage.com/uploads/FLE_2013v2a-saveable_autocalculable.pdf). The FLE allows examiners a choice of speech materials. For this study, the BKB-SAE sentences (Bamford, Kowal, & Bench, 1979) were the stimuli. There are eight different lists of short sentences; the sentence list order was counterbalanced. A different list was presented in each of the FLE listening conditions. The scorebox in Figure 1 shows the eight conditions; the sequence order for each condition is designated by the number in the top left hand corner of each data cell. The listening condition sequence was kept the same for each child.

Procedure

For a more detailed discussion of the methodology, see Dodd-Murphy & Ritter (2012). The FLE was administered by two undergraduate student researchers trained and supervised by a licensed, certified audiologist. Testing was conducted in an unoccupied classroom in the same building as the day camp the children were attending. During the FLE, the child sat in a desk, and the examiner read the sentences from three feet away in the 'Close' conditions and from 15 feet away in the 'Distant' conditions. For the 'Noise' conditions, a recording of multi-talker babble was adjusted so that its level averaged 60 dBA SPL at the child's ear. An acoustically transparent screen covered the examiner's face during the 'Auditory only' conditions.

The student researchers worked as a pair; one examiner presented the sentences via monitored live voice, and the other examiner marked the child's responses on a score sheet. An average of 75 dBA SPL speech presentation level was maintained using a sound level meter one foot away from the speaker. Every sentence was presented only once, and the child was asked to repeat each sentence exactly as the speaker read it. A wireless lapel microphone, worn by the child during the testing session, transmitted responses to a digital voice recorder, which enabled the session recording to be saved as a sound file. Responses were scored as correct if the entire sentence was repeated correctly. The FLE scorebox on the summary form (Figure 1) shows a score for each condition.

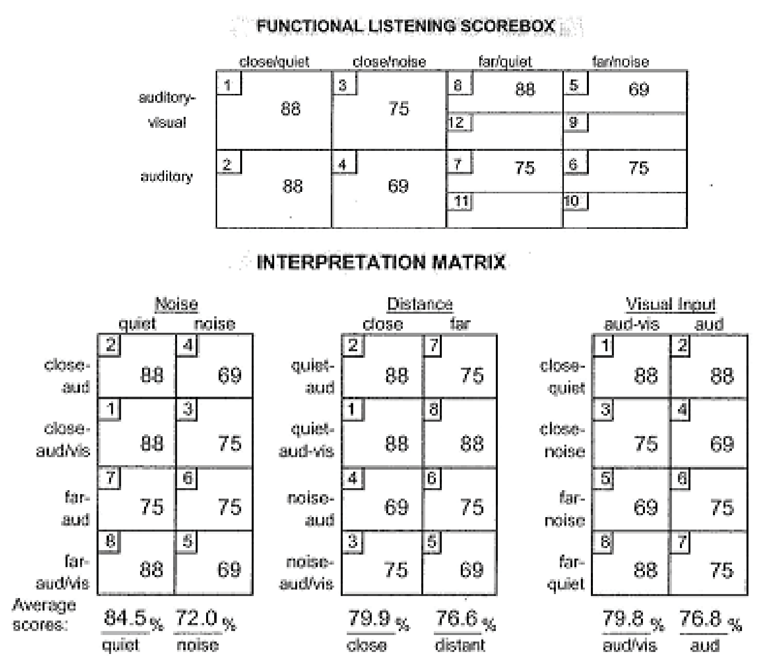

Figure 1. Individual FLE profile for child with educational need for HAT

A certified audiologist with experience in both clinical and educational audiology reviewed the FLE summary and interpretation forms for individual children to evaluate whether the pattern of results would support the recommendation of classroom HAT. The FLE interpretation matrix (see Figure 1) allows the examiner to observe the effects of noise, distance, and/or the presence of visual cues on speech recognition overall. For example, the average score for all conditions in quiet may be compared to the average score for all conditions presented with background noise; if the 'noise' score is significantly lower than the 'quiet' score, there is a detrimental effect of noise.

After an extensive literature search, the authors found no specific criteria that define what amount of noise or distance effects shown by the FLE would be considered educationally significant. Criteria were developed based on research using either the BKB-SAE materials or BKB-SIN to test the speech recognition in noise of children with normal-hearing and typical development, particularly those reports that provided sentence recognition scores in percent correct for multiple signal-to-noise ratios and that included children in the same age range as the current study (Crandell & Smaldino, 1996; Lewis, Hoover, Choi, & Stelmachowicz, 2010; Neuman, Wroblewski, Hajicek, & Rubinstein, 2010; Wroblewski, Lewis, Valente, & Stelmachowicz, 2012). Ceiling effects were indicated, particularly for quiet conditions and those with SNRs of +3 to +5 dB; standard deviations were low (rarely exceeding 5%) across studies and conditions for single measures of speech recognition. In addition, normative data for recognition of monosyllabic words at varying signal-to-noise ratios indicates children who were typically-developing averaged scores at 90% and above, even for the most difficult condition (0 dB SNR with the speech level at 35 dB HL; Bodkin, Madell, & Rosenfeld, 1999). The proposed criteria also took into consideration the FLE performance of five typically-developing children obtained as pilot data and using the same protocol as described in this report; these children showed uniformly excellent results across the conditions. The criteria used to indicate the need for HAT were the following: 1) noise effect of 5% or greater and average score in noise less than 90%; 2) distance effect of 6% or greater and average score in distance less than 90%; 3) average score < 80% in quiet conditions; or 4) any combination of the above.

Results

FLE profiles of 44% (17/39) of the participants were judged to indicate the need for HAT in the classroom. Almost half of the potential HAT candidates met the noise effect criteria alone, while six children met the criteria based on distance alone. Two children showed adverse effects of both noise and distance, while one child had a small noise effect in the auditory-only conditions and low scores overall (see Figure 2). The mean sentence recognition scores for children with FLE profiles supporting HAT recommendation were below 90 % in all conditions (ranging from 73 to 86%), while the mean sentence recognition scores for children without the need for classroom HAT were 90 % or greater in all FLE conditions. The largest group differences between children with and without educational need for HAT were present in the conditions combining noise and distance (Auditory-Visual/Distant/Noise: 78 vs. 94%; Auditory/Distant/Noise: 73 vs. 94%).

Two examples of individual FLE results are shown, one from a child judged to need HAT (Figure 1) and another from a child judged not to need HAT (Figure 3). Figure 1 shows the FLE interpretation matrix for a male aged 10;11 with sentence recognition scores less than 90% across all eight conditions. His average score for sentence recognition in quiet was 84.5% compared to an average score of 72% for sentences presented in noise, yielding a 12.5% noise effect that met the criteria for the need for classroom HAT. Figure 3 displays the FLE results for a nine-year-old female who demonstrated high scores overall, with no clear noise or distance effect. Her FLE profile did not meet the criteria for potential HAT candidacy.

Discussion

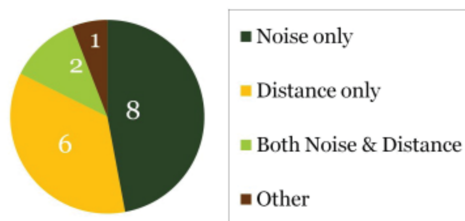

Figure 2. Distribution of criteria categories for children needing HAT

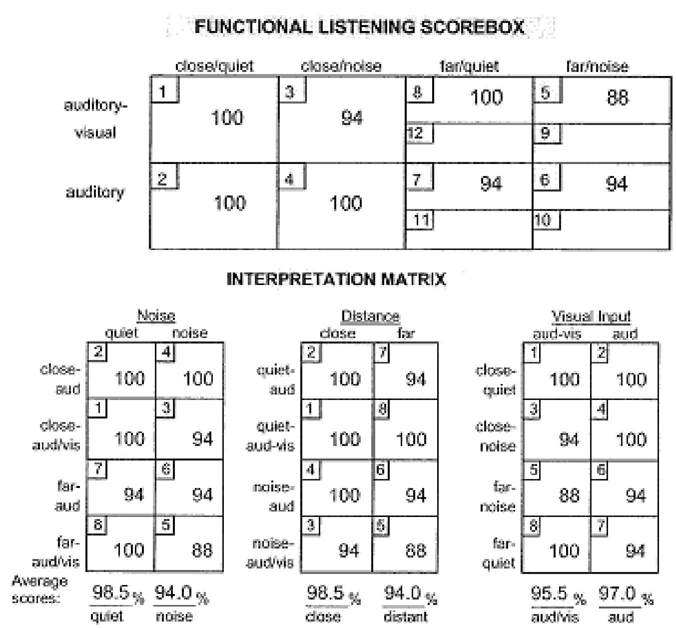

Figure 3. Individual FLE profile for child with no educational need for HAT

The current study is an extension of Dodd-Murphy & Ritter (2012) that focused on whether information gained from the FLE might facilitate professional decision-making by demonstrating the educational need of HAT for individuals within a clinical population—children with language and reading impairment who have typical hearing. FLE results provided quantitative evidence of adverse noise and/or distance effects on sentence recognition in a classroom setting for a large proportion (44%) of children with reading impairments and normal hearing. In addition, the better of the two FLE scores for the close, quiet conditions (with or without visual cues) can be used as a goal for speech recognition performance with HAT in conditions with noise and distance (Johnson, 2010). For example, for the child whose FLE results are shown in Figure 1, performance with classroom HAT would be expected to improve scores in all conditions with noise and/or distance to at least 88% sentence recognition.

In the current study, the focus is on interpretation of the FLE and what information it may supply on its own; however, comprehensive multi-faceted evaluation of HAT candidacy is considered best practice. The FLE would not be used alone to support the recommendation for HAT use, rather it would be one of multiple measures that clinicians integrate in determining HAT candidacy for a particular child (AAA, 2008; Eiten, 2008; Johnson, 2010; Schafer, 2010).

Participants of this study would qualify for school accommodations or special services (based on academic/reading delays and/or language impairment), as would many children with normal hearing and special listening requirements. The retrospective interpretation of the FLE in this analysis revealed that for slightly over half of the participants, the FLE did not show clear negative effects of noise and/or distance on sentence recognition. Even for children whose FLE results indicated reduced sentence recognition under typical classroom conditions, further targeted measures such as teacher rating scales and classroom observations would be necessary to supplement the results when requesting a school district to provide HAT. The current study focused on FLE testing without technology; however, demonstrating the potential for HAT to improve access to speech in noise or distance can be accomplished by adding conditions with and without technology to the noise/distance conditions of the FLE. This practice is recommended whenever possible to strengthen the documentation of educational need for HAT.

Classroom HAT is designed to improve the speech-to-noise ratio for a particular child, overcoming difficulties with increased noise level and distance between the speaker and listener. Accordingly, those FLE profiles that indicated negative effects of noise and/or distance on sentence recognition scores were considered to show educational need for HAT. Relatively low scores overall were also considered. The detrimental noise and/or distance effects were relatively small--the largest noise effect (i.e., average score for four quiet conditions minus the average score for the four noise conditions) among the children judged to need HAT was 16%, and the largest distance effect within the same group was 14%. When comparing the children who were judged to be potential HAT candidates with those who were not, the largest between-group performance differences were for the Distant/Noise conditions, reflecting the criteria for HAT candidacy. There are no specific indications in the literature for the FLE about what magnitude of noise or distance effect would be considered sufficient to support the recommendation of HAT; the flexibility of the protocol and the variety of speech materials that could be used prevent the establishment of criteria that would be accurate in all cases. Research measuring speech recognition in noise using the BKB sentences (Lewis, Hoover, Choi, & Stelmachowicz, 2010; Wroblewski, Lewis, Valente, & Stelmachowicz, 2012), as well as some normative word recognition data using similar SNRs (Bodkin, et al., 1999) suggest that typically-developing children with normal hearing of similar ages as those in the current study would perform similarly to older children and adults for SNRs as low as 0 dB. Even small decrements in speech recognition in adverse listening conditions may be educationally significant for children in a clinical population when compared to very high scores and low variability from typically-developing peers with normal hearing (Anderson, 2012).

There is a lack of available data regarding the FLE, particularly regarding its use for children with normal hearing. Expected FLE results for typically-developing children of various ages are needed. Dodd-Murphy and Ritter (2012) suggested modifications to the protocol that may help sensitize the FLE to listening difficulties that some children with typical hearing face, such as lowering the signal level to decrease SNR and using more difficult speech material. Future prospective research comparing FLE performance differences between normal-hearing children with language and reading impairments (or other special listening needs) and a matched control group is necessary to establish what magnitude of negative noise and/or distance effects could be considered educationally significant. Furthermore, comparing outcomes for children in this population with and without HAT use in the classroom would help guide audiologists as they make their recommendations. Finally, evidence is needed to determine how other direct measurements of speech recognition in noise compare to the FLE in their ability to predict which children are most likely to benefit from HAT in the classroom.

In conclusion, the FLE can contribute potentially valuable information about classroom listening function for typically-hearing children with language and reading impairment. Clinical interpretation of the FLE indicated that almost half of this group of children may have special listening needs that could be associated with academic delays. Findings from the FLE should be used within the context of a comprehensive evaluation of HAT candidacy on a case by case basis. Further prospective research is needed to evaluate the efficacy of the FLE in predicting which children will benefit from the use of HAT in the classroom.

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